Low Back Pain: Quantifying Risk Factors

Final Report

Arun Garg, Ph.D., C.P.E.
Kurt T. Hegmann, M.D., M.P.H.
J. Steven Moore, M.D., M.P.H.

This page is intentionally blank

Acknowledgements

Table of Contents:

Abstract

A large scale, multi-site prospective cohort study of Low Back Pain (LBP) was incepted in 2003 with follow-up of the workers through 2006. The primary aims of the study were to quantify relationships between job physical factors and risk of LBP, as well as impairments of LBP.

A total of 759 subjects were enrolled in the study, drawn from a total worker population of over 12,000 from 30 different industries in 4 diverse states (WI, UT, IL and TX). Complete baseline data were available on 647 subjects and complete follow-up data on 610 subjects with a total follow-up of 1033 person-days.

All subjects were rendered a questionnaire, structured interview and physical examination at the baseline to document and quantify demographic data, social history, psychosocial factors, past medical history, and low back pain status and related history at the time of enrollment. A comprehensive job physical exposure assessment was made for each worker using worker interview, actual measurements of job physical exposure variables and videotaping of the job. The cohort was followed monthly to ascertain low back pain status. Workers were followed quarterly to ascertain a change in job physical exposure. The health outcome assessment team and job physical exposure assessment team were blinded to each other.

One hundred forty eight participants (24.3%) never had a pain-free period that lasted 90 days or more. Out of 462 workers that were eligible, there were 182 incident cases of any LBP. The incidence rate for any LBP was 43.1 per 100 person-years.

There was no evidence of association ($p \geq 0.2$) between incident cases of any LBP and age, gender, height, body weight, BMI, race, education level smoking (pack-years). There was no evidence of association between incidence cases of any LBP and hobbies.

There was evidence of association between incidence of any LBP and psychosocial scales: modified work APGAR ($p \leq 0.01$), modified Zung depression scale ($p \leq 0.01$) and tense/edge/nervous composite scale ($p = 0.02$). There was evidence of association between any LBP and several different assessments of past history of LBP. Stratified analyses of job physical exposures showed evidence of association between job physical metrics and any LBP.

Lifting maximum weights near floor level (vertical height ≤ 5") ($p - 0.11$) showed suggestive evidence of association and lifting at a greater than 52" ($p < 0.01$) showed evidence of association with incidence of any LBP. This study found no evidence of association between peak compressive force and incidence of any LBP and peak moment and incidence of any LBP. Composite Lifting Index (CLI) for those lifts and lowers that had origin, destination or both at or below 30" height showed that there was evidence of association between CLI and incident cases of any LBP ($p \leq 0.05$).

This page is intentionally blank

iv

Section 1.
Highlights/Significant Findings

1. Low back pain is common among U.S. workers with significant severity. In this study, more than 6 out of 10 participants had experienced LBP in their lifetime. One out of nine (11.6%) participants reported that they were ever placed on light duty/modified duty due to LBP, 11.3% had lost workdays, 7.5% received workers compensation due to LBP-related injuries, 30.2% took any medication to treat their LBP and 33.1% ever saw a healthcare provider for their LBP. A small percentage of participants (3.7%) ever changed their jobs because of LBP.

   The incidence rate for any LBP was 43.1 per 100 person-years.

2. Practically all assessments of past history of LBP were predictive of future incident cases of LBP. These included: more than three separate lost-time episodes, pinched nerve/sciatica), changed job because of LBP, missed work because of LBP, ever been on light/modified duty, saw a healthcare provider), ever used medicine to treat LBP, ever received workers compensation for back injuries, and diagnosis of LBP strain/sprain by a healthcare provider.

3. Stratified analyses of job physical exposures showed evidence of association between job physical metrics and LBP. Composite Lifting Index (CLI) for those lifts and lowers that performed at or below 30" height was associated with incident cases of LBP.

4. Certain psychosocial scales, such as modified work APGAR, modified Zung depression scale and tense/edge/nervous composite scale were associated with incident cases of LBP.

5. This study did not find evidence of association between peak compressive force and incidence of any LBP or peak moment and incidence of LBP.

6. There was no evidence of association between incident cases of LBP and hobbies and physical activities outside of work. Similarly, there was no evidence of association between anthropometric dimensions, education level smoking, medical history other than LBP and incident cases of LBP.

Translation of Findings
Workers with a past history of LBP requiring medical attention are at an increased risk of developing future LBP. Therefore, efforts should be made to prevent the first incidence of low back pain. Both job physical demands and psychosocial factors are associated with future occurrence of LBP. The overall findings of this study have implications for the proactive prevention programs for LBP. It appears that a more holistic approach addressing both job physical demands and psychosocial issues might be more effective in prevention of work-related LBP.

Among different job analysis tools studied, the Revised NIOSH Lifting Equation was found to be most predictive of future cases of LBP. The study found that the Revised NIOSH Lifting Equation was effective in quantifying job physical demands associated with lifting and lowering tasks.

Certain health issues such as obesity, smoking, diabetes and cholesterol were not associated with future cases of LBP. Similarly, hobbies and physical activities outside of work were not predictive of future cases of LBP. This would suggest that the primary efforts should be directed in addressing job physical demands and psychosocial factors to prevent work-related LBP.

Outcomes/Relevance/Impact

The results of this study suggest that the three most important predictors of future LBP are (i) past history of LBP, (ii) job physical demands and (iii) psychosocial factors. The results suggest that there might be interactions between these three predictors. These interactions may be more effective in predicting future cases of LBP. Due to short duration of this prospective cohort study it was not possible to study these interactions. Further, this study may not have enough statistical power to study these interactions. Future research studies should be designed to address these interactions. It is highly recommended that efforts should be made to pool the data from three different prospective cohort studies that were partially supported by NIOSH and an analysis of the pooled data should be performed to study these interactions as well as better quantify risk factors for LBP with sufficient power.

Accurately quantifying job physical exposure and assigning physical exposure to a worker was the biggest challenge that this study faced. The study found that there were significant and frequent changes in job physical exposure within a day, within a week, within a month and between months of follow up. Accurately accounting for physical exposure would require substantial manpower and time, an issue that the future studies should carefully consider. More importantly, new strategies and procedures are needed for assigning job physical exposure at the worker level with varying exposure during a day. This study did not find that traditional approaches such as peak stress, cumulative stress and time-weighted average were associated with the incident cases of LBP. This is an important issue and adequately addressed in the literature.

Section 2

1. Hypotheses and Aims of the Study

The following were the hypotheses and aims of the study:

HYPOTHESES

Hypothesis 1: There are significant relationships between quantitative Job Physical Exposures and the subsequent risk for low back pain (LBP) in a cohort.

Hypothesis 2: There are significant relationships between quantitative Job Physical Exposures and subsequent risk of low back impairments (e.g. diminished range of motion) and LBP measures of severity (e.g. medication use, lost or restricted workdays).

Specific Aims:
1.   Measure Job Physical Exposures in low, medium and high exposure groups while blinded to health outcomes.
    a.   Measure Job Physical Exposures at baseline and record changes in exposures *quarterly* over an average 24 month follow-up period.
    b.   Quantify Job Physical Exposures such as weight, force, moments on the low back, horizontal and vertical location of the hands, repetition, posture, hours of exposure, etc.
    c.   Analyze exposures with existing job analysis models particularly including the Revised NIOSH Lifting Equation (RNLE), Maximum Acceptable Weights and Forces (MAWs), 3-D Static Strength Biomechanical Model (3D-SSPP), the Proposed TLV for Lifting (TLV-Lifting), and the Washington State Checklist (WA-List).
    d.   Classify exposures into Low, Medium and High exposure categories.

2.   Measure the incidence of LBP and related outcomes while blinded to exposure data.
    a.   Obtain questionnaire data, structured interviews, and physical examinations on all subjects at baseline.
    b.   Monitor the entire cohort *monthly* for relevant changes in low back health status and render structured interviews and physical examinations for those with either new LBP symptoms or changes in symptoms.
    c.   Perform exit questionnaires, structured interviews, and physical examinations on all subjects at the termination of the study (or upon termination of employment).

3. Assess relationships between the Job Physical Exposures and LBP-related Health Outcomes
    a. Measure the prevalence of prior LBP, current LBP, current sciatica, current low back impairments, LBP-related restricted duty, and healthcare utilization at baseline.
    b. Determine the incidence rates of LBP at the end of year 01 and again at the mid-point (18 months into the study) to determine whether additional enrollments are needed for achieving an adequate sample size.
    c. Determine the incidence rates for LBP, sciatica and low back impairments at the study termination.
    d. Determine LBP severity rates (lost time workdays, restricted workdays, and healthcare utilization).
    e. Evaluate the relationships between job physical exposures and LBP, sciatica, low back impairments, and LBP severity.

2. Methods

2.1   Research Teams:

The research team consisted of investigators located in Texas, Utah and Wisconsin. Each location had two teams (Figure 2.1): (i) Health Outcome Assessment Team and (ii) Job Physical Exposure Assessment Team. The Health Outcome Assessment Teams and Job Physical Exposure Assessment Teams were blinded to each other. A third team, Data Compilation and Statistical Analysis Team was located in Utah. This third team stored, complied and preformed relevant statistical analyses on the combined data from all three sites.

The Job Physical Exposure Assessment Teams enrolled the subjects in the study (except in Utah where worker enrollment was performed by the Health Outcome Assessment Team), performed baseline job physical exposure assessments, conducted quarterly follow-up of the cohort to determine changes in job physical exposure, analyzed job physical variables (except in Texas, Texas data were extracted in Texas, but analyzed in Wisconsin) to quantify job physical exposures and compute metrics of job physical exposure.

The Health Outcome Assessment Team administered the baseline questionnaires, structured interviews, physical examinations, and followed the workers monthly to assess low-back pain incident cases, status of prevalent cases and LBP-associated outcomes. The Health Outcome Assessment Team was primarily responsible for computation of the psychosocial and personal factor indices.

2.2   Worker and Company Participation in the Study:

2.2.1   Participating Companies and Subjects:

A total of 30 companies and or differing sites with a wide variety of operations participated in the study in order to obtain a diversity of employers, occupations and jobs (Table 2.1). This diversity was also incorporated to improve the generalizability of the results. Subjects were enrolled from four diverse states (Illinois, Texas, Utah, and Wisconsin). For purposes of this report, only those subjects completing all baseline data and having at least one monthly follow-up visit (minimum follow-up duration of 22 days) are included in Table 2.1. Subjects were enrolled from Illinois (n=21), Texas (n=128), Utah (n=249), and Wisconsin (n=212) beginning in January 2004 and continuing through September 2006.

2.2.2   Subject Inclusion and Exclusion Criteria:

Subjects were of 18 to 62 years of age at the time of enrollment. A few older subjects who planned to continue their employment beyond the age of 65 were also enrolled. No subject was excluded based on sex, race, ethnicity, or physical or mental disorders unless the subject (i) could not give informed consent, (ii) did not speak either English or Spanish, (iii) was planning to retire within the next 3 years, (iv) had major congenital spine or lower limb deformities including significant spina bifida, (v) a history of spinal fracture, (vi) had a history of spinal surgery (e.g., discectomy, fusion, etc...), (vii) had arthritis of the spine

(spondyloarthropathics), (viii) had any major impairment that affected lifting technique (e.g., multiple sclerosis with significantly impaired musculoskeletal coordination), or (ix) was

```
                          ┌─────────────────────┐
                          │   RESEARCH TEAMS    │
                          └─────────────────────┘
          ┌───────────────────────┼───────────────────────┐
          ▼                       ▼                       ▼
┌───────────────────┐   ┌───────────────────┐   ┌───────────────────┐
│  Health Outcomes  │   │   Job Physical    │   │ Data Management & │
│  Assessment Team  │   │  ExposurAssessment│   │  Statistics Team  │
│                   │   │       Team        │   │                   │
└───────────────────┘   └───────────────────┘   └───────────────────┘
          │                       │                       │
          ▼                       ▼                       │
┌───────────────────┐   ┌───────────────────┐             │
│ Subject Enrollment│   │ Subject Enrollment│             │
└───────────────────┘   └───────────────────┘             │
          │                       │                       │
          ▼                       ▼                       │
┌───────────────────┐   ┌───────────────────┐             │
│     Baseline      │   │ Baseline Physical │             │
│   Questionnaire   │   │     Exposure      │             │
│                   │   │    Assessment     │             │
└───────────────────┘   └───────────────────┘             │
          │                       │                       ▼
          ▼                       │           ┌───────────────────┐
┌───────────────────┐             │           │ Data Management   │
│ Baseline Structured│            │           │ and Data Storage  │
│    Inteviews      │             │           └───────────────────┘
└───────────────────┘             ▼                       │
          │           ┌───────────────────┐               │
          ▼           │ Quarterly Followup│               │
┌───────────────────┐ │ for Changes in Job│               │
│  Dual Baseline    │ │  Physical Exposure│               │
│    Physical       │ └───────────────────┘               │
│   Examinations    │           │                         │
└───────────────────┘           ▼                         │
          │           ┌───────────────────┐               │
          ▼           │  Data Analyses to │               │
┌───────────────────┐ │ Quantify Physical │               │
│ Monthly Followup  │ │     Exposure      │               │
│ for LBP Assessment│ └───────────────────┘               │
└───────────────────┘           │                         ▼
          │                     ▼           ┌───────────────────┐
          ▼           ┌───────────────────┐ │Statistical Analyses│
┌───────────────────┐ │  Computation of   │ │   to Determine    │
│  Computation of   │ │  Lifting Index    │ │   Relationships   │
│  Psychosocial and │ │ Compressive Force │ │    Between Job    │
│  Personal Factor  │ │      Etc...       │ │ Physical Factors  │
│     Indices       │ └───────────────────┘ │  and Measures of  │
└───────────────────┘                       │       LBP         │
                                            └───────────────────┘
```

Figure 2.1: Research teams and their responsibilities on the project.

4

Table 2.1: Different types participating of industries in the study and enrollment in each plant

State & Employment Setting	Workers with complete baseline data and at least one month of follow-up data
Wisconsin	
Poultry Processing	17
Toilet Seat Manufacturer	31
Automotive parts manufacturer (2 plants)	15
Glass window & door manufacturer	5
Repackaging operations	18
Plastic parts manufacturer	28
Metal parts manufacturer	11
Salt manufacturer	9
Soft drink distributions	3
Paint products manufacturer	5
Electric light manufacturer, warehouse	37
Lawnmower manufacturer	16
Small engine manufacturer	17
Illinois	
Printing Operations	21
Utah	
Commercial printer	130
Warehouse	5
Airbag manufacturer	43
Cabinetry manufacturer	3
Distribution center	68
Texas	
Grocery Warehouses (3 separate warehouses)	60
Meat processor	29
Ice cream manufacturer	2
Bakery	2
Office chair manufacturer	10
Chemical Plant Manufacturing	4
Salt manufacturer	9
Cosmetics manufacturer	12

working on the overnight shift (i.e. third shift workers). Subjects received their regular wages from the participating companies; no additional monetary benefits were provided for participation in the study.

2.2.3 Procedure for contacting and enrolling subjects:

Enrollment of volunteer workers began once the project was approved by the management and union (where applicable) of the participating company. Recruitment of volunteer workers was performed in one of two ways based on company preference. Either the

company management, safety department and union (or employee representatives) contacted the potential subjects and asked for their participation in the study, or representatives of the research team (Job Exposure team in Texas and Wisconsin, Health Outcomes team in Utah) solicited for participation on a worker-by-worker basis. In either case, fliers were placed on bulletin boards in the facilities to help spread the word that the research was being conducted in the facility. In facilities where company representatives recruited workers, principal investigators or other members of the research team met with potential subjects in small groups (10-15 workers) to explain the study and seek their formal participation through a signed consent form. In Utah, subjects were enrolled individually. Workers who were directly recruited by the research team had the study explained to them directly, and consent was taken immediately.

Once consent was given, each worker was assigned a unique number and a master list of participating workers and assigned numbers was given to both the Job Physical Exposure and Health Outcomes data collection teams. In Texas, Wisconsin and Illinois, these lists were established by the Job Physical Exposure teams, in Utah these lists were established by the Health Outcomes team. Prior to collecting any data, the research team member(s) verified the subject's name and reconfirmed that he/she had agreed to participate in the study. If a subject wanted to withdraw from the study, he/she was allowed to do so at any time throughout the study without any pressure or penalty.

2.2.4 Initial Classifications of Jobs into Low, Medium and High Exposure Categories: Jobs were initially classified into low, medium and high job physical exposures based on an initial walkthrough visit by the Job Physical Exposure Assessment Team members. Variables that were particularly used to initially classify jobs into their three categories for purposes of enrollments were: approximate weight, horizontal distance (low, medium, high), vertical location (low, medium, high) and repetition (low, medium, high). In most cases, using a "reduced version" of the Revised NIOSH Lifting Equation jobs were classified into low ($LI \leq 1$), medium ($LI > 1$ and $LI \leq 3$) and high ($LI > 3$) physical exposure groups. The primary purpose of these initial classifications was to attempt to ensure that approximately one-third of these subjects would be in the low, medium and high job physical exposures for purposes of assuring power to detect health effects across a spectrum of job physical exposures. The initial job classification scheme was otherwise not utilized in this study.

2.3 Inter-Rater Reliability:

2.3.1 Health Outcome Assessment:
The performance of the standardized physical examination was recorded on a CD and copies of the CD were distributed to all Health Outcomes Assessment Team members. One principal investigator responsible for all health outcome data worked with the health teams in Texas, Utah and Wisconsin in sessions where the procedures were demonstrated, practiced, and finalized. In addition the same principal investigator participated in early enrollment sessions (in Texas, Utah and Wisconsin to ensure that the physical examination procedures were uniform and consistently applied by the Health Outcomes teams at all three research centers).

6

2.3.2 Job Physical exposure Assessment:

Primary members of the Job Exposure Assessment Team met to precisely define, clarify, and discuss each exposure variable and its method of measurement. This information was prepared in writing and distributed to each member of the Job Exposure Assessment Team. Each member of the Job Physical Exposure Assessment Team collected data according to these standardized methods.

Critical variables, such as object weight, horizontal location of the hands, vertical location of the hands, twisting of the torso, and trunk flexion were clearly defined prior to initiation of field measurements in order to minimize errors in this phase of data collection. Prior to extracting the videotaped data, the principal investigator responsible for job physical exposure assessments worked closely with the job physical exposure analysts in Texas, Utah, and Wisconsin, to ensure standardization of these data measurements and analyses.

2.4   LBP Case Definition:

Many workers experienced more than one episode of LBP during the observation period (*"recurrent LBP"* characterized by the number of episodes). While recurrences were tracked in this study, this report considers only the conservative analysis of time to first event. It does not incorporate cumulative incidence measures. It is recognized that the most conservative analysis might be time to first lifetime event, however that measure was considered impractical due to the high cumulative prevalence of LBP observed at the baseline, necessitating a much larger sample size and commensurate resources. Therefore, workers who had had prior LBP or current LBP at baseline were not excluded from the cohort. They were considered to be eligible to become an incident case after completing a continuous symptom free period of at least 90 days.

An incident case of any LBP was defined as regional LBP of any pain intensity in one or more of 5 lumbosacral body areas (body diagram areas L,M,N,O,P; Figure 2.2) and lasting at least one day. Those with LBP at baseline or during the month previous to baseline were eligible to become an incident case provided they had a continuous pain free period of at least 90 days following baseline. An reported incident episode of LBP was excluded as an incident case according to the following criteria: (i) slip/trip/fall, (ii) any accident whether inside or outside of work, (iii) an outside of work activity that was thought to have caused the LBP, (iv) surgeries (fusion, laminectomy, laminotomy), and (v) baseline diagnosis or history of sciatica.

Case definitions for other outcomes of LBP are provided in Table 2.2.
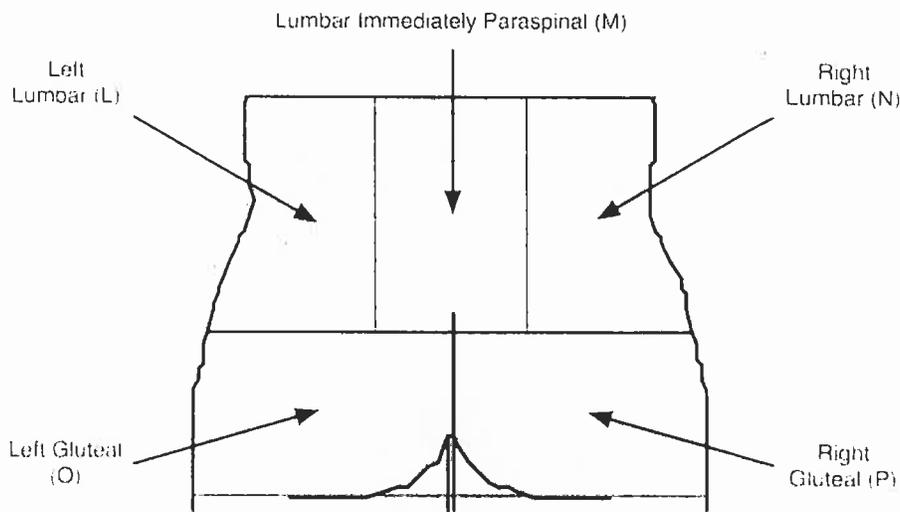
Figure 2.2: Lumbrosacral Body Areas Used to Define Location of LBP

Table 2.2: Low Back Pain Outcome Definitions

Health Outcome	Disease criteria for case	Exclusions
Low Back Pain of any intensity	1. Low Back Pain (LBP) of any intensity on a structured interview (areas L, M, N, O, or P) lasting at least one day 2. Individuals reporting cause as "Something at work (not an accident)" or "Unsure"	• Those who had a clinical impression of current sciatica at baseline. • Those who had a history of fusion, laminectomy, or laminotomy. • Those who met the case definition at baseline and were not asymptomatic for > 90 days. • If cause was "Accident (slip, trip, or fall)" or "Something outside of work."
Low Back Pain ≥3/10 intensity	1. Low Back Pain (LBP) of ≥3/10 intensity on a structured interview (areas L, M, N, O, or P) lasting at least one day 2. Individuals reporting cause as "Something at work (not an accident)" or "Unsure"	• Those who had a clinical impression of current sciatica at baseline. • Those who had a history of fusion, laminectomy, or laminotomy. • Those who met the case definition at baseline and were not asymptomatic for ≥ 90 days. • If cause was "Accident (slip, trip, or fall)" or "Something outside of work."

Table 2.2: Low Back Pain Outcome Definitions (continued)

Health Outcome	Disease criteria for case	Exclusions
Low Back Pain with medication	1. Low Back Pain (LBP) of any intensity on a structured interview (areas L, M, N, O, or P) lasting at least one day 2. Individuals reporting cause as "Something at work (not an accident)" or "Unsure" 3. Reported taking over-the-counter or prescription medications for LBP	• Those who had a clinical impression of current sciatica at baseline. • Those who had a history of fusion, laminectomy, or laminotomy. • Those who were taking medication for LBP at baseline and did not stop taking medication for $\geq$ 90 days. • If cause was "Accident (slip, trip, or fall)" or "Something outside of work."
Low Back Pain with Lost Time	1. Low Back Pain (LBP) of any intensity on a structured interview (areas L, M, N, O, or P) lasting at least one day 2. Individuals reporting cause as "Something at work (not an accident)" or "Unsure" 3. Reported having taken time off work for their LBP.	• Those who had a clinical impression of current sciatica at baseline. • Those who had a history of fusion, laminectomy, or laminotomy. • If cause was "Accident (slip, trip, or fall)" or "Something outside of work."
Low Back Pain with Light Duty	1. Low Back Pain (LBP) of any intensity on a structured interview (areas L, M, N, O, or P) lasting at least one day 2. Individuals reporting cause as "Something at work (not an accident)" or "Unsure" 3. Reported having been put on modified or restricted work for their LBP.	• Those who had a clinical impression of current sciatica at baseline. • Those who had a history of fusion, laminectomy, or laminotomy. • If cause was "Accident (slip, trip, or fall)" or "Something outside of work." • If an individual was on light duty at baseline, they were not elegible to become a case until they were off light duty for $\geq$ 90 days.

2.5 Health Outcomes Methods:

2.5.1 Baseline Health Outcomes Assessment:
At baseline, participating workers completed a questionnaire, structured interview and a medical examination. The data collection forms are in Appendices A1-A3.

Baseline Health Outcomes Questionnaire:
The baseline health outcomes questionnaire was self administered using a laptop computer, however, a member of the health team was present to assist with any problems, or clarifications the participating workers needed while completing the questionnaire. Some workers' questionnaires were administered by a research team member if they did not want to enter data or had other difficulty with use of computers. Administration of the questionnaire typically required 20 minutes.

The questionnaire (Appendix A1) included personal information about age, gender, marital status, ethnicity, highest completed education level, types and duration of various physical activities, time spent seated, types and durations of hobbies and physical activities outside of work, recalled body weight at age 20, and the most they ever weighed in their life. Employment-related questions included company name, department, current job title, duration of time with current company (months, years), duration of time on current job (months, years), and average distance and duration of commute to the job, and total miles traveled in an average day which included commuting to and from work, as well as non-work related commute. Workers were also asked questions regarding their sleeping habits. These included preferred sleep position, self-estimated mattress firmness and hours and quality of sleep.

Workers were also asked about the presence of a variety of self-reported medical conditions (e.g. chronic fatigue symptom, diabetes mellitus, thyroid, high cholesterol, high blood pressure, etc…), tobacco use, alcohol and caffeinated beverage consumption, and the presence of back or neck pain when getting out of bed in the morning or within one hour of driving or riding in a car. As a companion to these questions, workers were asked about their family medical history, including blood relatives experiencing pinched nerve (cervical or lumbar radiculopathy), sciatica, and lumbar or cervical radiculopathy. Women were additionally asked about current and past pregnancy(ies), symptoms of menopause and estrogen replacement.

The questionnaire also had a variety of psychosocial questions including individual questions, Modified APGAR, and a subset of questions from Zung Depression scale were employed, as well as a composite tension-edge-nervous scale.

The modified APGAR statements were answered using a three-point scale (almost always, some of the time, hardly ever). The statements included were: (i) I am satisfied that I can turn to a fellow worker for help if something is troubling me, (ii) I am satisfied with the way my fellow workers talk things over with me and share problems with me, (iii) I am satisfied that my fellow workers accept and support my new ideas and thoughts, (iv) I am satisfied with the way my fellow workers respond to my emotions, such as anger, sorrow, or laughter,

10

(v) I am satisfied with the way my fellow workers and I share time together, (vi) I enjoy the tasks involved with my job, (vii) I am satisfied with how well I get along with my closest or immediate supervisor.

The modified Zung statements were answered using a four-point scale (rarely or none of the time (less than one day per week), some or little of the time (1 to 2 days per week), a moderate of the time (3 to 4 days per week), most of the time (5 to 7 days per week). The statements included were: (i) I feel downhearted and sad, (ii) I feel that nobody cares, (iii) I get tired for no reason, (iv) I feel that I am useful and needed, (v) I am still able to enjoy those things I used to, (vi) I eat as much as I used to, (vii) I am more irritable that usual, and (viii) I feel hopeful about the future.

The tension-edge-nervous questions were answered using a four-point scale (never, sometimes, often, always). The questions included were: (i) how often do you feel tense, (ii) how often do you feel on the edge, and (iii) how often do you feel nervous or anxious.

Individual questions that were not part of standardized or other composite scales included: (i) job satisfaction, (ii) feeling of depression (iii) job pace, (iv) job pace control, (v) job order control (vi) Control over job breaks (vii) control over job tasks, (viii) job physically hard, (ix) physically exhausted, (x) mentally exhausted (xi) free from conflicting demands that others make, and (xii) family problems.

Baseline Health Outcomes Structured Interview:

A member of the research team (board certified occupational medicine physician, occupational medicine resident, physical or occupational therapist) conducted the structured interview (Appendix A2). In Utah, board certified physicians accompanied occupational medicine residents or therapists and performed monthly follow-up. The interviewer posed questions to the participant and recorded responses on a laptop computer. One section of structured interview emphasized the history of a variety of musculoskeletal conditions, accidents, injuries, and treatments. These included previous diagnoses by a healthcare professional of (i) rheumatoid arthritis, (ii) lupus, (ii) osteoarthritis, (iii) degenerative arthritis, (iv) fibromyalgia, (v) osteomyelitis, (vi) osteoporosis, or (vii) broken bones. There were additional questions about accidents or injuries to the neck, middle back, or low back such as motor vehicle accidents, whiplash, sports injury, or slip, trip or fall, surgeries to the neck, back, legs or feet; and other low back disorders including strains or sprains, sciatica, bulging discs, spina-bifida, or scoliosis.

There were more detailed histories of previous episodes of low back, middle back, and neck pain. These included current pain, pain in the last one month and lifetime experience of pain in these body regions. The questions dealt with the location of pain, intensity of pain, duration of pain and number of episodes of pain. A body diagram was used to specify the location of pain and a pain scale to quantify the intensity of pain. Workers were also asked what was their single, longest, continuous period of time they had experienced the pain. They were also asked what was the worst low back pain they ever experienced and what was the duration of their most recent episode of pain. There were questions dealing with past or current symptoms suggestive of lumbar radiculopathy. Additional data were collected

regarding lifetime treatment for LBP including types (seeing a medical doctor, physical therapist, chiropractor, having an CT scan, MRI, X-ray, work hardening, use of back belts, and narcotic, non-narcotic, prescription and/or over-the-counter medication use) with corresponding frequencies.

Questions were also asked regarding how many episodes of lost workday low back pain they experienced and workdays lost. Similarly, how many episodes of low back pain they had resulting light/modified duty or number of days of modified duty. Whether they ever received workers' compensation due to (i) low back pain or (ii) due to any other injuries. The presence of numbness and tingling in the legs was noted using a body diagram.

Baseline Anthropometric Measurement, Heart rate and Blood Pressure:
A few anthropometric variables and heart rate and blood pressure were measured during the baseline data collection process. These measurements included: (i) resting heart rate, (ii) blood pressure, (iii) chest, waist and hip circumference, (iv) body segment lengths for arms and legs, (v) range of motion, (vi) height and weight. These measurements were made by a member of the health outcomes data collection team.

Baseline Health Outcomes-Physical Examinations:
The primary (first) physical examination of the worker was performed by a physical therapist, occupational therapist, occupational medicine resident or physician who was a member of the health outcomes data collection team. The medical examination focused on the presence or absence of physical signs and provocative maneuvers related to the neck, middle back, and low back, including (i) Spurlings sign, (ii) cervical range of motion, (iii) tendon reflexes, (iv) muscle strength grading, (v) recumbent straight leg raise, (vi) seated straight leg raise, (vii) sacroiliac joint test, (viii) inspection for evidence of scar or surgery and (ix) simulated axial loading test.

Tender points were evaluated using an applied force of 4 kg. Ten points on the low back and 8 points on the neck/shoulder were evaluated. Subjects were required to identify the locations as "pain" rather than merely tender or sore. Patellar and ankle jerk tendon stretch reflexes were with a reflex hammer while seated. They were graded 0-4+. A zero "0" meant the reflex could not be elicited, and a four plus "4+" produced clonus. Observational data were collected regarding signs of rheumatoid arthritis, Heberden's and Bouchard's nodes and overreaction to physical exam maneuvers.

A board certified occupational medicine physician performed the secondary physical examination. The occupational medicine physician performed an examination that reproduced all positive findings from the first examination, as well as ascertained pertinent negative findings. This was done both to determine the consistency and validity of the results. In addition the physician provided his or her overall diagnostic impression regarding the low back health status of the worker based on the examination performed.

12

Monthly Follow-up Health Outcomes Interview:
After completing the baseline health outcomes evaluations, workers were placed into a monthly follow-up system. Each month, a member of the health outcomes assessment team would visit each of the facilities, and conduct a brief interview with each of the participating workers. These interviews typically lasted for less than five minutes and were conducted at the worker's workstation. All interviews were conducted using laptop computers to enable referencing of the health status from previous month except at one facility that did not allow electronic devices on the production floor. In that case paper copies of the interview were used, with the previous month's data printed on the data collection forms. To be eligible to be included in the analyses for this report, a worker *must* have undergone baseline evaluation, *and* at least one monthly follow-up cycle.

Linking to Previous Monthly Interviews:
The monthly follow-up interview began by referencing the worker's health data from the last follow-up (baseline data for first follow-up). If the workers had pain and/or numbness and tingling during the last follow-up, they were asked if the pain and/or numbness and tingling had changed or resolved. If the worker's pain and/or numbness and tingling had resolved since the last follow-up, the workers was asked how many days ago did the pain go away. If the pain did not go away, the workers were asked to provide pain rating and percent of days they had pain since last follow-up. A pain scale was used to determine pain intensity (0 – no pain at all, 10 = worst possible pain).

New Pain Episode:
The workers were next asked if they had developed any new pain in either the low back and/or legs since the last follow-up. If new pain was identified, the workers filled out the low back pain diagram (Appendix A4) to document the location(s) of pain, rated the intensity of pain on the pain scale, were asked when did the pain start (date), how many days they had pain, what they believed was the cause of the pain, and when did the pain occur (time lag).

When asked to provide their opinion about what caused the new pain, the following options were used: (i) unsure, (ii) accident outside of work (slip/trip/fall, motor vehicle accident, etc…), (iii) other cause outside of work (poor sleep/mattress, single lift, multiple lifts, single push, multiple pushes, single pull, multiple pulls, other), (iv) accident at work (slip/trip/fall, motor vehicle accident, etc…), (v) work (anything job related, but *not* previously classified as a work accident), and (vi) relapse or aggravation of previously reported pain (previously reported during baseline or during follow-up period of this study).

Next, the workers were asked to describe when/how each new episode of pain or symptoms first occurred. The following choices were provided to the workers to describe new pain or symptoms onset: (i) sudden (within 30 minutes of the incident), (ii) same day (but more than 30 minutes after the incident), (iii) next day or after, and (iv) don't know. If the worker was unsure of the causation of new pain or symptoms, he/she was *not* asked to describe when/how that new pain or symptoms first occurred.

For new pain that started after the last follow-up, but was resolved prior to the current monthly follow-up, low back pain was documented using the previously described questions. That they resolved prior to the current interview.

New Episodes Numbness and/or Tingling:
The next section of the monthly interview dealt with numbness and tingling in thigh, lateral calf, medial calf, foot or toes. If the worker had new numbness and/or tingling they were asked to identify the location using a body diagram, duration of numbness/tingling in each of the identified locations, how often (days) they had numbness/tingling in the identified locations upon waking up in the morning, how often they had numbness/tingling at night and what they felt had caused the new numbness/tingling. The workers had the same choices to assign the cause for the new numbness/tingling as those used to determine the cause of new low back pain episode. An additional choice was fell "asleep" sitting or lying on "it." Next, the workers were asked to describe when/how each new episode of numbness/tingling first occurred using the same choices as those used for low back pain.

Identifying Outcomes of Low Back Pain and Numbness/Tingling:
Workers were asked if they experienced any restricted (light-duty) workdays, or lost workdays as a result of new or existing low back pain or numbness/tingling. They were asked to provide begin and end dates for restricted workdays. If the workers experienced lost workdays, they were asked to provide the total number of lost workdays since the last monthly interview.

Treatments for Pain/Symptoms/Numbness/Tingling:
Treatments were first divided between low-back and mid-back. For each of these, the workers were asked if they had seen a (i) chiropractor, (ii) physician, and/or (iii) a physical or occupational therapist. They were also asked if they had (i) undergone a surgery, (ii) given an injection (such as steroid injections, etc...), and/or (iii) used a back brace. In addition, a variety of other treatments were questioned. These included: (i) non-steroid anti-inflammatory drug (NSAID), (ii) over the counter medications, (iii) prescription medications (not NSAID or narcotic), (iv) narcotic killer prescription medication, (v) aerobic exercises, (vi) strengthening exercises, and (vii) stretching exercises.

Recording of Job Changes:
Workers were asked to describe any job changes they had since the previous monthly interview. The objective was to assist the Job Physical Exposure teams to determine if additional follow-up of job (more frequent than quarterly) was required. Job changes questions included (i) moving to a new job/line, (ii) using new equipment/tools, (iii) an increase or decrease in production rate, (iv) a change in work hours (≥ 5 hours per week), and (v) any "other" changes. Workers were also asked when these changes occurred.

Miscellaneous Monthly Interview Questions:
A series of non-specific questions were included in the monthly interview. During monthly follow-ups in Wisconsin, it was found that some subjects reported a "tired back." They

14

specifically denied pain. Each month, if the worker self-reported a "tired back," the analyst conducting the interview recorded it on the data collection form.

A few other questions were asked yearly. These included: (i) total time do you spent per week in aerobic exercises, (ii) current weight (lbs) and diagnosis of (iii) diabetes, (iv) high blood pressure or (v) high cholesterol. Female workers were asked if they were currently pregnant and due date if applicable.,

Monthly Interview Physical Examination:
If a worker reported new pain or their level of existing pain increased by at least three on the ten-point pain scale, they were administered a brief standardized physical examination that included components from the baseline examination. This examination was divided into two parts, low back and neck, and given at the worker's workstation.

Standardized physical examination elements included: (i) palpation of pre-defined anatomic locations, (ii) back flexion measured as locked knees, right middle finger to floor distance, and (iii) non-organic "Waddell" signs. The non-organic signs included gentle pelvic rotation (approximately $20°$ to $30°$), superficial tenderness and over-reaction to palpation. Palpation was performed at 13 predefined locations on the workers low back (using 4kg of palpation force). The worker was asked which of the 13 locations if any produced "pain" (not merely sore or discomfort) and which produced the greatest level of pain. If any of those 13 locations produced pain, then an additional 6 locations were palpated on the neck. If the therapist/physician believed if the pain was 'more involved,' and required recumbency for examination, additional diagnostic tests, such as straight leg raises, reflexes, etc. were performed in a private area. Finally, the therapist/physician gave his/her diagnostic impression of the worker's current health status based on interview and examination.

Quarterly Interview with Physician:
Every three months, a physician accompanied the therapist to perform a second follow-up interview and physical examination. The second quarterly interview and physical examination by a physician were identical to those performed by a therapist. In this way, the health outcomes data were checked for consistency, and a physician's diagnostic impression was provided four times per year for each employee.

Exit Interview:
Wherever possible, workers in Utah and Wisconsin were given an exit interview (Appendix A.5).

2.6   Job Physical Exposure:
2.6.1. Job Physical Exposure Data Collection Teams:
Field data collection was performed using teams of two to three analysts. Teams would visit one facility per day, and collect data for 8-10 hours per day. If the team had three members, one member video recorded the job, a second member took physical measurements, and the third member recorded data. If the team had only two members, one member made measurements, while the other recorded data, then one of the two members video recorded

the job. As much as possible, field data was collected using three-member teams. To ensure the video captured an accurate representation of frequencies of different exertions, all video was recorded in "real time," without the worker being interrupted by the analysts.

2.6.2. Data Collection:
All job physical exposure data were collected at the facilities of the participating companies. Both quantitative and subjective measurements were recorded. All jobs performed by participating workers were recorded on digital videotape using hand-held video cameras. Video was taken perpendicular to the sagittal plane to facilitate biomechanical analyses performed in laboratories. Each job performed by the worker was recorded for at least 15 minutes. For those jobs with very long cycle times, at least tree to four cycles were recorded.

Quantitative Measurement Tools:
Quantitative measurements included: (i) object weights (using digital platform scale), (ii) pushing and pulling forces (force gauge, model # CSD250, manufactured by Chattilon), (iii) horizontal and vertical hand locations for each hand (tape measures) (iv) push/pull and walk/carry distances (rolling tape measuring device), and (v) duration of task activities (digital stopwatches).

Subjective Scales for Measurement:
Forces and exertions (including some of those measured quantitatively) were rated using the Borg CR-10 Scale (Borg 1982). Using the Borg CR-10 scale, workers were asked to rate how hard they felt their low back muscles were working to perform certain tasks. At most sites analysts also provided their Borg CR-10 rating for the same tasks.

2.6.3 Baseline Job Physical Exposure Data Collection:
Whenever new employees were recruited into the study, they underwent baseline job physical exposure data collection. Baseline data collection was broken into two major components: (i) position specific data collection and (ii) job specific data collection. Baseline data collection was performed within two months of the worker having their baseline health data assessment performed. Time to perform baseline job physical exposure varied based on the number of jobs performed by the worker, but typically required a total of 2.5 hours spread over two to three days.

In this study, *position* refers to the worker's overall activities. *Job* refers to specific, but unique, activities performed by the worker throughout a given day (Figure. 2.3). A position can be comprised of a single job or multiple jobs (e.g. job rotation). Distinct activities within jobs were called *tasks* (e.g. multiple steps to complete one cycle of a particular job). This terminology was adopted to accommodate the complexity encountered during the study. Rotation among one or more jobs and the performance of multiple jobs within the position or multiples tasks within a job were encountered frequently.

16

```
                    ┌─────────────────────────┐
                    │      Worker Level        │
                    │  (Position Data Form)    │
                    ├─────────────────────────┤
                    │     Worker Inteview      │
                    └─────────────────────────┘
```

```
  ┌───────┐      ┌───────┐      ┌───────┐      ┌───────┐
  │ Job 1 │      │ Job 2 │      │ Job 3 │      │ Job n │
  └───────┘      └───────┘      └───────┘      └───────┘
```

```
              ┌──────────────────────────────────┐
              │            Job Level              │
              │        (Job Data Form)            │
              ├──────────────────────────────────┤
              │        Worker Interview           │
              │    Physical Job Measurements      │
              │       Videotape Analysis          │
              └──────────────────────────────────┘
```

```
  ┌────────┐   ┌────────┐   ┌────────┐   ┌────────┐   ┌────────┐
  │ Task 1 │   │ Task 2 │   │ Task 3 │   │ Task 4 │   │ Task n │
  └────────┘   └────────┘   └────────┘   └────────┘   └────────┘
```

```
                    ┌─────────────────────────┐
                    │     Task Variables       │
                    └─────────────────────────┘
```

```
 ┌────────┐ ┌──────────┐ ┌──────────┐ ┌────────┐ ┌──────────┐ ┌──────────┐ ┌──────┐
 │ Weight │ │Horizontal│ │ Vertical │ │ Trunk  │ │Frequency │ │ Travel   │ │ Etc…│
 │or Force│ │ Location │ │ Location │ │Posture │ │          │ │ Distance │ │      │
 └────────┘ └──────────┘ └──────────┘ └────────┘ └──────────┘ └──────────┘ └──────┘
```

```
          ┌────────────────────────────────────────┐
          │     Job Physical Exposure Measures       │
          ├────────────────────────────────────────┤
          │            Lifting Index                 │
          │          Compressive Force               │
          │           Low Back Moment                │
          │          Trunk Flexion Angle             │
          │                 Etc…                     │
          └────────────────────────────────────────┘
```

Figure 2.3: Job physical exposure data hierarchy

Position Specific Job Physical Exposure Data:
Position specific data were collected to tie a given worker to the job or jobs they performed.
(Appendix B1) Position data included: (i) shift starting time, (ii) shift ending time, (iii) days
worked per week, (iv) jobs performed in the position, (v) previous positions held at the

current or past companies, (vi) active second jobs, and (vii) Borg CR-10 Ratings for the overall position at the company. Position specific data typically required 20 minutes to collect.

Shift starting time, ending time, and days per week were recorded by interviewing the worker on the production floor. For those workers where starting and/or ending time varied, workers were asked for what they felt was a "typical" time for each in the most recent three months. To help reconcile instances where starting or ending times varied, workers were also asked to provide the maximum number of hours they worked in a week during the most recent month, and the "typical" number of hours they worked in a week during the most recent month. Workers were also asked to provide the maximum and typical number of days they worked in a week during the most recent month.

Next, workers were asked to briefly describe each of the jobs they performed as a part of their position held with the company. Majority of workers worked only one job. For those workers who worked multiple jobs, each job was recorded. For each job performed by the worker, the total consecutive hours the job was worked before switching to a different job was recorded (e.g. for a worker rotating to a different job every 2 hours, the consecutive hours for any one of those jobs would be 2). In addition, each job performed by a worker was expressed as a "percentage of whole" relative to all jobs performed. This percentage was taken across a "typical" work week. (e.g. a worker working two jobs, A and B, 5 days per week, where job A is performed for 4 days, and job B is performed for 1 day; job A would be 80% and job B would be 20% duration). Each of the jobs identified by the workers were recorded, and the consecutive hours and percentage of total were recorded.

Workers were then asked to list their previous positions held, the length of time, in years, that the position was held and provide a corresponding Borg CR-10 rating for each of the jobs listed. The first position listed was the "Current" position the employee held. Previous positions were listed until the total previous employment duration summed to 10 years, or 5 previous (6 total, including the current) jobs were recorded, whichever occurred first.

Secondary employment, or second positions held were recorded next. If the worker held a second position, a brief description of the type of work was recorded. The worker was then asked how long they held the second position, how many hours per week they worked at the second position, and for the Borg CR-10 rating corresponding to the second position.

Lastly, with regard to their primary position, the worker was asked to provide Borg CR-10 ratings for the level of physical stresses they felt on their low back at the beginning of their work shift (about 30 minutes after they started their typical work day) and at the end of their work shift (about 30 minutes before the end of their typical work day). This information was gathered to estimate the accumulation of fatigue as a result of performing their various job activities

Job Specific Job Physical Exposure Data:
Data were collected for each job performed by a worker on a series of job data forms (Appendix B). General information included: time spent performing certain activities, use of

back belts, percentage of time spent sitting, standing and back bent greater than 20°. Specific information regarding lifting and lowering tasks, pushing and pulling tasks, and walking and carrying tasks, such as hand locations and forces were also collected. As much as possible, physical measurement of hand locations and weight/force were directly measured in the field. In cases where worker's were required to work very quickly, and could not be interrupted, or where worker's worked in very confined or dangerous areas, direct measurements could not be taken. For those situations, video was taken from a variety of angles so that estimates for hand locations could be made later during laboratory data extraction.

Job Specific Data Form:
Data was collected for each job performed by a worker on a series of job data forms (Appendix B3). General information The job specific data form collects basic information regarding each job held by a worker including (i) percentage of time activities are performed, (ii) Borg CR-10 Ratings for activities performed, (iii) peak task Borg CR-10 rating, (iv) time spent sitting and standing, (v) exposure to whole body vibration, (vi) use of anti-fatigue mats, use of back belts, and (vii) the job work environment.

Each job was broken into five categories: (i) manual material handling, (ii) assembly, (iii) paperwork, (iv) fork-truck riding, and (v) resting/waiting. All the worker's time spent on the job was represented as 100% and divided into each of the five categories. Workers were asked to approximate the percentage of time spent performing each of the activities. If a given activity was not performed by the worker, the activity received a zero for percent of time performed. Within each of the five categories, it was noted if the activity was predominantly performed sitting, or standing. For the assembly task, it was further noted if the assembly operations predominantly required "light" or "heavy" force to perform.

In Wisconsin and Utah, each of the activities performed by the worker were assigned both a worker and analyst Borg CR-10 rating. Analysts provided their ratings first to avoid biasing their ratings based on the worker's answer. Similarly, workers were not allowed to see the analyst's ratings. For those activities that received a zero for percentage of time performed, a "slash" was placed through both the analyst and worker Borg CR-10 rating box.

Workers were asked to identify the most stressful task they performed with regard to the low back. Once identified, both the worker and analyst provided Borg CR-10 ratings for that task. Unlike the ratings for the five activity categories, this task rating was given for performing the task *only one time*. For the peak task, the Borg CR-10 rating was a representation of the force required to perform the most difficult task of the job.

Time spent sitting and standing while performing the job was expressed as a percentage of total time. One hundred percent of time was accounted for between the two categories. Standing was further divided into time with back bent greater than 20 degrees and time spent squatting. Time spent sitting was further divided into time with back bent greater than 20 degrees. Analysts measured time by observation, and recorded the percentages of time to the nearest 10%.

Whole body vibration, use of anti-fatigue mats, use of insoles in shoes, use of back-belts, and work environment such as floor condition and work space were recorded using a series of yes/no checkbox questions. If anti-fatigue mats were used, the time spent using them was recorded as a percentage of total time performing the job. Floor condition was recorded as either "normal," "uneven," or "slippery." Work space for performing manual material handling operations was recorded as "open" or "obstructed."

Lift/Lower Tasks:
Each lift/lower task performed by the worker was recorded. Weights of objects were either read from the object (e.g. 50 lb bag) or measured using a platform scale. Horizontal locations of the left and right hand measured from their respective ankles along the transverse plane. Vertical location of the left and right hand were measured from the floor along the sagittal plane. Horizontal and vertical hand locations were measured at both the origin and destination of the lift. Origin measurements were taken at the moment the worker "assumed" the weight of the object (i.e. the worker visibly lifted the object from its resting location). Destination measurements were taken at the moment the worker released the weight of the object. This could be when the object was set down, or when the worker's hands left the object, if the object was thrown or tossed.

Lifting and lowering tasks for jobs with limited diversity of lifting and lowering were collected using the "steady state" lifting/lowering form (Appendix B4). "Steady state" jobs included activities such as line loading operations, where the lifting/lowering activities of the worker were limited in number and were predictable in sequence, weight and hand locations. Jobs with very irregular lifting, such as warehouse material handlers were collected using the "variable" lifting/lowering form (Appendix B5). Variable lifting jobs involved taking many more measurements than steady lifting jobs, therefore the variable form consolidated individual left and right hand measurements into average hand location measurements to allow for more rapid collection of data.

Pushing/Pulling Tasks:
All push/pull tasks were recorded except those directly involved with the lifting or lowering of an object (e.g. if an object was pulled forward, and lifted in one continuous motion, the pull was not measured) (Appendix B6). Each pull had the initial force, sustained force, hand height, push/pull distance and push/pull time recorded. Distances of less than two feet were recorded as one foot, distances of two to five feet were recorded as five feet, and distances of five to ten feet were recorded as ten feet. Distances greater than ten feet were measured directly using a rolling tape.

Walk/Carry Tasks:
For walk/carry tasks, the weight of the object carried, the distance carried, and the time spent carrying the objects were recorded (Appendix B7). Each carry was automatically accompanied by a corresponding walk, unless the object or another object was carried back to the origin. Walks were recorded with a weight of zero. Distances of less than two feet were recorded as one foot, distances of two to five feet were recorded as five feet, and distances of five to ten feet were recorded as ten feet. Distances greater than 10 feet were measured directly using a rolling tape.

20

2.6.4 Follow-up Job Physical Exposure Data Collection:

During their monthly follow-up cycle, members of the health exposure team would ask each participating worker a question to determine if there was a change in his/her position jobs, job rotation, job requirements, or tools used. Questions were simple and direct, such as "During the last month, have any of your jobs changed?" The worker's answers to those questions were forwarded to the job exposure team. This was done to assist the job exposure team in determining if there was a change in job physical exposure that would require that some or all of the worker's job data be re-measured. In addition to the monthly health team questions, every three months, a member of the job physical exposure team visited each employee. The job team had a computerized position form (Appendix B1) with them that showed the analyst what jobs the worker was performing as of the last visit (3 months prior). The analyst carefully inspected all the jobs listed and determined if there were any substantial changes to the jobs. In most cases, the changes were minor and did not affect exposure levels. In cases where the job parameters substantially changed, or the worker changed jobs all together, the new/revised jobs were measured using all the job specific data forms (Appendix B3).

Regardless of whether or not the worker's job(s) changed, the computerized position form was updated to reflect the current work hours, including shift start and stop times, the Borg CR-10 ratings at the beginning and end of shift, the jobs the worker was performing as of follow-up time, and continuous duration and percentage of total time for those jobs.

2.6.5 Job Exposure Raw Data Extraction:

Job specific data forms colleted information regarding tasks performed by the workers while performing their jobs, however, these data had to be "assembled" in specific ways to enable analyses using models such as the Revised NIOSH Lifting Equation and 3D Biomechanical Model. This process was referred to as data extraction, and was conducted by the job exposure teams in laboratories in Texas, Utah, and Wisconsin.

Job Video Processing:

Each job performed by each worker had its own video. This video was taken in the field and was typically 5 to 30 minutes in duration. Prior to data extraction, these videos were digitized and catalogued onto servers in the laboratories so that analysts had quick access to each of the videos. Videos were given a unique code that embedded company, worker and job information so the videos could be easily matched to their corresponding data collection forms.

Job Physical Exposure Task Level Data:

Raw data from the field acquired physical parameters for tasks, such as hand location and weight, but did not attempt to collect frequency information. In addition, though every effort was made, it was not possible to physically measure forces and hand locations for every task. Data extraction from video was required to obtain the hand locations for those "missing" tasks, and to gather "snapshots" of tasks to use in the 3D Biomechanical Model.

Anthropometric Data Used to Estimate Distances:

Estimates for horizontal, vertical, and lateral location of hands were made using 10th, 50th, and 90th percentile male and female anthropometric data. Table 2.3 was created to assist with this process. Lifts from the job video were gathered and using the anthropometric data closest to the worker in the video (e.g. a large male would require 90th percentile male anthropometric data), simple geometry was used to obtain the horizontal, vertical and lateral locations of the hands.

All estimates of hand location were checked against "rational" measures to ensure accuracy. For example, if a worker was carrying a 20-inch wide box with hands in the center of the box, horizontal distance must be greater than or equal to 18 inches (half the box width plus minimum abdomen depth). Similarly, if a small female was lifting an object and her hands were clearly below knee height, vertical hand location could not be more than 16.2 inches.

Field measurements of horizontal and vertical locations of hands were used in all calculations. Estimated measurements from videotapes were used to verify the accuracy of field measurements. In those situations where field measurements appeared to be in gross error they were replaced by measurements taken from videotapes.

Extracting Snapshots for 3D Biomechanical Analysis:

Every lift/lower and push/pull task required snapshots (still images extracted from video) to be used to approximate postures in the 3D Biomechanical Model. As task level data were being extracted from video, these snapshots were taken. The first snapshot was taken at the origin of the task (moment the object was held by the worker for lifting/lowering, moment the object began to move for pushing/pulling). From the origin, a snapshot was taken every one third of a second, such that there were a total of three snapshots per second for every task. Snapshots were taken at these regular intervals until the task destination snapshot, which was the final snapshot for the task. Destination snapshots were taken without regard for how much time had passed since the previous snapshot, such that the duration of time between the second to last snapshot and the last (destination) snapshot was always less than or equal to one third of a second, but rarely ever exactly one third of a second.

Each snapshot taken was given a unique code that contained information regarding plant, worker, job, task and snapshot sequence. This coding was used to generate certain job outcome variables such cumulative compressive force.

Table 2.3: U.S. population anthropometric measurements used to assist with task analyses

#	Measurements	Males			Females		
		5th	50th	95th	5th	50th	95th
1	Height/Stature	65.6	69.9	74.1	61	65	68.9
2	Eye Height, Standing	62	65.9	69.8	57.2	60.8	64.4
3	Shoulder Height, Standing	53.9	57.8	61.7	48.7	53.1	57.5
4	Elbow Height, Standing	41.7	44.7	47.7	39.3	41.6	43.9
5	Waist Height, Standing	39.7	43.1	46.5	37.9	41.2	44.5
6	Hip Height, Standing	35.3	37.6	39.9	33.5	35.7	37.8
7	Knuckle Height, Standing	28.3	30.9	33.5	26.6	29.2	31.8
8	Tibial/Knee Height, Standing	17.3	19.1	20.9	16.2	17.7	19.2
9	Trunk Link Length	17	18.1	19.8	16.2	17	18.3
10	Upper Leg Length, Seated	21.6	23.4	25.2	21	22.6	24.2
11	Upper Arm Length	13.4	14.5	15.6	12.7	13.4	14.1
12	Lower Arm Length	9.4	10	10.7	8.8	9.4	9.9
13	Fist Length	4.1	4.4	4.7	3.3	3.5	3.7
14	Fist+Lower Arm+Upper Arm (Length)	25.5	27.2	28.9	22.4	23.9	25.3
15	Elbow to Fist Length	12.7	14.2	15.7	10.9	12.7	14.5
16	Acromial Process to Functional Pinch	24.1	26.9	29.7	22.5	24.6	26.7
17	Abdominal Extension to Functional Pinch	18.7	24.4	30.1	19.5	23.8	28.6
18	Shoulder Breadth	16.6	17.9	19.2	14.1	15.4	16.7
19	Hip Breadth	12.5	14	15.5	13.4	15	16.6

NOTE: All Heights include shoe height of 1.2 inches

Generating Task Level Data:

During the data extraction process, all data were compiled into a series of sequential tasks for each job performed by each worker. Data were compiled onto specific data collection forms by task type: (i) lifting/lowering, (ii) pushing/pulling, and (iii) walking/carrying. Each task was given a unique number appended to the end of the existing code for the job (codes contained embedded information regarding plant, worker and job). Task sequence was maintained by recording video time stamps on a record sheet and noting the corresponding task number next to its time stamp. Task numbers were unique for types of tasks, but not necessarily unique in the total task sequence. For example, if a worker was performing a packaging and palletizing job, where the same lift was required to package each box, but a different lift/lower was required to palletize the finished boxes, the same lift form for packaging might be referenced several times. Actual frequency for each task was determined by counting the number of times the task was present in the sequence list and dividing by the total observation time (total cycle time; note total cycle time often included more than one job cycle for short cycle work)

Generating Lift/Lower Task Data Forms:

Each lift/lower task data form (Appendix B8) contained information regarding the type of load being lifted, such as (i) type of container (box, bag, other), (ii) type of load (stable unstable, balanced, unbalanced), (iii) type of grasp (good, fair, or poor according to the Revised NIOSH Lifting Equation definition), (iv) lifting technique used (stand, stoop, squat, semi-squat and side lift), and (v) weight of the object being handled. In addition the parameters of the lift were recorded for both the origin and destination. These included: (i) left and right hand horizontal locations, (ii) left and right hand vertical locations, (iii) left and right hand lateral locations, (iv) asymmetric angles (measured using the Revised NIOSH Lifting Equation definition), (v) the object travel distance between the origin and destination, and (vi) whether the object required substantial control at the destination (careful, or precise placement as opposed to a simple toss onto a pile or stack). As stated earlier, field measurements of horizontal and vertical locations of hands were used in all calculations. Estimated measurements from videotapes were used to verify the accuracy of field measurements. In those situations where field measurements appeared to be in gross error they were replaced by measurements taken from videotapes. To facilitate final data checking, each time the task form was used in the task sequence, the time stamp was placed both on the task sequence sheet, and on the task data form.

Generating Push/Pull Task Data Forms:

Each push/pull task data form (Appendix B9) contained information regarding the type of cart being used (4-wheel cart, 2-wheel hand truck, pallet jack, box only, etc…), height of hands while pushing/pulling, the posture (lean forward, lean back, lean side, stand), distance per push/pull, time per push/pull, initial force, and sustained force.

Generating Walk/Carry Task Data Forms:

Each walk/carry task data form (Appendix B10) contained information regarding the carrying technique being used (waist, thighs, side, other), object weight, distance per walk/carry, and time per walk/carry.

24

Sequencing Tasks Together:
During data extraction, tasks were segregated as much as possible into lift/lower, push/pull, and walk/carry. However, in practice, many of these tasks blended together. For example, many lifts/lowers were preceded by a very short pull. In some cases those minor subtasks were ignored. The following criteria were used to ignore tasks. A push/pull task that was continuously integrated into a lift/lower (i.e. no pause or change in hand position when transitioning from push/pull to lift/lower or from lift/lower to push/pull) and the object being handled was pushed/pulled less than 18 inches, was considered a part of the lift/lower and *not* a separate push/pull. Similarly, a walk carry that separated a lift/lower was generally ignored, provided that the carry was less than two steps in length (i.e. when a second step was taken, the carry was separated from the lift/lower).

The sequencing of carry tasks in the middle of a lift/lower task created a frequency doubling effect. Consider the following example. A worker lifted a box from a table, turned, took one step and placed the object on a pallet. This sequence of events was recorded as one lift/lower task with origin measured at the table, destination measured at the pallet, and frequency of lift/lower of one (no walk/carry task was recorded). If the worker took two or more steps to go from the table to the pallet, rather than just one, the situation and therefore the tasks changed. The sequence was now recorded as a lift/lower with origin at table height and destination at carry height. This was followed by a walk/carry task of the object from the table to the pallet. Next, a new lift/lower task was started with origin at carry height, and destination at the pallet. Finally, a new walk/carry task was started for the return walk from the pallet to the table. In this situation, the lift/lower frequency was two, and the walk/carry frequency was two, where previously the lift/lower frequency was one and the walk/carry task was zero. This frequency amplification affected the job exposure variables in a variety of ways, perhaps most significantly, it had the potential to raise the calculated Revised NIOSH Lifting Index scores in a dramatic way by substantially increasing the frequency penalty assigned to the job.

2.6.6 Job Physical Exposure Data Analyses and Creation of Job Physical Exposure Indicator Variables:

All extracted tasks were entered into a central database for use in creating various Job physical exposure measures. These measures included: (i) the Revised NIOSH Lifting Equation Cumulative Lifting Index, (ii) the Compressive Force at the L_5/S_1 lumbar disc, (iii) the flexion/extension moment at the L_5/S_1 lumbar disc, (iv) the percent capable for gender of the person performing the job, and other measures that are listed in the end of this section, 2.6. Each job physical variable can be calculated in a variety of ways based upon criteria for the inclusion or exclusion of tasks.

Reconciling Job Rotation for the Creation of Job Physical Exposure Measures:
Each participating worker had one or more jobs they performed as a part of their primary position. For those workers performing only one job, there was no problem in creating job physical exposure measures, as there was only one specific measure per worker. (e.g. a given job will have only one peak compressive force, and that compressive force can be

assigned directly to the worker (position)). However, for those workers performing two or more jobs, a problem occurs where there are two or more of the same job exposure measures, one for each job, but only one can represent the worker's exposure at one time (exposure at position level) (e.g. a worker performing three jobs will have three peak compressive forces, one for each of the three jobs; only one of these at a time can be used to represent exposure to the worker (position level)). Using a simple method, each job physical exposure measure, collected at the job level, was divided into two representations: (i) exposure from the highest job and (ii) exposure from the typical job.

Summarizing Position Exposure Based on the Highest Job Performed:
If a worker performed multiple jobs, one option was to use job physical measure from the highest exposure job to reflect worker's physical exposure. For example, if a worker worked three different jobs, A, B and C, and job A had a peak compressive force of 630 lbs, job B had a peak compressive force of 1,240 lbs, and job C had a peak compressive force of 810 lbs, then job B would be selected as the "highest job" and its peak compressive force of 1,240 lbs would be assigned to peak compressive force measure at the position (worker) level. Among those same three jobs, job A might generate the highest Lifting Index. In that case Job A would be the highest job, and the Lifting Index value from job A would be used to describe physical exposure at the position (worker) level.

Using this process, a "highest job" physical exposure measure was created for each physical exposure measure. It should be noted that the highest job might not necessarily be the same job for different job physical measures, as shown above. The highest job is defined as the job that yields the highest (or lowest in the case of percent capable) score or value for a given job physical exposure measure.

Summarizing Position Exposure Based on the Typical Job Performed:
Another method for resolving the multiple job problem was to look at the job that the worker performed the majority of the time. The duration of time a job was performed was recorded as a percentage of total time on the initial Position Specific data form and on subsequent computerized quarterly follow-up forms. The job with the highest percentage of total time was considered the typical exposure job (e.g. if a worker performed two jobs, A and B, and job A was performed 40% of the time, and job B was performed 60% of the time, job B was considered the "typical job"). For most workers, the typical job was either the only job they performed (the worker had only one job assigned to their position), or was the job with the clear majority of time (the worker performed the job for a greater percentage of time than any other job). Some workers had multiple jobs that were "tied" for time (e.g. two jobs, each performed 50% of the time, or 3 jobs where two were performed 40% of the time each, and the third was performed 20% of the time). In those cases, the ties were broken using the same process as defining the highest job. For example, consider a worker who performed 3 jobs, A, B, and C, where the peak compressive force was being considered to describe physical exposure. Jobs A and C were performed for 35% of the time each (total 70%), and job B was performed for 30% of the time. In this scenario, jobs A and C were tied for longest typical exposure. Looking further, Job A had peak compressive force of 900 lbs and job

C had peak compressive force of 980 lbs. In this example, job C would be selected to represent the typical job, as it broke the percentage time with a higher score in the physical exposure measure being analyzed.

3D Biomechanical Data Analyses:

Snapshots extracted from video were used to approximate postures for the University of Michigan 3D Static Strength Prediction Model (3DSSPP ver. 5.0.8). Approximations were made by manipulating the joint angles of the on screen mannequin until the mannequin closely resembled the worker in the snapshot. Hand loads were then applied based on measurements taken by the analysts in the field. Although many snapshots were taken between the origin and destination for most lift/lower activities, only the origin and destination values have been analyzed at this time. For consistency, all 3D biomechanical analyses were performed using a 50th percentile population anthropometry. Gender was set to match the worker being studied. The complete results for each analyzed snapshot were exported to the job specific data computerized database where it could be manipulated to generate a variety of job physical exposure measures..

The following is a list of 3D biomechanical based job physical exposure measures studied for this report (each of these variables is further divided into typical and highest job:

- *Minimum % Capable Population (%)*
  Minimum percent capable for a given job based on all tasks performed within the job. Percent capable strengths considered for the minimum are torso, shoulder, elbow and hip.

- *Max Compressive Force (lbs)*
  Maximum L_5/S_1 compressive force for a given job based on all tasks performed.

- *Cumulative Compressive Force/min (lbs-sec/min)*
  Cumulative L_5/S_1 compressive force for a given job. The cumulative force is represented "per minute" (i.e. units of lbs/minute). Calculations are performed by averaging the origin and destination compressive force for each task, multiplying the average by the number of exertions per minute for the tasks, then summing the lbs/minute across all tasks.

- *Max Comp Force x Frequency ($CF_{max}*F$) (lbs/min)*
  Peak compressive force from [Max Compressive Force (lbs)] multiplied by total task frequency (frequency of all tasks for a job).

- *Average Compressive Force/Exertion (lbs/exertion)*
  Average L_5/S_1 compressive force for a given job based on all tasks performed.

- *Max Flexion/Extension Moment (in-lbs)*
  Maximum trunk flexion/extension moment for a given job based on all tasks performed.

- *Cumulative Flexion/Extension Moment (in-lbs-sec./min)*
  Maximum trunk flexion/extension moment from [Max Flexion/Extension Moment (in-lbs)] multiplied by total task frequency (frequency of all tasks for a job).

Revised NIOSH Lifting Equation Analyses:
The Revised NIOSH Lifting Equation Cumulative Lifting Index (CLI) scores were calculated by running the raw lift/lower task data through a Visual Basic calculator embedded into a Microsoft Excel spreadsheet. The spreadsheet took the raw data for a job from the database, and performed the CLI calculations as described by the Revised NIOSH Lifting Equation. The following assumptions and limitations were placed on both the raw data eligible for calculation and on the Lifting Equation itself.

First, only tasks that were performed with a frequency of one lift (lower) every 20 minutes (0.05 lifts per minute) or greater were used in the calculation of CLI scores. This eliminated the possibility that very infrequent, heavy tasks were amplifying the CLI score (the Revised NIOSH Lifting Equation CLI was not intended to be used to study infrequent or rare lifting along with frequent lifting tasks). There were three exceptions to this imposed limitation. (i) Tasks occurring intermittently, but with very similar weight ($\pm$ 5 lbs) and hand locations ($\pm$ 1 inch horizontal, $\pm$ 3 inches vertical) were grouped together. When their summed frequency exceeded one lift (lower) every 20 minutes, they were included in the job. (ii) Tasks that were infrequent, and considerably higher in weight than the frequent tasks were separated into a different job, allowing those infrequent tasks to be eligible to become the 'highest' exposure job (e.g. palletizing of lightweight objects, where the heavy pallet is handled infrequently). (iii) Warehouse material handling jobs (order selectors), where each item varied considerably, and therefore almost no individual items were handled more frequently than one lift every 20 minutes. In those order selector situations, all tasks were included no matter how infrequent the lift (lower) was performed. Using one of these methods practically all tasks performed by workers were accounted for.

Second, no restrictions were placed on any of the variables used in the calculation of the CLI (e.g. the horizontal distance multiplier was not set to zero when the horizontal distance became larger than 25 inches). Rather, the equations used to determine the individual multipliers were used without the restrictions prescribed by NIOSH. Relaxing these multiplier restrictions ensured that all jobs received a valid CLI score.

Third, the table for lifting frequency was extended so that its final values in each column were effectively extended out to infinity rather than reverting to zero. This modification was necessary to accommodate the inflated lifting frequencies that resulted in occasionally counting carries between lift/lower tasks using the process described above. Again, this was required to ensure that every job received a valid CLI score.

28

The following is a list of Revised NIOSH Lifting Equation based job physical exposure measures studied for this report (each of these variables is further divided into typical and highest job:

- *CLI (Cumulative Lifting Index)*
  The CLI score for each job calculated as described above but *without* the minimum frequency modification.

- *CLI for Lifts/Lowers ≤ 30"*
  The CLI score for each job calculated as described above from only tasks with an origin and/or destination vertical location below 30 inches, but *without* the minimum frequency modification.

Job Specific Survey Based Exposure Measures:
Several job physical exposure variables were based on survey data collected on the Job Specific Data collection form (Appendix B3). These variables were either taken directly from the form, or were mathematically summarized from two or more variables on the Job Specific Data form (e.g. Borg CR-10 Ratings).

The following is a list of Job Specific job physical measures studied for this report (each of these variables was further divided into typical and highest job exposures:

- *TWA Borg CR-10*
  Time weighted worker Borg CR-10 rating calculated by multiplying the worker Borg CR-10 rating by its associated percentage of time performed and then summing the products across all five activity categories.

- *Peak Activity Rating (Borg CR-10)*
  The peak worker Borg CR-10 rating from the five activity categories

- *Peak Task Rating (Borg CR-10)*
  The peak task worker Borg CR-10 rating

- *% of Time Spent Back Bent > 20°*
  The percentage of time spent with the back bent as stated on the job specific data form.

- *Lifting Frequency (lifts/min)*
  The lift/lower frequency for a given job.

- *Lifting Frequency for Lifts ≤ 30"*
  The lift/lower frequency for a given job for only those tasks whose origin and/or destination vertical location is below 30 inches.

Position Specific Survey Based Job Physical Exposure Measures:
Several job physical variables were based on survey data collected on the Position Specific Data collection form. (Appendix B1). The majority of these variables were taken directly from the form. A few of the variables were mathematically summarized from two or more variables on the Position Specific Data form (e.g. beginning and end of shift Borg CR-10 ratings, and past work history).

The following is a list of Position based job physical exposure measures studied for this report:

- *Typical Hours/Week (hours/week)*
  The typical number of hours the worker works per week

- *Maximum Hours/Week (hours/week)*
  The maximum number of hours the worker works per week

- *Typical Days/Week (days/week)*
  The typical number of days the worker works per week

- *Maximum Days/Week (days/week)*
  The maximum number of days the worker works per week

- *Borg-Years*
  The sum product of each of the workers previous jobs and their associated Borg CR-10 rating

- *Maximum Borg CR-10 Rating*
  The peak Borg CR-10 rating from the worker's work history

- *Workers with Second Job*
  Coded as "yes" if the worker holds a second position, "no" if the worker does not hold a second position.

- *Years on Second Job (years)*
  If the worker holds a second position, this variable contains the number of years the worker has held that second position. If the worker does not work a second position, the variable is recorded as zero.

- *Hours per Week on Second Job (hours/week)*
  If the worker holds a second position, this variable contains the number of hours per week the worker works the second position. If the worker does not work a second position, the variable is recorded as zero.

- *Typical Borg Rating on Second Job (Borg CR-10)*
  If the worker holds a second position, this variable contains the Borg CR-10 rating for the second position. If the worker does not work a second position, the variable is recorded as zero.

- *Borg-Hours on Second Job*
  If the worker holds a second position, this variable contains the Borg CR-10 rating multiplied by the hours per week the position is worked. If the worker does not work a second position, the variable is recorded as zero.

- *Borg CR-10 Rating – Beginning of Shift*
  The worker Borg CR-10 rating for the beginning of the typical work shift

- *Borg CR-10 Rating – End of Shift*
  The worker Borg CR-10 rating for the end of the typical work shift

- *Delta Borg (Borg CR-10)*
  The difference between [Borg CR-10 Rating – End of Shift] and [Borg CR-10 Rating – Beginning of Shift]

2.7   Sample Size and Statistical Analyses:

The unit of analysis in this study is an individual worker. Using baseline data, we calculated, prevalence of LBP, one-month period prevalence of LBP and point prevalence of LBP.

2.7.1   Incidence rates:

During longitudinal observations, there were many workers who experienced more than one episode of LBP during the observation period (recurrent LBP characterized by the number of episodes). While recurrences were tracked in this study, this report considers only the conservative analysis of time to first event during the observation period. Workers who had had prior LBP or current LBP at baseline were considered to be eligible to become an incident case after completing a continuous symptom free period of at least 90 days.

For longitudinal data, some health outcomes, such as incident cases of LBP, are binomial variables and were analyzed using the Proportional Hazards regression model (Cox regression models). The Cox proportional hazards model (Cox 1972) was used as it takes advantage of more powerful person-time data that were available from this study and because this modeling does not need to quantify the underlying hazard function. Tests of proportionality assumption were performed, and no violations if this assumption were found in these analyses time-varying covariates were included in these models, especially changes in job exposures.

Information from subjects withdrawn from the study were incorporated by calculating linearized rates using all available time, as well as by calculating Kaplan-Meier rates of freedom from symptoms/disorder at a particular point in time using survival analysis methods (Kaplan 1958).

Univariate comparisons were made between the LBP outcome variables and non-physical variables in order to identify relevant covariates. The hypothesis regarding the role of job physical risk factors were assessed using unadjusted and adjusted Cox regression models. When adjusting for confounder effects, we carefully assessed potential colinearity between predictors.

The assessment of LBP of any intensity incidence rates involved careful adjustment for confounders and assessments for effect modifiers, e.g., prior exposures and past injuries. We first examined and described the distribution of each potential risk factor. We then assessed the hazard ratio, with 95% confidence intervals, for each factor in a Cox model adjusted for confounding variables. The significance of each potential risk factor was evaluated using the likelihood ratio statistic in the model adjusted for confounders.

31

Model fit was examined by likelihood ratio test for nested models, assessing Akaike information criterion for non nested models and assessing both Cox-Snell residuals and martingale residuals (Fleming and Harrington 1991) where appropriate.

In this initial univariate analysis, the job exposure measures (e.g. Lifting Index, estimated L5/S1 compressive force, low back moments, percent capable population) were analyzed both as continuous and categorical variables. A selected number of job physical exposure measures (Lifting Index, compressive force and percent capable population) were stratified using established guidelines such as compressive force ≤ 770 lbs, percent capable population < 75%. Additional analyses were performed on data classified into different categories where the ratio of cases to non-cases appeared to be substantially changed. Preferences were given to maintain equal intervals for the exposure variables where data would allow.

2.7.2   Dropouts and Missing Data:
Data were analyzed to attempt to address whether the data were missing completely at random (MCAR), especially regarding dropouts and whether they were unrelated to the study outcomes. While we anticipated some potential difficulties with dropouts related to LBP, this did not prove to be significant factor, thus the data appeared to provide valid inferences under the MCAR assumption (Rubin 1976).

2.7.3   Multiple Comparisons Issues:
We recognized that our analyses involved examination of several indices of exposure and multiple potential risk factors, leading to a potential for chance associations due to multiple statistical tests. We were aware of formal "pure frequentist" approaches such as Bonferroni correction for significance of all tests performed. However, we believed that it was preferable and acceptable to perform a very limited number of "primary analyses" that were performed using uncorrected significance levels, given that the intended (and actual, if different) analysis plan for the study is clearly stated.

3. Results

3.1 Subjects:

A total of 759 subjects were enrolled in the study, drawn from a total worker population of over 12,000 from 29 different industries in 4 diverse states (WI, UT, IL and TX). Baseline health assessments were performed on 733 workers (Figure 3.1). Baseline job physical exposure data were collected on 673 workers. Complete baseline data (both health and job physical exposure data) were available on 647 subjects (Figure 3.1). Follow-up data were available on 610 workers with at least one monthly follow up (22 days of follow-up). The 610 participants were followed for a total of 1032.9 person-years. The mean follow-up observation time was 604 days/worker (range = 22-998 days) (Figure 3.1).

3.2 Baseline Descriptive Statistics:

For purposes of analyses and discussion, variables were categorized into demographic factors, social activities (physical activity including sports, hobbies), psychosocial, medical history (other than back), back history and job physical factors. It should be noted that there might be complex interactions between these various variable domains that remain to be analyzed. Psychosocial factors include both occupational and non-occupational factors.

3.2.1 Demographic Data:

Demographic data from participants (n =610) are summarized in Tables 3.1 and 3.2. The mean age of the cohort was 37.8 ± 11.9 years (range = 8.5 – 69.0). About 60% of workers were less than 40 years old and about 3% of subjects were age 60 or older at the time of enrollment (Figure 3.2). A significant majority (64.75%) of participating workers were male (mostly male workers were employed in manual materials handling jobs in the participating companies). The mean weight of the participants was 84.5 ± 20.7 kg (range-- 43.2 – 189.3 kg). A large number of subjects (73.7%) were either overweight or obese based on their body mass indices (BMIs) (Figure 3.3). A small minority of participants (1.3%) was underweight (Figure 3.3). The population's mean measured BMI was 29.12 ± 6.0 kg/m^2. Lumbosacral flexion averaged 85.3 ± 24.3 degrees.

About 57% of the participants were married, and most of the single participants had never been married (27%) (Table 3.2). Most subjects completed either high school or higher education (88.4%). Nearly half of subjects (47%) were non-white (Table 3.2). About 42% of subjects were either current or past smokers and the mean pack-years for these subjects was 11.6 ± 14.0 (range = 0 – 68).

Workers had been on their current job for 4.08 ± 4.95 years. A sizable minority (n=55, 9.4%) had second jobs.

Total Ever Enrolled
(January - May 2004)
n = 759

Health Baseline
n = 733

Job Baseline
n = 673

Total Combined Baselin
n = 759

Dropouts
n = 37

Total with at least 1
monthly follow up
n = 610

Follow-Up in Months:

State	n (followed)	Mean	Std. Dev.	Range
TX	128	482.13	188.71	(57.0 - 790.0)
UT	249	675.42	292.70	(22.0 - 998.0)
WI	233	595.86	186.51	(60.0 - 805.0)
TOTAL	610	604.48	246.57	(22.0 - 998.0)

Total follow-up time = 1032.9 person-years

Worker Attrition by Type During Follow Up Period:

State	n (baseline)	Terminated / Laid Off	Quit Job	Withdrew	Other	No Information Available	Total Attrition
TX	128	482.13	9	1	0	5	24
UT	249	675.42	78	7	6	0	93
WI	233	595.86	32	0	19	0	59
TOTAL	610	604.48	119	8	25	7	176

Figure 3.1: Subjects enrollment and follow-up statistics

Table 3.1: Summary of Continuous Demographic Variables

No.	Variable	N	Mean	Standard Deviation	Range
1.	Age (years)	610	37.80	11.89	18.50 - 69.00
2.	Measured height (cm)	610	169.74	9.92	143.00 - 201.00
3.	Measured weight (kg)	610	84.52	20.70	43.20 - 189.30
4.	BMI (kg/m²)	610	29.12	6.00	15.87 - 54.72
5.	Hip to shoulder length (lateral iliac crest to posterior acromion process, cm)	516	42.90	7.18	28.00 - 95.00
6.	Upper Arm length (posterior acromion process to upper olecranon process, cm)	516	32.74	4.69	22.00 - 65.00
7.	Chest circumference (cm)	598	103.89	13.22	61.00 - 190.00
8.	Waist circumference (cm)	598	97.51	15.83	58.00 - 158.00
9.	Hip circumference (cm)	598	108.85	13.58	53.00 - 203.00
10.	Distance from middle fingertip to floor (stand erect, knees locked, without shoes, cm)	609	65.38	5.66	35.00 – 96.00
11.	Forward spinal flexion (cm)	606	8.95	12.32	-32.00 - 74.00
12.	Full trunk flexion (using goniometer, in degrees)	594	85.49	24.02	31.00 - 180.00
13.	Pack-years (only those who smoked)	256	11.65	14.01	0.00 - 68.00
14.	Total miles traveled per day (bus, work & non-work, miles/day)	606	28.30	26.32	0.40 - 300.00
15.	Time to commute to work per day, one way (min)	607	18.53	12.31	0.00 - 105.00
16.	Number of job rotations per rotating worker	263	3.97	2.25	2.00 - 11.00
17.	% Time spent on typical job per rotating worker	263	48.50	24.02	15.00 - 99.00

Table 3.2: Summary of Categorical Demographic Variables

No.	Variable	n	%
1.	Gender		
	Male	395	64.75
	Female	215	35.25
2.	Education		
	Some high school	70	11.59
	High school graduate or GED	294	48.68
	Some college	199	32.95
	College graduate (Bachelor's degree or higher)	41	6.79
3.	Marital Status		
	Never married	164	27.06
	Married	346	57.10
	Divorced	77	12.71
	Separated	15	2.48
	Widowed / Widowered	4	0.66
4.	Recorded Race		
	White	322	52.79
	African American	64	10.49
	Hispanic	167	27.38
	Other	57	9.34
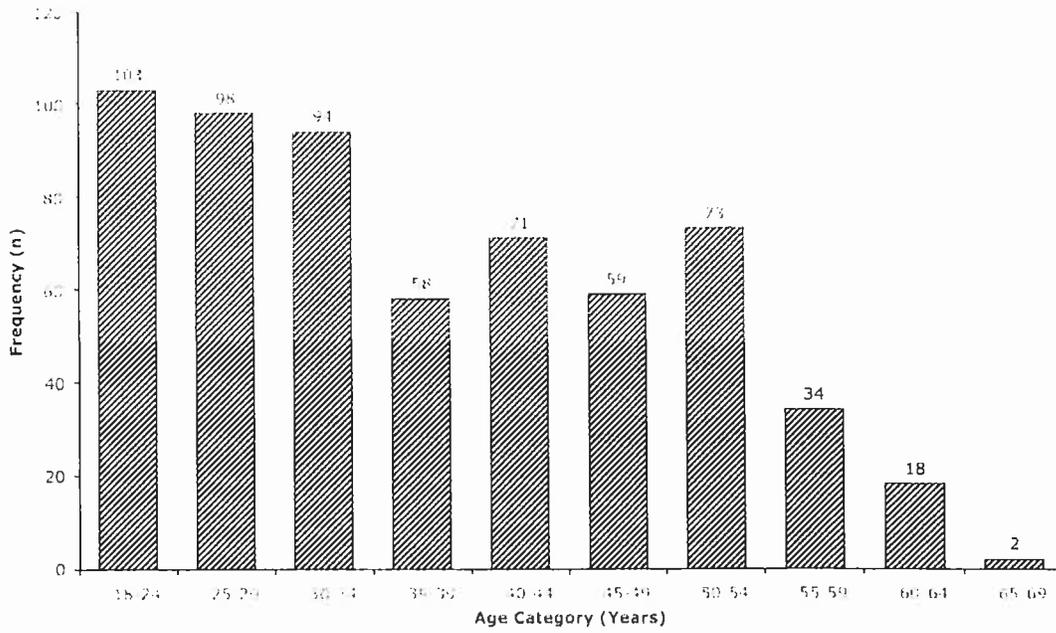
Figure 3.2: Frequency Distribution of Age at Baseline
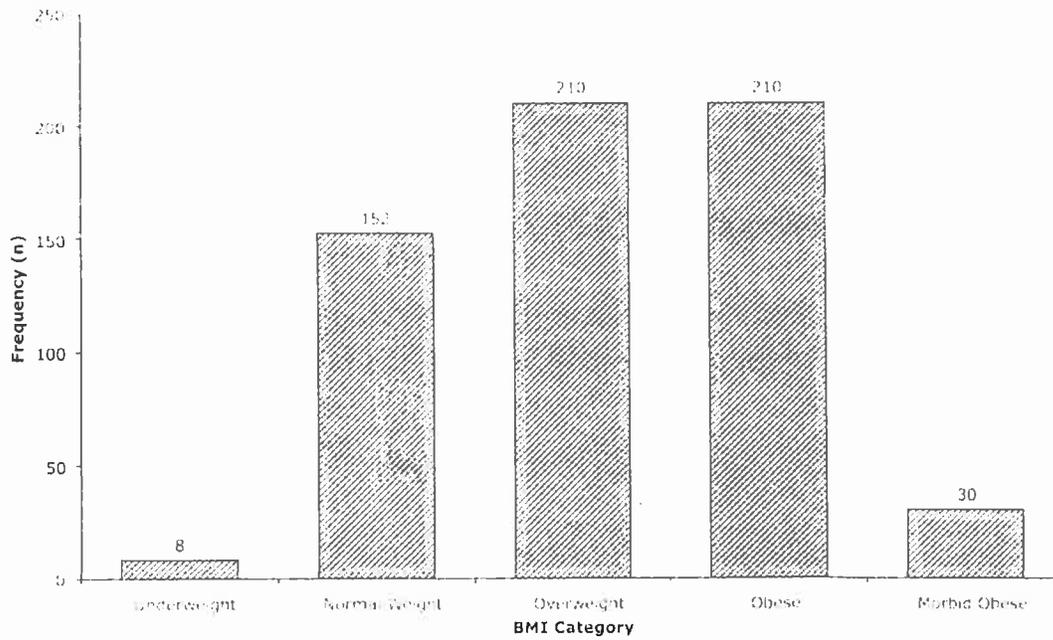
Figure 3.3: Frequency Distribution of BMI at Baseline

On the average, the participants traveled 28.3 ± 26.3 (range = 0.4 – 300) miles per day. This included travel between home and work as well as non-work-related travel. The average time to commute to work (one way) was 18.5 ± 12.3 (range =0 – 105) minutes/day. The total time estimated to have been spent sitting per day was 3.4 ± 1.77 hours.

3.2.2 Social Activities-Hobbies:

A large number of participants (85%) had one or more hobbies (Table 3.3). The top 10 hobbies that the subjects participated in are reported in Table 3.3. The most common hobby was housework (70.3%), followed by gardening (46.1%), shoveling (44.3%), maintenance work (23.8%) and knitting (13.9%). The other top 10 hobbies included fishing, remodeling, woodworking, hunting and riding a motorcycle or ATV. The only other hobby listed by the participants was snowmobiling (n =16).

The most common physical activity was housework (n=429, 70.33%), followed by gardening (n=281, 46.07%), shoveling snow (n=270, 44.26%), and maintenance work (n=145, 23.77%).

3.2.3 Social Activities-Physical Exercises:

Most of the subjects (84.9%) participated in one or more physical exercises. The top nine physical exercises that the subjects participated in are listed in Table 3.4. The most common exercise was walking (57.4%), followed by lifting weights (20.3%), basketball (16.7%), running (15.9%) and bicycling (15.3%). The other top nine physical exercises included swimming (7.9%), aerobics (5.6%), baseball (4.8%), and yoga (4.6%). In addition to these exercises, some workers participated in football (n = 16), racquetball (n = 11), water skiing (n = 11) and tennis (n= 10).

Exercises were also categorized into presumptive categories of protective (running, walking, aerobics, swimming, yoga and soccer) versus at-risk (baseball, basketball, bicycling, bowling, football, handball, racquetball, skiing, water-skiing, and weight lifting) and low impact versus high impact exercises based on a priori presumptive risks for LBP. At-risk and protective exercises were performed on average for 160.3 ± 187.6 (range = 2.5 – 1,230.5) minutes/week and 169.3 ± 235.5 (range = 0.8 – 2,371.6) minutes/week respectively. Low impact and high impact exercises were performed on average for 179.6± 224.7 (range = 0.8 – 1,994.5) minutes/week and 118.6 ± 196.9 (2.5 – 1,984.6) minutes/day, respectively.

3.2.4 Psychosocial Factors:

Findings from the three modified, composite psychosocial scales are summarized in Table 3.5. Table 3.6 summarizes results for individual psychosocial questions not included in the three composite scales. The mode and median for the modified APGAR scale both were 5 (Table 3.5). Sixty-six participants had a score of 0 and only one participant had the maximum score of 14 (Figure 3.4). Scores were skewed towards the lower end of the scale (Figure 3.4). The mode and median for the modified Zung composite scale were 3 and 6, respectively (Table 3.5). Twenty-four participants had a score of 0 and one participant had the highest score of 19 (out of possible maximum of

38

Table 3.3: Summary of Participants' Hobbies

No.	Hobby	Total N	Number Participating	
			n	%
1.	Having one or more hobbies	610	519	85.08
2.	Housework	610	429	70.33
3.	Gardening	610	281	46.07
4.	Shoveling	610	270	44.26
5.	Maintenance	610	145	23.77
6.	Knitting	610	85	13.93
7.	Fishing	610	73	11.97
8.	Remodeling	610	62	10.16
9.	Woodworking	610	51	8.36
10.	Hunting	610	48	7.87
11.	Motorcycle / ATV	610	48	7.87

Table 3.4: Summary of Participation in Various Exercises

No.	Exercise	Total N	Number Exercising	
			n	%
1.	Participating in one or more exercises	610	518	84.92
2.	Walking	610	350	57.38
3.	Lifting weights	610	124	20.33
4.	Basketball	610	102	16.72
5.	Running	610	97	15.90
6.	Bicycling	610	93	15.25
7.	Swimming	610	48	7.87
8.	Aerobics	610	34	5.57
9.	Baseball	610	29	4.75
10.	Yoga	610	28	4.59
11.	Low impact exercise (min/week)	610	432	$\overline{X} = 179.6 \pm 224.7(0.8\text{-}1{,}994.5)$
12.	High impact exercise (min/week)	610	183	$\overline{X} = 118.6 \pm 196.9(2.5\text{-}1{,}984.6)$
13.	Protective exercise (min/week)	610	413	$\overline{X} = 169.3 \pm 235.5(0.8\text{-}2{,}371.6)$
14.	At-risk exercise (min/week)	610	257	$\overline{X} = 160.3 \pm 187.6(2.5\text{-}1{,}230.5)$

Table 3.5: Summary of Modified APGAR, Zung, Composite Tense, Edge and
Nervous Psychosocial Scales

No.	Psychosocial Scale	Total N	Mode	Median	Range
1.	Modified APGAR	600	5	5	0-14
2.	Modified Zung	580	3	6	0-19
3.	Composite Tense Edge Nervous	580	3	3	0-9
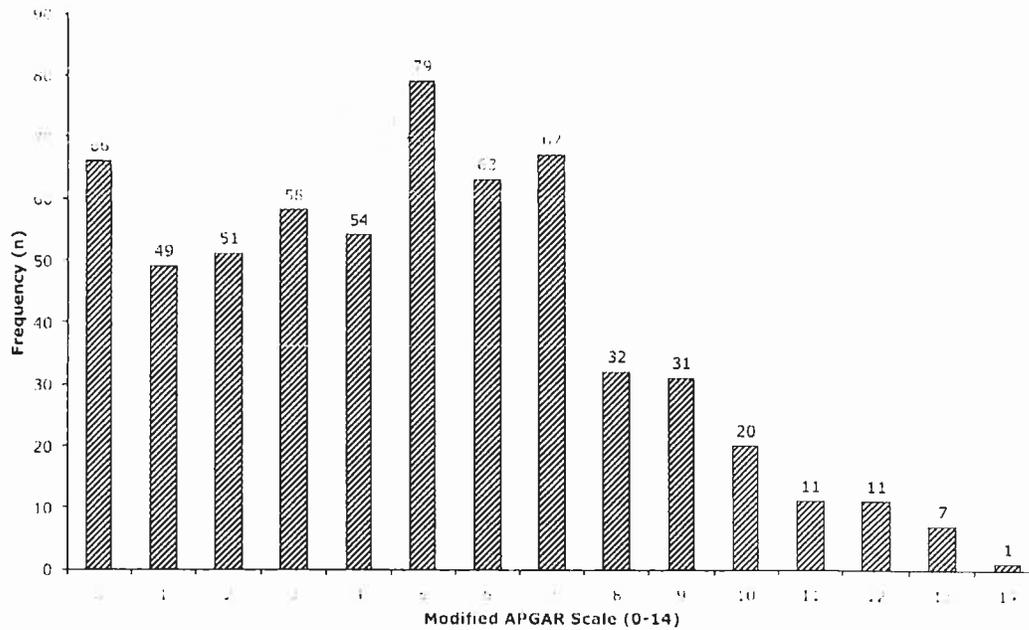
Figure 3.4: Frequency Distribution of Modified APGAR Scale at Baseline

24) (Figure 3.5). Scores were heavily skewed towards the lower end of the scale (Figure
3.5). The composite scores for the scale tense/on edge/nervous had mode and median of
3. The frequency distribution of the scores on this scale are given in Figure 3.6. Similar
to the modified APGAR and Zung scores, the scores for this scale were skewed towards
the lower end of the scale.

40
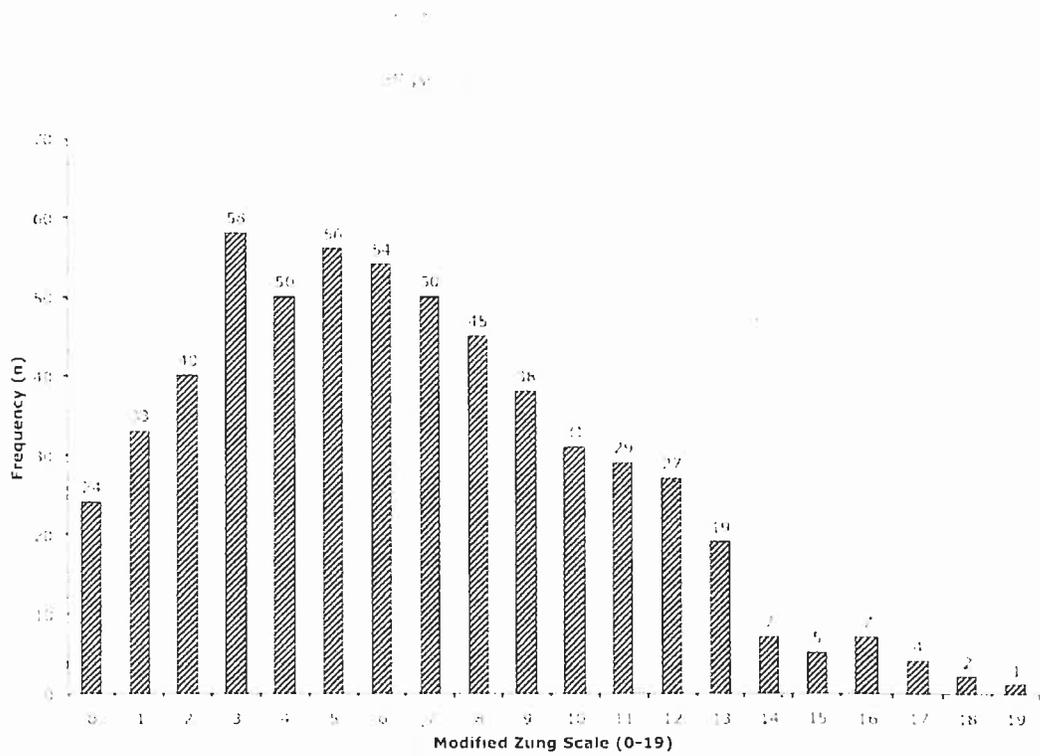
Figure 3.5: Frequency Distribution of Modified Zung Scale at Baseline
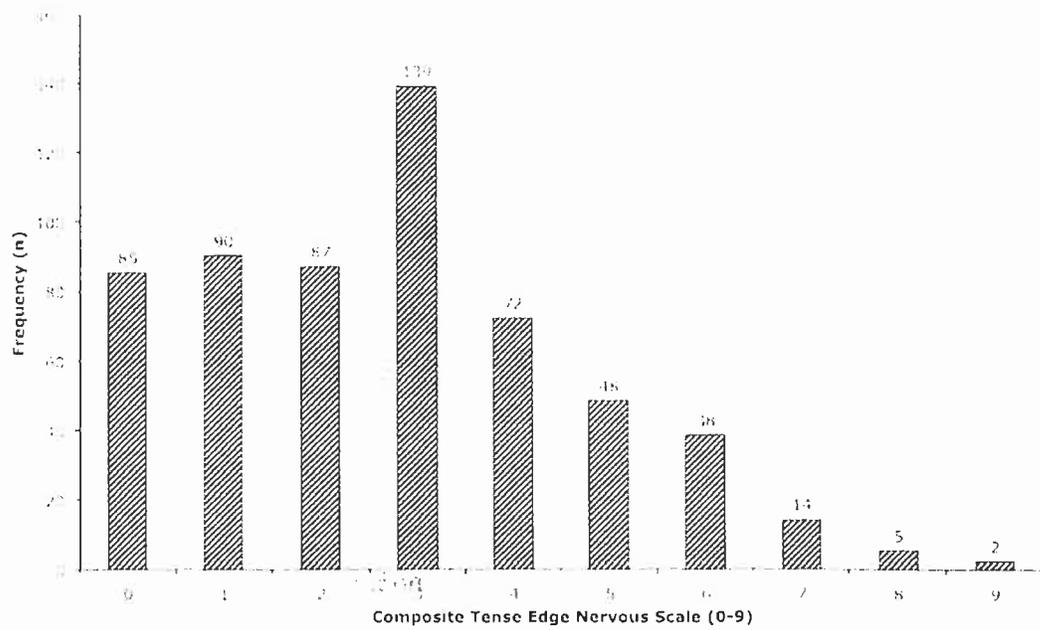
Figure 3.6: Frequency Distribution of Composite Tense/Edge/Nervous Scale at Baseline

Nearly half of the participants (49.5%) reported that they had little or very little control over short beaks or the work they performed (Table 3.6). About one-third of the participants (30.9%) had a little or very little control over the order of tasks they performed (Table 3.6). About 30% of the participants reported that they a little or very little control over the variety of tasks they performed. About 35.7 % of participants' jobs were line-paced, 14.1% were piecework and the remaining 50.2% jobs were self-paced. Three out of 10 workers (30.8%) reported that they had a little or very little control over the pace of their work. A large number of workers (85.2%) reported that that their jobs required working very fast (agree or strongly agree) but only about half of the workers (50.7%) reported that their jobs required working physically hard ((agree or strongly agree). Two out of three participants (67.6%) reported that others made free conflicting demands (strongly agree or agree). A majority of workers (62.4%) felt physically exhausted and 15.9% felt mentally exhausted (often or always). Practically all participants (95.4%) felt satisfied with their jobs (very satisfied or somewhat satisfied). One out of six participants (16.4%) felt depressed and had family problems (17.7%) and one out of five participants (19.9%) felt uneasy (often or always). About 28.9% of workers reported having restless sleep often or always. Two out of three participants (67.1%) reported sleeping for 6.5 hours or less.

3.2.5 Prevalence of LBP and LBP History:

The point prevalence, one-month period prevalence and lifetime prevalence of low back pain of any intensity lasting at least 1 day were 21.6%, 45.6% and 64.5%, respectively (Table 3.7). In this study, more than 6 out of 10 participants had experienced LBP in their lifetime. One-month period and lifetime prevalence of LBP of intensity ≥ 3 on the pain scale were 30.47% and 56.6%, respectively.

The duration of the most recent episode of LBP was usually one day. The longest continuous duration of most recent pain was 1 - 2 days for 35.9%, 3 - 6 days for 11% and 7 days or more for 5.7% of participants. Among subjects with a prior history of LBP, the most common length of duration of pain was one day (n = 236, 39.3%). The longest continuous duration of lifetime LBP was 1 - 2 days for 39.3%, 3 - 6 days for 15.5% and 7 or more days for 9.7% of the participants.

One out of nine (11.6%) participants reported that they were ever placed on light duty/modified duty and about the same number (11.3%) had lost workdays due to LBP. Twelve percent of participants had 1 - 2 episodes of lost-time LBP and another 4.1% had 3 or more episodes.

A small percentage of participants (3.7%) ever changed their jobs because of LBP.

Table 3.6: Individual Psychosocial Factors

No.	Psychosocial Factors	Total N	%
1.	Able to control short brake		
	Very much	61	10.52
	Much	120	20.69
	Moderate amount	112	19.31
	A little	124	21.38
	Very little	163	28.10
2.	Able to control the order of tasks		
	Very much	91	15.69
	Much	152	26.21
	Moderate amount	158	27.24
	A little	80	13.79
	Very little	99	17.07
3.	Able to control over the variety of Tasks		
	Very much	90	14.95
	Much	149	24.75
	Moderate amount	187	31.06
	A little	85	14.12
	Very little	91	15.12
4.	Job Pace		
	Self paced	259	50.20
	Line paced	184	35.65
	Piece paced	73	14.15
5.	Able to control the pace of work		
	Very much	112	18.64
	Much	156	25.96
	Moderate amount	148	24.63
	A little	90	14.98
	Very little	95	15.81
6.	Job requires working very fast		
	Strongly disagree	8	1.38
	Disagree	78	13.43
	Agree	310	53.36
	Strongly agree	185	31.84

Table 3.6: Individual Psychosocial Factors (Contd.)

No.	Psychosocial Factors	Total N	%
7.	Job requires physically working hard		
	Strongly disagree	178	29.57
	Disagree	117	19.44
	Neither agree nor disagree	2	0.33
	Agree	298	49.50
	Strongly agree	7	1.16
8.	Free conflicting demands that others make		
	Strongly agree	61	10.50
	Agree	332	57.14
	Disagree	164	28.23
	Strongly disagree	24	4.13
9.	Felt Physically Exhausted		
	Never	73	17.14
	Seldom	87	20.42
	Often	200	46.95
	Always	66	15.49
10.	Felt Mentally Exhausted		
	Never	131	21.76
	Seldom	351	58.31
	Often	91	15.12
	Always	29	4.82
11.	Job Satisfaction		
	Very Satisfied	175	29.07
	Satisfied	12	1.99
	Somewhat satisfied	387	64.29
	Not at all satisfied	28	4.65
12.	Felt Depressed		
	Never	221	36.71
	Seldom	282	46.84
	Often	84	13.95
	Always	15	2.49
13.	Felt Uneasy		
	Never	167	28.64
	Seldom	300	51.46
	Often	107	18.35
	Always	9	1.54
14.	Have Family Problems		
	Never	186	30.79
	Seldom	311	51.49
	Often	84	13.91
	Always	23	3.81

44

Table 3.6: Individual Psychosocial Factors (Contd.)

No.	Psychosocial Factors	Total N	%
15.	Restless Sleep		
	Never	144	24.74
	Seldom	270	46.39
	Often	139	23.88
	Always	29	4.98
16.	Recoded Sleep Hours/day		
	Sleep 8-10 hours	61	10.55
	Sleep 7-7.5 hours	129	22.32
	Sleep 6-6.5 hours	204	35.29
	Sleep 2-5.5 hours	184	31.83

Table 3.7: Summary of LBP Prevalence

No.	Low Back Pain Outcome	Total N	Participants with LBP outcome	
			n	%
1.	Point prevalence of LBP of any intensity	610	132	21.64
2.	One month period prevalence for LBP of any intensity	594	271	45.62
3.	One month period prevalence for LBP of intensity > 3	594	181	30.47
4.	One month prevalence for LBP lasting $\geq$ 3 months	594	81	13.64
5.	Lifetime prevalence of LBP of any intensity	610	387	64.50
6.	Lifetime prevalence of LBP of intensity > 3	594	336	56.57
7.	Lifetime prevalence of LBP of any intensity lasting $\geq$ 3 months	594	98	16.50
8.	Prevalence of ever being on light/modified duty due to LBP	594	69	11.62
9.	Prevalence of ever having lost work time due to LBP	594	67	11.28
10.	Prevalence of ever changing jobs because of LBP	594	22	3.70
11.	Prevalence of ever seeking a healthcare provider for LBP	610	202	33.11
12.	Prevalence of ever taking medication to treat LBP	610	184	30.16
13.	Longest continuous time for LBP ever (days)	600		
	0		213	35.50
	1 - 2		236	39.33
	3 - 6		93	15.50
	$\geq$ 7		58	9.67
14.	Longest duration of most recent LBP (days)	610		
	0		289	47.38
	1 - 2		219	35.90
	3 - 6		67	10.98
	> 7		35	5.74

Table 3.7: Summary of LBP Prevalence (continued)

No.	Low Back Pain Outcome	Total N	Participants with LBP outcome	
			n	%
15.	Pinched nerve/sciatica (ever told by a physician)	610	58	9.51
16.	LB strain/sprain (ever told by a healthcare provider)	610	124	20.33
17.	Number of episodes of lost-time LBP	610		
	0		511	83.77
	1 - 2		74	12.13
	≥ 3		25	4.10
18.	Bulging Disk in the Lower Back (Told by a physician)	610		
	No		577	94.59
	Yes		33	5.41
19.	Received workers' compensation for a back related injury	610		
	No		564	92.46
	Yes		46	7.54
20.	Ever received workers' compensation due to work related injury for the back or other	610		
	No		492	80.66
	Yes		118	19.34

One out of three participants (33.1%) ever saw a healthcare provider for their LBP and about the same number of participants (30.2%) took any medication to treat their LBP. Over-the-counter medications had been used to treat LBP by 82 (13.4%), non-narcotic medications by 82 (13.4%) and narcotics/opioids by 56 (9.2%). One-fifth of the participants (20.3%) were ever diagnosed with LBP strain/sprain and 9.5% with pinched nerve/sciatica by a physician. One out of five participants (19.3%) reported having ever received workers compensation for any reason and 7.5% due to LBP-related injuries.

Regarding some other LBP related history issues, histories of having a 'bulging disc' in the back (n = 33, 5.4%) and neck (n = 10, 1.6%); degenerative lumbosacral disease (n = 26, 4.3%) and cervical disease (n = 12, 1.9%) were uncommon. A bone alignment problem was uncommon (n = 29, 4.8%). Scoliosis (n = 22, 3.6%), spina bifida (n = 2, 0.3%) and spondylolisthesis (n = 4, 0.7%) were also uncommon.

Five participants (0.82%) had been treated in a work hardening program. Back belts had been used by 67 (10.98%). Epidural steroid injections had been used on 25 (4.10%) participants. X-rays had been performed on 109 (17.87%). Computerized tomograms had been performed on 26 (4.26%), magnetic resonance imaging on 44 (7.21%). Either a CT or an MRI had been performed on 52 (8.52%).

3.2.6 Medical History other than LBP:

Relevant medical history of the participants other than LBP is summarized in Table 3.8. A small number of participants had diabetes (4.4%) or a thyroid disorder (4.6%). Fifteen percent of participants were told by their physicians that they had high cholesterol. Nearly, one-third of the participants (32.1%) had high blood pressure either at the time of enrollment or were told by their physicians. One out of twelve participants (8.7%) were told by a physician that he/she had a hernia. Nearly one out of four participants (23.8%) had a broken bone. Heberden's or Bouchard's nodes were uncommon (n = 24, 3.9%), as were inflammatory arthropathy (n = 9, 1.5%), osteoporosis (n = 2, 0.3%), chronic fatigue (n = 8, 1.3%), irritable bowel syndrome (n = 23, 3.8%), fibromyalgia (n = 2, 0.3%), myofascial pain syndrome (n = 1, 0.2%), gout (n = 7, 1.2%) and kidney failure (n = 3, 0.5%).

3.2.7 Physical Examination:

Relevant findings from the baseline physical examination are summarized in Table 3.9. A small number of participants had a positive straight leg raise test in either lower extremity (2.6%). Reflexes were typically rated 2+ for more than 70% of participants. Patellar and Achille's deep tendon reflexes were not elicited in approximately 2% and 5% of those examined, respectively. A little over 4% of the participants had a positive SI joint test on either side. Signs of rheumatoid arthritis (n = 7, 1.2%) were uncommon.

Table 3.8: Summary of Medical History Other than LBP

No.	Health Condition	Total N	With Medical History	
			n	%
1.	Diabetes (told by a physician)	610	27	4.43
2.	Thyroid condition (told by a physician)	610	28	4.59
3.	High blood pressure (either told by a physician and/or had at enrollment)	610	196	32.13
4.	High cholesterol (told by a physician)	610	93	15.25
5.	Hernia (told by a physician)	610	53	8.69
6.	Broken bone (told by a physician)	610	145	23.77

Table 3.9: Descriptive Statistics for Physical Examination Variables

No.	Physical Exam	Total N	Positives	
			n	%
1.	Straight Leg Raise Test (right side)	610	9	1.48
2.	Straight Leg Raise Test (left side)	610	7	1.15
3.	Right patellar reflex (grade)	608		
	0 (Absent)		13	2.14
	1		107	17.60
	2		461	75.82
	3		23	3.78
	4 (Hyperactive with clonus)		4	0.66
4.	Left patellar reflex (grade)	595		
	0 (Absent)		12	2.02
	1		104	17.48
	2		448	75.29
	3		27	4.54
	4 (Hyperactive with clonus)		4	0.67
5.	Right Achilles reflex (grade)	606		
	0 (Absent)		31	5.12
	1		121	19.97
	2		445	73.43
	3		7	1.16
	4 (Hyperactive with clonus)		2	0.33
6.	Left Achilles reflex (grade)	593		
	0 (Absent)		30	5.06
	1		126	21.25
	2		426	71.84
	3		9	1.52
	4 (Hyperactive with clonus)		2	0.34
7.	Right SI joint test	610	26	4.26
8.	Left SI joint test	610	27	4.43

3.3   Job Physical Exposure Descriptive Statistics

Job physical exposure variable descriptive statistic results are broken into three major categories: (i) physical exposure from prior history of work, (ii) physical exposure from second job, and (iii) physical exposure from current job. Physical exposure from current job is further divided into exposure at the worker level and exposure at the job level. This is done because some workers perform more than one job, and certain variables, such as lifting frequency, weight(s) handled and lifting index may be very different for each job performed by the worker. Therefore, physical exposure measures at the job level are expressed for the highest job, and typical job as explained in the section 2.6.6 of

48

Methods. Once again, exposures from prior history of the worker, second job, and current job are exposures at the worker level. Exposures from highest job and typical job each describe different exposures to a worker at the job level and are used to represent exposure to the worker at the worker level.

Descriptive statistics associated with a specific worker, such as typical hours worked per week, are listed in Table 3.10. Descriptive statistics for each of the workers' jobs, such as worker Borg CR-10 ratings, are in Table 3.11. Descriptive statistics for the Revised NIOSH Lifting Equation results are found in Table 3.12 and biomechanical results in Table 3.13.

3.3.1. Physical Exposure Descriptive Statistics - Worker Level:

Prior History, Second Job, Current Job:

Workers participating in this study worked an average of 40.33 ± 3.94 (mean ± standard deviation) hours per week, and a maximum of 47.34 ± 9.02 hours per week. They worked these hours across an average of 4.97 ± 0.38 days per week, and a maximum of 5.55 ± 0.64 days per week. At the beginning of a typical work shift, workers reported an average Borg CR-10 rating of 1.92 ± 1.79. At the end of a typical work shift, workers reported an average Borg CR-10 rating of 3.52 ± 2.12. On average, each worker's Borg CR-10 rating rose by an average of 1.60 ± 1.93 units from the beginning to the end of their work shift.

While performing their various jobs, workers handled an average maximum weight of 40.66 ± 26.27 lbs. They handled this weight an average maximum horizontal location of 19.43 ± 5.12 inches from the L_5S_1 disc and an average minimum vertical location of 31.57 ± 15.12 inches from the floor. (These averages are found by first identifying the maximum weight handled by the worker across all jobs performed by the worker. Once the maximum weight was identified and recorded, the maximum horizontal distance from either the origin or destination was recorded. Finally, the minimum vertical location associated with the maximum horizontal location was recorded.)

Including their current position and all other positions dating back up to ten years from baseline, the average peak Borg CR-10 rating in workers' history was 4.73 ± 2.16. By multiplying the number of years each past position was worked by the Borg CR-10 rating for that position and then summing all the products, a measure of past job physical exposure, Borg*Years, was determined. The workers in this study had an average of 38.40 ± 34.73 Borg*Years of prior to baseline work experience.

Fifty-five of the 610 workers participating in this study had 'second jobs.' Those workers employed in second jobs worked an average of 17.34 ± 12.17 hours per week, and had been working those second jobs for an average of 5.48 ± 7.33 years. The average Borg CR-10 rating for second jobs was 3.77 ± 2.21. A measure of cumulative exposure from a worker's second job was calculated by multiplying the hours the second job was worked per week by the Borg CR-10 rating for the job (Borg*Hours). Workers with second jobs had an average of 75.11 ± 76.56 Borg*Hours.

Table 3.10: Baseline Descriptive Statistics for Participating Workers

Variable	N	Mean	Std. Deviation	Range
Duration Exposure Variables				
Typical Hours/week (hours/week)	587	40.33	3.94	7.7 – 56.0
Maximum Hours/week (hours/week)	587	47.34	9.02	5.0 – 104.0
Typical Days/Week (days/week)	588	4.97	0.38	3.0 – 7.0
Maximum Days/Week (days/week)	588	5.55	0.64	3.0 – 7.0
Intensity of Exposure Variables				
Borg CR-10 Rating-Beginning of Shift	567	1.92	1.79	0.0 – 8.0
Borg CR-10 Rating-End of Shift	567	3.52	2.12	0.0 – 10.0
Delta Borg	567	1.60	1.93	-8.0 – 9.0
Maximum Weight (lbs)	602	40.66	26.27	0.2 – 132.0
Maximum Horizontal Distance (in)	602	19.43	5.12	3.6 – 36.0
Minimum Vertical Location (inches)	602	31.57	15.12	-1.1 – 75.0
Prior Work History				
Maximum Borg CR-10 Rating	571	4.73	2.16	0.0 – 10.0
Borg-years	570	38.40	34.73	0.0 – 250.0
Second Job Exposure Variables				
Workers with Second Job	55	---	---	---
Hours per Week on Second Job (hrs/week)	50	17.34	12.17	1.0 60.0
Years on Second Job (years)	51	5.48	7.33	0.1 – 40.0
Typical Borg rating on Second Job	35	3.77	2.21	0.5 – 8.0
Borg-Hours on Second Job (hrs/week)	32	75.11	76.56	4.0 – 280.0

3.3.2. Physical Exposure Descriptive Statistics – Job Level:

The average 'highest' job performed by a worker had a lifting frequency of 3.78 ± 3.90 lifts per minute; 1.82 ± 2.26 of those lifts were performed with the workers' hands at or below 30 inches from the floor. While performing the average 'highest' job, the workers had their backs bent forward more than 20° 20.30 ± 20.61 percent of the time. The time-weighted average Borg CR-10 rating across the five activity categories (material handling, assembly, paperwork, fork-truck riding, and resting) for the 'highest' job was 3.01 ± 1.60. Of those five individual Borg CR-10 ratings, the average maximum for the 'highest' job was 3.98 ± 1.88. Workers cited an average 'peak task Borg CR-10 rating' for the 'highest' job of 4.68 ± 2.04.

Similarly, the average 'typical' job performed by a worker had a lifting frequency of 3.05 ± 3.58 lifts per minute; 1.46 ± 2.14 of those lifts were performed with the workers' hands at or below 30 inches from the floor. While performing the average 'typical' job, the workers had their backs bend forward more than 20° 18.16 ± 19.36 percent of the time. The time weighted average Borg CR-10 rating across the five activity categories (material handling, assembly, paperwork, fork-truck riding, and resting) for the 'typical' job was 2.68 ± 1.50. Of those five individual Borg CR-10 ratings, the average maximum

for the 'typical' job was 3.68 ± 1.80. Workers cited an average 'peak task Borg CR-10 rating' for the 'typical' job of 4.38 ± 2.00.

Table 3.11: Baseline Descriptive Statistics for Individual Jobs Performed by Participating Workers. Jobs are Segregated by 'Highest' and 'Typical' Job Performed.

Variable	N	Mean	Std. Deviation	Range
'Highest' Job Variables				
Lifting Frequency (lifts/min)	594	3.78	3.90	0.0 - 35.7
Lifting Frequency for Lifts ≤ 30"	495	1.82	2.26	0.0 – 15.0
% of Time Spent Back bent > 20°	518	20.30	20.61	0.0 – 92.0
TWA Borg CR-10	511	3.01	1.60	0.0 - 8.5
Peak Activity Rating (Borg CR-10)	549	3.98	1.88	0.0 – 10.0
Peak Task Rating (Borg CR-10)	536	4.68	2.04	0.0 – 10.0
'Typical' Job Variables				
Lifting Frequency (lifts/min)	594	3.05	3.58	0.0 - 26.5
Lifting Frequency for Lifts ≤ 30"	461	1.46	2.14	0.0 – 15.0
% of Time Spent Back bent > 20°	497	18.16	19.36	0.0 – 92.0
TWA Borg CR-10	498	2.68	1.50	0.0 - 8.5
Peak Activity Rating (Borg CR-10)	544	3.68	1.80	0.0 – 10.0
Peak Task Rating (Borg CR-10)	532	4.38	2.00	0.0 – 10.0

Revised NIOSH Lifting Equation:

The Revised NIOSH Lifting Equation composite lifting index for the average 'highest' job was 3.58 ± 5.04. When only lifts performed with the hands at or below 30 inches vertically from the floor were considered, the lifting index for the average 'highest' job was 2.64 ± 2.60. For the average 'typical' job the lifting index was 3.26 ± 5.08. When only lifts performed with hands at or below 30 inches vertically from the floor were considered, the lifting index for the average 'typical' job was 2.52 ± 2.71.

Table 3.12: Revised NIOSH Lifting Equation Based Baseline Descriptive Statistics for Individual Jobs Performed by Participating Workers. Jobs are Segregated by 'Highest' and 'Typical' Job Performed.

Variable	N	Mean	Std. Deviation	Range
'Highest' Job Variables				
CLI	594	3.58	5.04	0.25 – 57.00
CLI for Lifts/Lowers ≤ 30"	495	2.64	2.60	0.25 - 33.90
'Typical' Job Variables				
CLI	594	3.26	5.08	0.25 – 57.00
CLI for Lifts/Lowers ≤ 30"	461	2.52	2.71	0.25 - 33.90

Biomechanical Measures:

For the average 'highest' job performed by the workers, the maximum L_5S_1 disc compressive force was 759 ± 277 lbs. When only lift/lower tasks were considered, the average maximum compressive force for the 'highest' job was 746 ± 279 lbs. The average maximum compressive force multiplied by the number of lifts per minute for the 'highest' job was $2,039 \pm 2,186$. The average compressive force per exertion was 515 ± 190 lbs. The average cumulative compressive force per minute for the 'highest' job was $2,319 \pm 2,252$ lb-sec.

The average maximum flexion/extension moment measured from the L_5S_1 disc for the 'highest' job performed by the workers was $1,763 \pm 732$ in-lbs. The average 'highest' maximum flexion/extension moment measure from the L_5S_1 for tasks with the hands at or below 30 inches from the floor was $1,503 \pm 873$ in-lbs. The average total moment per minute for all tasks performed in the 'highest' job was $2,980 \pm 3,130$ in-lbs-seconds. The average minimum percent cable for the 'highest' job was 46.23 ± 34.89 percent.

For the average 'typical' job performed by the workers, the maximum L_5S_1 disc compressive force was 702 ± 270 lbs. When only lift/lower tasks were considered, the average maximum compressive force for the 'typical' job was 681 ± 280 lbs. The average maximum compressive force multiplied by the number of lifts per minute for the 'typical' job was $1,631 \pm 2,181$. The average compressive force per exertion was 481 ± 185 lbs. The average cumulative compressive force per minute for the 'typical' job was $1,599 \pm 1,810$ lb-sec.

The average 'typical' maximum flexion/extension moment measured from the L_5S_1 was $1,626 \pm 721$ in-lbs. The average 'typical' maximum flexion/extension moment measured from the L_5S_1 for tasks with the hands at or below 30 inches from the floor was $1,255 \pm 938$ in-lbs. The average total moment per minute for all tasks performed in the 'typical' job was $2,371 \pm 3,128$ in-lbs-seconds. The average minimum percent cable for the 'typical' job was 53.52 ± 35.25 percent.

Table 3.13: Biomechanical Baseline Descriptive Statistics for Individual Jobs Performed by Participating Workers. Jobs are segregated by 'Highest' and 'Typical' Job Performed.

Variable	N	Mean	Std. Deviation	Range
'Highest' Job Variables				
Max. Compressive Force (lbs)	557	759.22	277.58	50.0 – 1655.0
Max. Comp. Force x Frequency ($CF_{max}*F$) (lbs/min)	557	2,039.49	2,185.86	0.8 – 14,672.9
Average Compressive Force/Exertion (lbs/exertion)	557	515.39	189.78	49.0 – 1,450.9
Cumulative Compressive Force/min (lbs-sec/min)	557	2,319.30	2,252.41	0.0 – 17,084.1
Max. Flexion/Extension Moment (in-lbs)	557	1,763.91	732.21	6.1 – 3,690.0
Cumulative Flexion/Extension Moment (in-lbs-sec./min)	557	2,980.76	3,129.56	0.6 – 18,979.1
Minimum % Capable Population (%)	557	46.23	34.89	0 – 99
'Typical' Job Variables				
Max. Compressive Force (lbs)	557	701.86	269.53	50.0 – 1,655.0
Max. Comp. Force x Frequency ($CF_{max}*F$) (lbs/min)	557	1,630.87	2,180.87	0.8 – 14,672.9
Average Compressive Force/Exertion (lbs/exertion)	557	481.27	185.02	49.0 – 1,450.9
Cumulative Compressive Force/min (lbs-sec/min)	557	1,598.65	1,809.71	0.0 – 12,280.7
Max. Flexion/Extension Moment (in-lbs)	557	1,625.96	720.65	6.1 – 3,690.0
Cumulative Flexion/Extension Moment (in-lbs-sec./min)	557	2,371.25	3,127.52	0.6 – 18,979.1
Minimum % Capable Population (%)	557	53.52	35.25	0 – 99

3.4 Incidence Analyses:

Univariate comparisons were made between any LBP incident cases, as defined in chapter 2, and non-physical variables in order to identify relevant covariates. The hypothesis regarding the role of job physical risk factors were assessed using unadjusted and adjusted Cox regression models.

3.4.1 Incidence Rates:

Incidence rates for any LBP, LBP ≥ 3, LBP with light/modified duty, LBP with lost workdays and LBP with medication are summarized in Table 3.14. For any LBP (LBP ≥ 1) 148 participants (24.3%) out of 610 were ineligible to become a case because they never had a pain-free period that lasted 90 days or more. Out of 462 workers that were eligible, there were 182 incident cases of any LBP. The incidence rate for any LBP was 43.1 per 100 person-years. The incidence rates (per 100 person-years) for other LBP

outcomes were: 39.3 for LBP ≥ 3, 3.3 for LBP with light/modified duty and 4.4 for LBP with lost workdays.

Table 3.14: Incident Cases of LBP (First Event, Follow-Up Data, n = 610)

No.	LBP Outcome	Ineligible		Total eligible to become an incidence case	Eligible Cases		Incidence Rate* (per 100 person-years)
		n	%		n	%	
1.	LBP > 1	148	24.3	462	182	39.4	43.1
2.	LBP > 3	148	24.3	462	169	36.6	39.3
3.	LBP with modified duty	23	3.8	587	36	6.1	3.3
4.	LBP with lost workdays	23	3.8	587	42	7.2	4.4

* Incidence Rate - Number of cases per 100 person-years from those who were eligible to become a case

3.4.2   Univariate Hazard Ratios for Non-Physical Factors:

Demographic Variables:
Univariate hazard ratios for demographic variables are given in Table 3.15. There was no evidence of association ($p ≥ 0.2$) between incident cases of any LBP and age, gender, height, body weight, BMI, race, education level smoking (pack-years) (Table 3.15). There was evidence of potential association between incident cases of any LBP and time to commute to work one way (HR = 1.01/minute, $p ≤ 0.09$) and total miles traveled per day (HR = 1.01/mile, $p ≤ 0.06$). Anthropometric measurements, such as maximum trunk flexion and chest, hip or waist circumferences, showed no evidence of association with incidence cases of any LBP.

Figure 3.7 shows frequency distributions for cases and non-cases by age categories. Visually, it appears that the risk of any LBP may be lower in 40-44 year age group and higher among 45-49 year age group and those above 55 years of age. Figure 3.8 shows frequency distribution of cases and non-cases according to BMI categories. The underweight group appears to be at increased risk (HR = 2.14; 95% CI = 0.84 – 5.45); however, there were only 25 eligible participants in this group.

54

Table 3.15: Univariate Hazard Ratios for Demographic Variables (Any Low Back Pain Incidence Cases)

No.	Variable	Total Eligible N	Cases n	Cases %	Hazard Ratio	95% Confidence Interval	p-value
1.	Gender						
	Male	302	125	41.39	1.00	-	-
	Female	160	57	35.63	0.84	0.61-1.15	0.27
2.	Age (Years)						
	Non-Cases $\overline{X}$ = 38.4 ± 11.96 (18.5 – 61.3)						
	Cases $\overline{X}$ = 38.4 ± 11.96 (18.5 – 61.3)	462	182	39.39	1.00	0.99-1.01	0.97
3.	Height (cm)						
	Non-Cases $\overline{X}$ = 38.4 ± 9.8 (143 – 195)						
	Cases $\overline{X}$ = 170.2 ± 10.1 (148 - 201)	462	182	39.39	1.01	0.99-1.02	0.36
4.	Weight (Kg)						
	Non-Cases $\overline{X}$ = 84.4 ± 20.9 (43.2 – 170)						
	Cases $\overline{X}$ = 84.5 ± 21.2 (48 – 189)	462	182	39.39	1.01	0.99-1.02	0.73
5.	BMI (Kg/m^2)						
	Cases $\overline{X}$ = 28.9 ± 6.0 (18.3 – 54.7)	462	181	39.39	1.00	0.97-1.02	0.88
	Non-Cases $\overline{X}$ = 29.10 ± 6.12 (15.9 – 54.3)						
6.	Race						
	White	240	98	40.83	1.00	-	-
	Hispanic	126	45	35.83	0.84	0.59-1.19	0.33
	Black	53	24	45.28	1.08	0.69-1.69	0.72
	Other	43	15	34.88	0.82	0.48-1.41	0.47
7.	Highest grade in school						
	High school graduate	220	82	37.27	1.00	-	-
	College graduate	33	11	33.33	0.82	0.44-1.54	0.53
	Some college	156	64	41.03	1.19	0.86-1.64	0.31
	Some high school	48	22	45.83	1.35	0.84-2.16	0.21
8.	Total Miles Traveled/day (bus, work & Home - work)						
	Non-Cases $\overline{X}$ = 26.1 ± 24.1 (1 – 160)						
	Cases $\overline{X}$ = 29.40 ± 23.0 (0.4 – 120)	458	179	39.08	1.01	1.00-1.01	0.06
9.	Time to commute to work one way/day						
	Non-Cases $\overline{X}$ = 26.1 ± 24.1 (1 – 160)						
	Cases $\overline{X}$ = 19.1 ± 11.7 (2 - 65)	458	179		1.01	1.01-1.02	0.09
10.	Smoking (Pack-Years)						
	Non-Cases $\overline{X}$ = 4.63 ± 11.0 (0 - 68)						
	Cases $\overline{X}$ = 4.88 ± 9.7 (0 – 44)	178	456		1.00	0.99-1.02	0.68
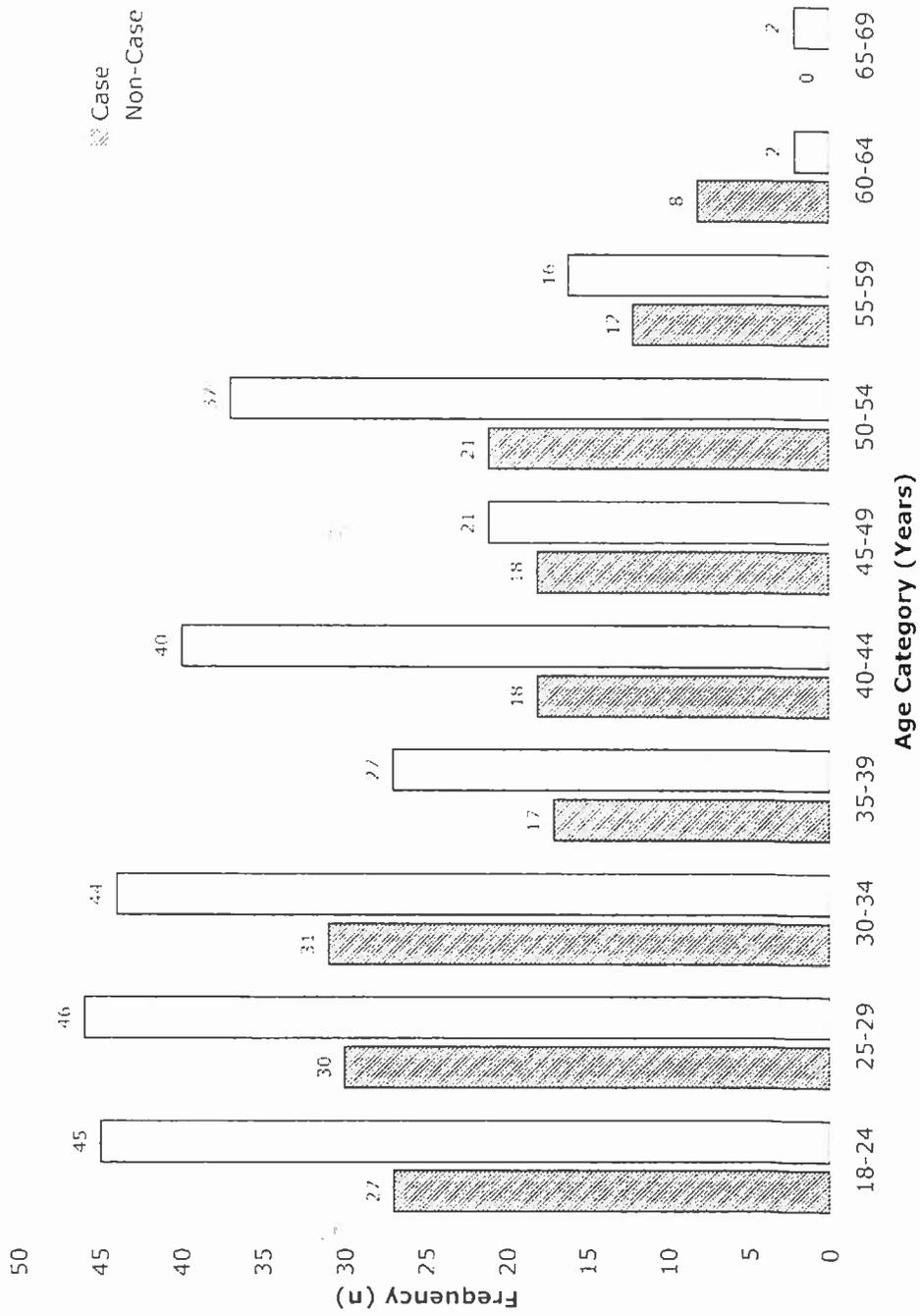
Figure 3.7: Age Frequency Distributions for Cases and Non-Cases
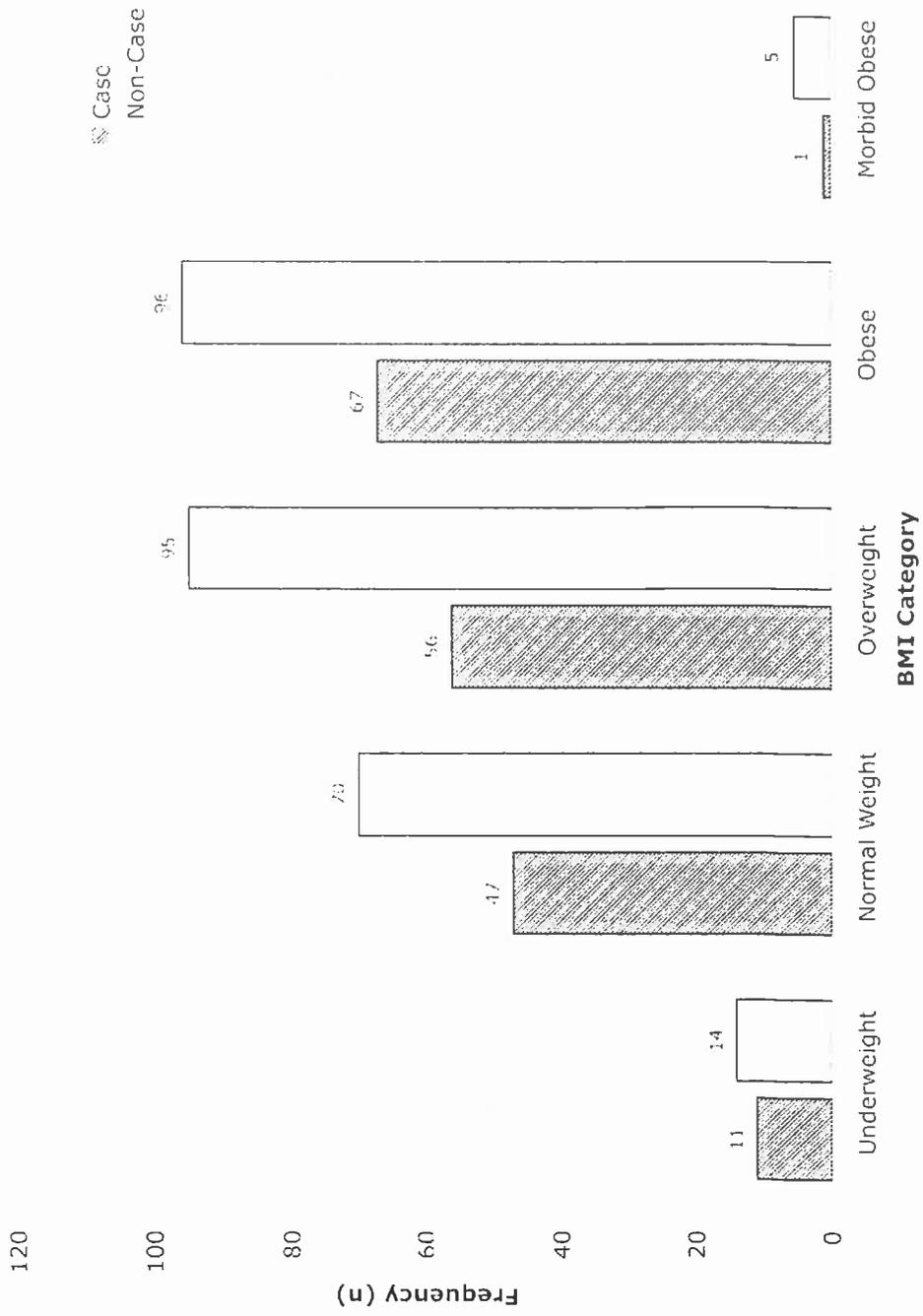
Figure3.8: BMI Frequency Distributions for Cases and Non-Cases

Social Activities:

Univariate hazard ratios for hobbies are given in Table 3.16. There was no evidence of association between incidence cases of any LBP and different hobbies except for the following three hobbies: remodeling (HR = 1.51, p = 0.06), woodworking (HR = 1.45, p = 0.12) and having one or more hobbies (HR = 0.12, p = 0.12). All other hobbies such as housework, gardening, snow shoveling, maintenance work, knitting, fishing, hunting and motorcycle/ATV use had p-values > 0.20.

Univariate hazard ratios for physical exercises are given in Table 3.17. There was no evidence of association between incidence cases of any LBP and different physical exercises. Physical exercises such as walking, running, bicycling, swimming, aerobics, yoga, basketball, baseball, lifting weights all had p > 0.20. The same was true for participation in one or more exercises and minutes spent per week on low impact exercises, high impact exercises, protective exercises and risk exercises.

Psychosocial Factors:

Univariate hazard ratios for the modified APGAR, modified Zung and tense/edge/nervous composite scales are given in Table 3.18. All three scales showed evidence of association with incidence cases of any LBP. The hazard ratio was 1.08 (p ≤ 0.01) for the modified APGAR, 1.07 (p ≤ 0.01) for the modified Zung and 1.10 (p = 0.02) for the composite of tense/edge/nervous. Distributions of cases and non-cases for the modified APGAR, modified Zung and tense/edge/nervous composite scales are shown in Figures 3.9 to 3.11. Both cases and non-cases were skewed towards the lower end of the scale for all three scales.
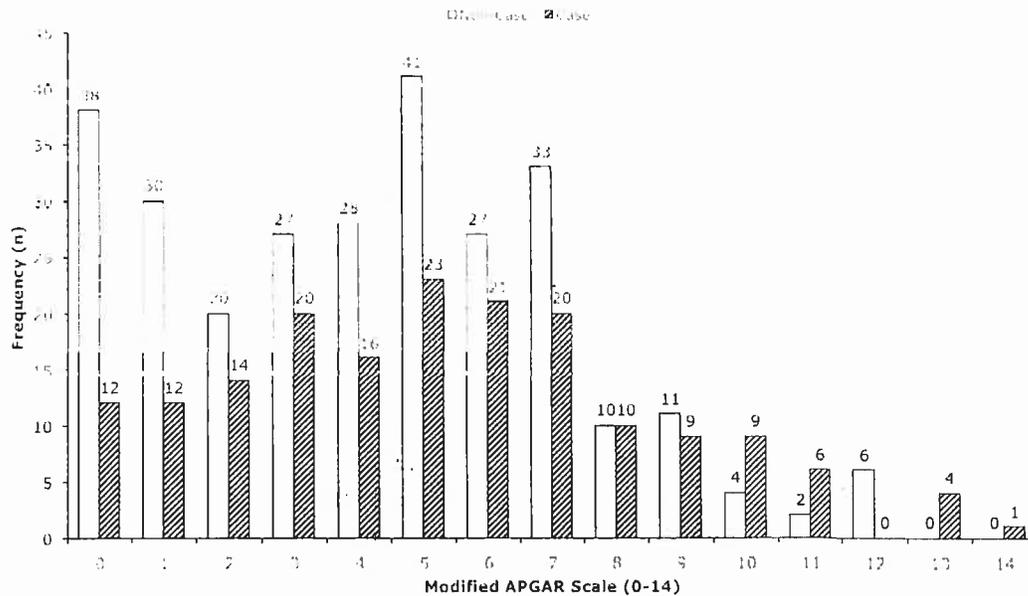
Figure 3.9:   Frequency Distribution of Cases and Non-Cases for Modified APGAR Scale

58
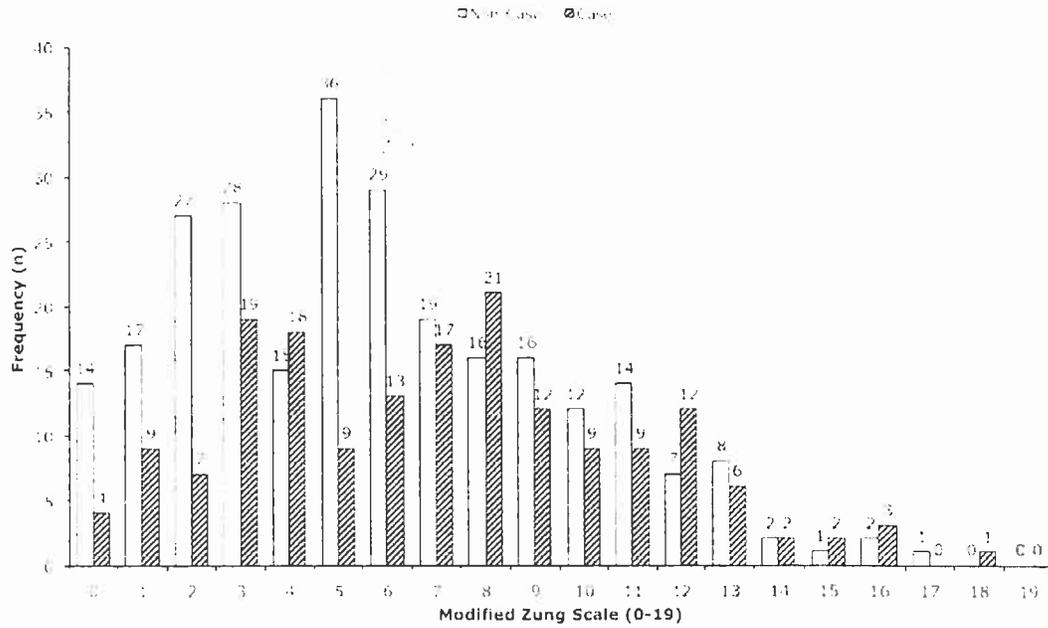
Figure 3.10:   Frequency Distribution of Cases and Non-Cases for Modified Zung Scale
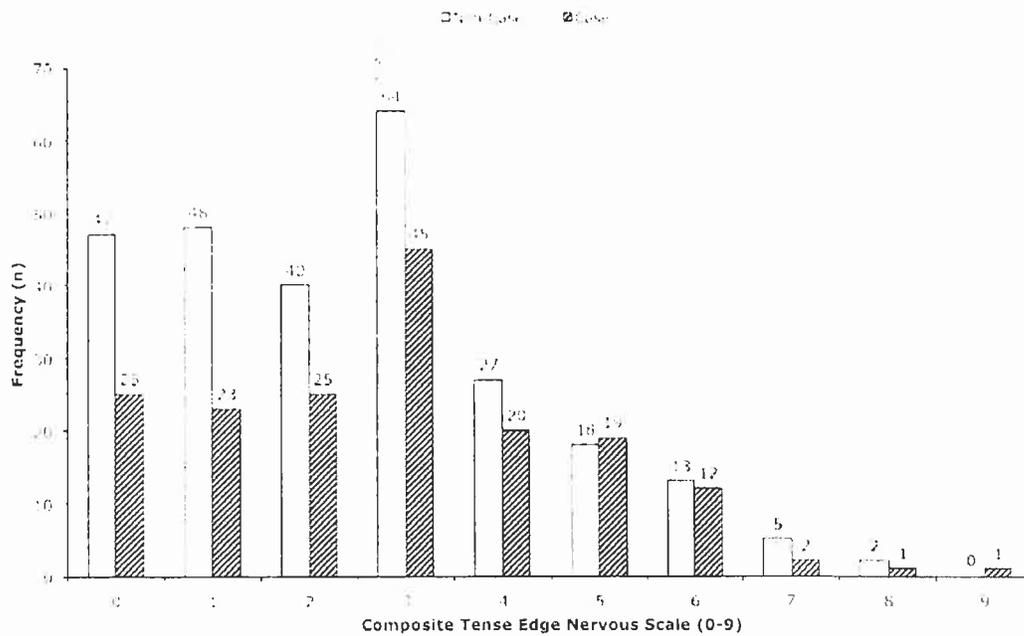
Figure 3.11:   Frequency Distribution of Cases and Non-Cases for Composite
Tense/Edge/Nervous Scale

Univariate hazard ratios for individual psychosocial factors, other than those included in the above three scales, are summarized in Table 3.19. With a few exceptions, there was no evidence that any of the sixteen individual psychosocial factors were associated with incidence cases of any LBP. The two measures of physical and mental fatigue (felt physically and mentally exhausted) showed potential evidence of a trend. Hazard ratios for seldom, often and always categories of 'felt physically exhausted' were 1.22 (p = 0.50), 1.48 (p = 0.14) and 1.67 (p = 0.11), respectively. Hazard ratios for seldom, often and always categories of 'felt mentally exhausted' were 1.33 (p = 0.15), 1.48 (p = 0.15) and 1.82 (p = 0.10), respectively. Similarly, 'felt uneasy' showed a trend. Hazard ratios for seldom, often and always categories of 'felt uneasy' were 1.11 (p = 0.56), 1.40 (p = 0.13) and 2.56 (p = 0.07), respectively. There was evidence that having family problems often (HR = 1.54, p = 0.05), 'felt depressed' often (HR = 2.10, p ≤ 0.01), much control variety of tasks (HR = 0.61, p ≤ 0.04), much control over pace of work (HR = 0.61, p = 0.04) were associated with incidence cases of LBP.

There was no evidence of association between line-paced work and the incidence of any LBP (p = 0.47) (Table 3.19). However, there was evidence of association between piece work and the incidence of any LBP (HR = 1.61, p = 0.03) (Table 3.19).

Table 3.16: Univariate Hazard Ratios for Social Activities – Hobbies (Any LBP Cases)

No.	Hobby	Eligible N	Cases		Hazard Ratio	95% Confidence Interval	p - value
			n	%			
1.	Having one or more hobbies						
	No	70	21	30.00	1.00	-	-
	Yes	392	161	41.07	1.44	0.91 - 2.26	0.12
2.	Housework						
	No	135	48	35.56	1.00	-	-
	Yes	327	134	40.98	1.14	0.82 - 1.59	0.42
3.	Gardening						
	No	257	99	38.52	1.00	-	-
	Yes	205	83	40.49	1.004	0.75 - 1.35	0.98
4.	Shoveling						
	No	248	96	38.71	1.00	-	-
	Yes	214	86	40.19	1.06	0.79 - 1.42	0.71
5.	Maintenance						
	No	351	133	37.89	1.00	-	-
	Yes	111	49	44.14	1.17	0.84 - 1.63	0.34
6.	Knitting						
	No	397	154	38.79	1.00	-	-
	Yes	65	28	43.08	1.15	0.77 - 1.73	0.49
7.	Fishing						
	No	410	164	40.00	1.00	-	-
	Yes	52	18	34.62	0.81	0.50 - 1.31	0.39
8.	Remodeling						
	No	414	158	38.16	1.00	-	-
	Yes	48	24	50.00	1.51	0.98 - 2.32	0.06
9.	Woodworking						
	No	424	162	38.21	1.00	-	-
	Yes	38	20	52.63	1.45	0.91 - 2.31	0.12
10.	Hunting						
	No	428	168	39.25	1.00	-	-
	Yes	34	14	41.18	1.17	0.68 - 2.03	0.57
11.	Motorcycle/ATV						
	No	422	164	38.86	1.00	-	-
	Yes	40	18	45.00	1.30	0.80 - 2.12	0.29

Table 3.17: Univariate Hazard Ratios for Social Activities – Exercises (Any LBP Cases)

No.	Exercise	Eligible N	Cases n	Cases %	Hazard Ratio	95% Confidence Interval	p - value
1.	Participating in one or more exercises						
	No	201	77	38.31	1.00	-	-
	Yes	261	105	40.23	1.01	0.76 - 1.36	0.93
2.	Walking						
	No	195	78	40.00	1.00	-	-
	Yes	267	104	38.95	0.89	0.66 - 1.19	0.44
3.	Lifting Weights						
	No	366	139	37.98	1.00	-	-
	Yes	96	43	44.79	1.19	0.85 - 1.68	0.31
4.	Basketball						
	No	391	154	39.39	1.00	-	-
	Yes	71	28	39.44	0.98	0.65 - 1.46	0.91
5.	Running						
	No	392	153	39.03	1.00	-	-
	Yes	70	29	41.43	1.11	0.75 - 1.66	0.59
6.	Bicycling						
	No	386	152	39.38	1.00	-	-
	Yes	76	30	39.47	1.09	0.74 - 1.62	0.65
7.	Swimming						
	No	430	170	39.53	1.00	-	-
	Yes	32	12	37.50	0.90	0.50 - 1.62	0.72
8.	Aerobics						
	No	437	170	38.90	1.00	-	-
	Yes	25	12	48.00	1.40	0.78 - 2.52	0.26
9.	Baseball						
	No	440	172	39.09	1.00	-	-
	Yes	22	10	45.45	1.08	0.57 - 2.05	0.81
10.	Yoga						
	No	443	176	39.73	1.00	-	-
	Yes	19	6	31.58	0.76	0.34 - 1.72	0.51
11.	Low Impact Exercises (min/week)						
	Non-Cases $X = 126.0 \pm 285.7$ (0 - 3443)						
	Cases $\quad X = 121.9 \pm 211.7$ (0 - 1995)	462	182	39.39	1.00	0.999 - 1.001	0.53

Table 3.17: Univariate Hazard Ratios for Social Activities – Exercises (Any LBP Cases) (Contd.)

No.	Exercise	Eligible N	Cases n	Cases %	Hazard Ratio	95% Confidence Interval	p - value
12.	High Impact Exercises (min/week)						
	Non-Cases $X = 34.1 \pm 147.0$ (0 - 1985)						
	Cases $X = 40.6 \pm 107.8$ (0 - 700.8)	462	182	39.39	1.00	0.999 - 1.001	0.63
13.	Protective Exercises (min/week)						
	Non-Cases $X = 126.0 \pm 285.7$ (0 - 3443)						
	Cases $X = 126.4 \pm 255.7$ (0 - 2372)	462	182	39.39	1.00	1.000 - 1.001	0.85
14.	Risk Exercises (min/week)						
	Non-Cases $X = 74.4 \pm 159.0$ (0 - 1138.7)						
	Cases $X = 62.5 \pm 116.3$ (0 - 583.5)	462	182	39.39	1.00	0.998 - 1.001	0.40

Table 3.18: Univariate Hazard Ratios for Modified APGAR, Modified Zung, and Tense, Edge, Nervous Conposite Scales (for Any LBP Cases)

No.	Psychosocial Scale	Total Eligible N	Cases					Non-Cases					Hazard Ratio	95% Confidence Interval	p-value
			n	%	Mode	Median	Range	n	%	Mode	Median	Range			
1.	Modified APGAR	454	177	38.99	5	5	0-14	277	61.01	5	4	0-12	1.08	1.03-1.13	<0.01
2.	Modified Zung	437	173	39.59	8	7	0-18	264	60.41	5	5	0-17	1.07	1.03-1.11	<0.01
3.	Composite Tense, Edge, Nervous	437	173	39.59	3	3	0-9	264	60.41	3	2	0-8	1.10	1.02-1.19	0.02

Table 3.19: Univariate Hazard Ratios for Individual Psychosocial Factors (Any LBP Cases)

No.	Psychosocial Factors	Eligible N	Cases		Hazard Ratio	95% Confidence Interval	p-value
			n	%			
1.	Able to control the short brake						
	Very much	45	14	31.11	1.00	-	-
	Much	88	33	37.50	1.18	0.631-2.203	0.61
	Moderate amount	91	34	37.36	1.08	0.579-2.012	0.81
	A little	92	43	46.74	1.53	0.836-2.794	0.17
	Very little	121	48	39.67	1.27	0.700-2.304	0.43
2.	Able to control the order of tasks						
	Very much	69	33	47.83	1.00	-	-
	Much	116	42	36.21	0.77	0.490-1.221	0.27
	Moderate amount	120	45	37.50	0.73	0.462-1.136	0.16
	A little	65	32	49.23	1.14	0.701-1.856	0.60
	Very little	67	20	29.85	0.61	0.351-1.066	0.08
3.	Able to control over the variety of tasks you perform						
	Very much	73	34	46.58	1.00	-	-
	Much	109	34	31.19	0.61	0.380-0.985	0.04
	Moderate amount	145	59	40.69	0.83	0.541-1.259	0.37
	A little	65	32	49.23	1.11	0.690-1.814	0.65
	Very little	63	19	30.16	0.66	0.377-1.159	0.15
4.	Job Pace						
	Self Paced	200	77	38.50	1.00	-	-
	Line Paced	138	49	35.50	0.88	0.61-1.25	0.47
	Piece Work	55	27	49.10	1.61	1.04-2.51	0.03
5.	Able to control the pace of work						
	Very much	86	38	44.19	1.00	-	-
	Much	114	36	31.58	0.61	0.389-0.968	0.04
	Moderate amount	116	47	40.52	0.85	0.556-1.307	0.46
	A little	70	28	40.00	0.78	0.480-1.274	0.32
	Very little	68	28	41.18	0.83	0.508-1.350	0.45
6.	Job requires working very fast						
	Agree	230	89	38.70	1.00	-	-
	Strongly disagree	7	3	42.86	1.36	0.429-4.287	0.60
	Disagree	61	26	42.62	1.20	0.773-1,853	0.42
	Strongly agree	140	55	39.29	1.02	0.727-1.425	0.92
7.	Requires physically working hard						
	Strongly disagree	7	2	28.57	1.00	-	-
	Disagree	91	37	40.66	1.17	0.282-4.851	0.83
	Neither agree nor disagree	2	1	50.00	1.32	0.12-14.61	0.82
	Agree	226	92	40.71	1.13	0.278-4.583	0.87
	Strongly agree	129	46	35.66	1.01	0.246-4.170	0.99

Table 3.19: Univariate Hazard Ratios for Individual Psychosocial Factors (Any LBP Cases) (Contd.)

No.	Psychosocial Factors	Eligible N	Cases		Hazard Ratio	95% Confidence Interval	p-value
			n	%			
8.	Free of conflicting demands that others make						
	Strongly agree	51	16	31.37	1.00	-	-
	Agree	250	101	40.40	1.34	0.791-2.271	0.28
	Disagree	122	51	41.80	1.43	0.813-2.499	0.22
	Strongly disagree	15	5	33.33	1.12	0.409-3.046	0.83
9.	Felt Physically Exhausted						
	Never	60	19	31.67	1.00	-	-
	Seldom	74	28	37.84	1.22	0.682-2.189	0.50
	Often	144	58	40.28	1.48	0.883-2.493	0.14
	Always	44	19	43.18	1.67	0.884-3.159	0.11
10.	Felt Mentally Exhausted						
	Never	108	35	32.41	1.00	-	-
	Seldom	267	110	41.20	1.33	0.906-1.939	0.15
	Often	59	23	38.98	1.48	0.872-2.500	0.15
	Always	21	10	47.62	1.82	0.899-3.667	0.10
11.	Job Satisfaction						
	Very Satisfied	139	50	35.97	1.00	-	-
	Satisfied	11	5	45.45	1.26	0.501-3.154	0.63
	Somewhat satisfied	284	117	41.20	1.24	0.892-1.731	0.20
	Not at all satisfied	21	6	28.57	0.76	0.324-1.760	0.52
12	Felt Depressed						
	Never	175	57	32.57	1.00	-	-
	Seldom	214	85	39.72	1.32	0.947-1.852	0.10
	Often	58	34	58.62	2.10	1.371-3.213	0.01
	Always	8	2	25.00	0.84	0.204-3.423	0.80
13	Felt Uneasy						
	Never	140	49	35.00	1.00	-	-
	Seldom	220	86	39.09	1.11	0.782-1.577	0.56
	Often	73	35	47.95	1.40	0.908-2.162	0.13
	Always	7	4	57.14	2.56	0.921-7.087	0.07
14	Have Family Problems						
	Never	151	56	37.09	1.00	-	-
	Seldom	231	87	37.66	1.00	0.715-1.401	1.00
	Often	62	32	51.61	1.54	0.998-2.381	0.05
	Always	13	4	30.77	1.04	0.376-2.860	0.94

* Not enough data to converge

66

Table 3.19: Univariate Hazard Ratios for Individual Psychosocial Factors (Any LBP Cases) (Contd.)

No.	Psychosocial Factors	Eligible N	Cases		Hazard Ratio	95% Confidence Interval	p-value
			n	%			
15.	Restless Sleep						
	Never	115	41	35.65	1.00	-	-
	Seldom	208	83	39.9	1.18	0.811-1.715	0.39
	Often	99	41	41.41	1.42	0.919-2.187	0.11
	Always	17	8	47.06	1.47	0.691-3.145	0.32
16.	Recoded Sleep Hours/day						
	Sleep 8-10 hours	46	17	36.96	1.00	-	-
	Sleep 7-7.5 hours	99	40	40.4	1.21	0.688-2.143	0.50
	Sleep 6-6.5 hours	161	62	38.51	1.06	0.619-1.811	0.83
	Sleep 2-5.5 hours	129	51	39.53	1.10	0.636-1.908	0.73

LBP History:

Univariate hazard ratios for measures of LBP history are given in Table 3.20. Eleven out of twelve measures of LBP history listed in Table 3.20 showed evidence of association with incident cases of any LBP. The only exception was duration of most recent continuous pain.

Number of separate lost- time episodes (> 3, HR = 2.63, $p \le 0.01$), pinched nerve/sciatica (HR = 2.48, $p \le 0.01$), changed job because of LBP (HR = 2.23, p = 0.02), missed work because of LBP (HR = 2.19, $p \le 0.01$), ever been on light/modified duty (HR = 2.07, $p \le 0.01$), saw a healthcare provider (HR = 2.07, $p \le 0.01$) and ever used medicine to treat LBP (HR = 2.03, $p \le 0.01$) showed the strongest evidence of association with any LBP incident cases. Ever received workers compensation for back injuries and any injuries had HR = 1.98 ($p \le 0.01$) and 1.61 ($p \le 0.01$), respectively. A continuous duration of longest LBP ever lasting at least 7 days had a HR of 1.82 (p = 0.03). Diagnosis of LBP strain/sprain by a healthcare provider had a HR of 1.78 ($p \le 01$).

Medical History-Other than LBP:

Univariate hazard ratios for relevant medical history variables are given in Table 3.21. There was some evidence of association between hernia and any LBP (HR = 1.41, p = 0.14). There was no evidence of association between diabetes, a thyroid condition, high blood pressure, high cholesterol or broken bone and incident cases of any LBP ($p \ge 0.20$). Other medical history variables, such as diagnosis of scoliosis, Heberden's or Bouchard's nodes, inflammatory arthropathy, osteoporosis, chronic fatigue, irritable bowel syndrome, fibromyalgia, myofascial pain syndrome, gout and kidney failure had too few cases to be considered as possible risk factors.

Physical Examination Variables:

Univariate hazard ratios for relevant physical examination variables are given in Table 3.22. There was no evidence of association between straight leg raise test, patellar reflex, Achilles reflex and SI joint test and incident cases of any LBP ($p \ge 0.40$). Signs of rheumatoid arthritis on physical examination showed evidence of association (HR=6.0, 95% CI 1.45-25.0) but the number of cases was considered too small for practical relevance.

68

Table 3.20: Univariate Hazard Ratios for Low Back Pain History Variables (Any Low Back Pain Incidence Case)

No.	LBP History	Total N	Cases		Hazard Ratio	95% Confidence Interval	p-value
			n	%			
1.	Missed work because of low back pain						
	No	418	157	37.56	1.00	-	-
	Yes	44	25	56.82	2.19	1.432-3.342	<0.01
2.	Ever been on the light duty						
	No	417	158	37.89	1.00	-	-
	Yes	45	24	53.33	2.07	1.343-3.185	<0.01
3.	Received worker compensation for a back related injury						
	No	437	168	38.44	1.00	-	-
	Yes	25	14	56.00	1.98	1.146-3.423	0.01
4.	Ever received work compensation due to work related injury for the back or other part of the body						
	No	388	143	36.86	1.00	-	-
	Yes	74	39	52.70	1.61	1.131-2.299	0.01
5.	Changed job because of LBP						
	No	448	173	38.62	1.00	-	-
	Yes	19	9	64.29	2.23	1.141-4.363	0.02
6.	Duration of single longest continuous LBP ever (days)						
	0	179	53	29.61	1.00	-	-
	1 to 2	161	75	46.58	1.67	1.176-2.377	<0.01
	3 to 6	66	30	45.45	1.68	1.075-2.634	0.02
	> 7 Days	46	19	41.30	1.82	1.074-3.067	0.03
7.	Duration of most recent continuous LBP (Days)						
	0	51	20	39.22	1.00	-	-
	1 to 2	145	66	45.52	1.25	0.760-2.067	0.38
	3 to 6	52	26	50.00	1.51	0.840-2.697	0.17
	> 7 Days	26	12	46.15	1.46	0.711-2.978	0.30

Table 3.20: Univariate Hazard Ratios for Low Back Pain History Variables (Any Low Back Pain Incidence Case) (Contd.)

No.	LBP History	Total N	Cases		Hazard Ratio	95% Confidence Interval	p-value
			n	%			
8.	Pinched Nerve/Sciatica (Told by a healthcare Professional)						
	No	434	165	38.02	1.00	-	-
	Yes	28	17	60.71	2.48	1.499-4.085	<0.01
9.	LB Strain/sprain (ever told by a healthcare professional)						
	No	376	135	35.90	1.00	-	-
	Yes	86	47	54.65	1.78	1.276-2.482	<0.01
10.	Ever used any medicine to treat LBP						
	No	342	117	34.21	1.00	-	-
	Yes	120	65	54.17	2.03	1.499-2.757	<0.01
11.	Saw a healthcare professional for LBP						
	No	331	110	33.23	1.00	-	-
	Yes	131	72	54.96	2.07	1.533-2.783	<0.01
12.	Number of separate lost time episodes due to LBP						
	0	399	145	36.34	1.00	-	-
	1 to 3	50	28	56.00	2.02	1.347-3.032	<0.01
	> 3	13	9	69.23	2.63	1.338-5.155	0.01

Table 3.21: Univariate Hazard Ratios for Medical History Variables (Any Low Back Pain Incidence Case)

No.	Health Condition	Total Eligible N	Cases n	Cases %	Hazard Ratio	95% Confidence Interval	p - value
1.	Diabetes (told by a physician)						
	No	441	176	39.91	1.00	-	-
	Yes	21	6	28.57	0.64	0.28 - 1.44	0.28
2.	Thyroid (told by a physician)						
	No	441	173	39.23	1.00	-	-
	Yes	21	9	42.86	1.29	0.66 - 2.51	0.46
3.	High blood pressure (either told by a physician and/or had at enrollment)						
	No	304	121	39.80	1.00	-	-
	Yes	146	58	39.73	1.02	0.74 - 1.39	0.92
4.	High cholesterol (told by a physician)						
	No	391	149	38.11	1.00	-	-
	Yes	71	33	46.48	1.27	0.87 - 1.85	0.21
5.	Hernia (told by a physician)						
	No	421	161	38.24	1.00	-	-
	Yes	41	21	51.22	1.41	0.89 - 2.22	0.14
6.	Broken bone (told by a physician)						
	No	103	43	41.75	1.00	-	-
	Yes	359	139	38.72	1.23	0.87 - 1.73	0.24

Table 3.22: Univariate Hazard Ratios for Physical Examination Variables

No.	Physical Exam	Eligible N	Cases n	Cases %	Hazard Ratio	95% Confidence Interval	p-value
1.	Raise right leg straight test						
	Negative	187	77	41.18	1.00	-	-
	Positive	3	2	66.67	1.49	0.21 - 10.65	0.69
2.	Raise left leg straight test						
	Negative	188	78	41.49	1.00	-	-
	Positive	2	1	50.00	1.81	0.45 - 7.28	0.41
3.	Right patellar reflex (grade)						
	0 (Absent)	13	5	38.46	0.82	0.34 - 2.01	0.67
	1	80	33	41.25	1.05	0.72-1.54	0.80
	2 (Normal)	345	134	38.84	1.00	-	-
	3	19	9	47.37	1.11	0.57-2.18	0.75
	4 (Hyperactive with clonus)	4	1	25.00	0.51	0.07-3.64	0.50
4.	Left patellar reflex (grade)						
	0 (Absent)	12	5	41.67	0.96	0.39-2.34	0.92
	1	77	32	41.56	1.04	0.71-1.53	0.85
	2 (Normal)	333	131	39.34	1.00	-	-
	3	22	10	45.45	1.02	0.54-1.94	0.95
	4 (Hyperactive with clonus)	4	1	25.00	0.51	0.07-3.62	0.50
5.	Right Achilles reflex (grade)						
	0 (Absent)	26	11	38.46	1.14	0.62-2.11	0.68
	1	93	39	41.25	1.08	0.75-1.54	0.68
	2 (Normal)	334	130	38.84	1.00	-	-
	3	5	2	47.37	1.04	0.26-41.2	0.96
	4 (Hyperactive with clonus)	2	0	25.00	*	*	0.98
6.	Left Achilles reflex (grade)						
	0 (Absent)	22	10	38.46	1.14	0.60-2.18	0.68
	1	97	39	41.25	1.01	0.71-1.45	0.94
	2 (Normal)	319	128	38.84	1.00	-	-
	3	7	2	47.37	0.62	0.15-2.49	0.49
	4 (Hyperactive with clonus)	2	0	25.00	*	*	0.98
7.	Right SI joint test						
	Negative	448	176	39.29	1.00	-	-
	Positive	14	6	42.86	1.04	0.46-2.34	0.92
8.	Left SI joint test						
	Negative	448	176	39.29	1.00	-	-
	Positive	14	6	42.86	1.04	0.46-2.34	0.92

* Insufficient data

3.4.3 Hazard ratios for Job Physical Exposure Measures:

As described in section 3.3, pre-selected job physical exposure measures were divided into three categories: (i) workers' previous employment exposure history (prior job exposure), (ii) workers' exposure from secondary employment (second job exposure), and (iii) workers' exposure from current employment exposure (current exposure). The worker's current employment was further divided into two sub-categories: (i) exposure at the worker level, and exposure at the job level.

Univariate hazard ratios were determined for several pre-selected job physical exposure measures. First, job physical exposure measures were analyzed treating them as continuous variables. Those job physical exposure measures that have established guidelines in literature, such as compressive force ≤ 770 lbs and Lifting Index $\leq 1, >1$ to ≤ 3, and >3 were also analyzed as categorical measures based on their published guidelines. In addition, those job physical exposure measures that: (i) showed suggestive statistical association with incidence of any LBP ($p \leq 0.20$) when they were analyzed as continuous variables, or (ii) when cases and non-cases were plotted against the physical exposure measure and presented visual evidence suggestive of a trend with incident cases of LBP; were analyzed using categories of exposure measurement values.

Adjusted hazard ratios were determined for those continuous and categorical job physical exposure measures that showed evidence of association with incident cases of any LBP ($p \leq 0.20$). Adjusted hazard ratios were also determined for a few job physical exposure measures that have traditionally been used to describe job physical exposure, even though their p-value might have been greater than 0.20. The adjusted model included age, BMI, gender, psychosocial factors (composite APGAR), and past history of any low back pain (one or more episodes of low back pain lasting one or more days) as covariates.

Prior Work History:

When analyzed as continuous variables, there was no evidence of association between peak Borg CR-10 rating from the workers' prior work history or from prior work experience expressed in total Borg-Years and incident cases of any LBP ($p = 0.57$) (Table 3.23). When cases and non-cases were plotted, peak Borg CR-10 rating from the workers' past work history appeared to show a relationship with incident cases of any LBP and was, therefore, categorized (Table 3.25). Categorized univariate analysis of peak Borg CR-10 ratings from workers' history showed that for ratings between > 1 to $\leq$ 3 (HR = 2.09, p = 0.09) there was suggestive evidence of association, and for ratings between > 3 to ≤ 7 there was evidence of association with incident cases of any LBP (HR = 2.49, p = 0.03) (Table 3.23). However, ratings of > 7 showed no association with the incidence of any LBP ($p = 0.60$) (Table 3.23). In the adjusted model, peak Borg CR-10 rating between > 1 to ≤ 3 (adjusted HR = 1.79, p = 0.18) and between > 3 to ≤ 7 (adjusted HR = 1.82, p = 0.16) both showed suggestive evidence of association with the incidence of any LBP. Peak Borg ratings > 7 showed no association with incidence of any LBP (p = 0.84) Table (3.25).

Table 3.23: Continuous, Univariate Hazard Ratios for Previous Job Exposure and Second Job Exposure

Variable	n	$\bar{X}$ ($\pm$ SD)	Range	Hazard Ratio	95% C.I.	p-Value
Previous Job Exposure Measures						
Borg-years						
Non-Cases	263	36.2 ($\pm$ 34.29)	0 - 250	1.00	-	-
Cases	171	36.7 ($\pm$ 31.54)	0 - 180	1.000	0.9 - 1.01	0.82
Maximum Borg CR-10 Rating						
Non-Cases	264	4.54 ($\pm$ 2.26)	0 - 10	1.00	-	-
Cases	171	4.57 ($\pm$ 1.91)	0 - 10	1.02	0.95 - 1.09	0.57
Second Job Exposure Measures*						
Years on Second Job (years)						
Non-Cases	278	0.25 ($\pm$ 1.18)	0 - 12	1.00	-	-
Cases	180	0.43 ($\pm$ 2.28)	0 - 25	1.08	1.00 - 1.16	0.04
Hours per Week on Second Job (hrs/week)						
Non-Cases	276	1.04 ($\pm$ 4.45)	0 - 40	1.00	-	-
Cases	181	1.64 ($\pm$ 6.70)	0 - 40	1.01	0.99 - 1.01	0.10
Typical Borg rating on Second Job						
Non-Cases	270	0.16 ($\pm$ 0.85)	0 - 7	1.00	-	-
Cases	174	0.19 ($\pm$ 1.00)	0 - 8	1.02	0.87 - 1.20	0.78
Borg-Hours on Second Job (hrs/week)						
Non-Cases	268	2.24 ($\pm$ 18.46)	0 - 280	1.00	-	-
Cases	173	5.17 ($\pm$ 31.5)	0 - 245	1.000	0.99 - 1.01	0.10

*NOTE: 55 of the 610 workers studied were employed on second jobs. For univariate analyses, all workers *not* working a second job were assigned a value of 0 (zero) for each of these variables.

Table 3.24: Continuous, Adjusted Hazard Ratios for Previous Job Exposure and Second Job Exposure

Variable*	n	$\bar{X}$ ($\pm$ SD)	Range	Hazard Ratio	95% C.I.	p-Value
P_Years on Second Job (years)						
Non-Cases	271	0.26 ($\pm$ 1.20)	0.00-12.00	1.00	-	-
Cases	172	0.35 ($\pm$ 2.14)	0.00-25.00	1.06	0.97 - 1.16	0.22
Hours per Week on Second Job (hrs/week)						
Non-Cases	269	1.07 ($\pm$ 4.51)	0.00-40.00	1.00	-	-
Cases	173	1.31 ($\pm$ 5.79)	0.00-40.00	1.00	0.98 - 1.03	0.78
Typical Borg rating on Second Job						
Non-Cases	263	0.16 ($\pm$ 0.86)	0.00-7.00	1.00	-	-
Cases	166	0.12 ($\pm$ 0.73)	0.00-7.00	1.00	0.99 - 1.01	0.88

*NOTE: 55 of the 610 workers studied were employed on second jobs. For adjusted Hazard Ratio analyses, all workers *not* working a second job were assigned a value of 0 (zero) for each of these variables.

Second Job:
Fifty-five of the 610 participating workers had a second job. Hazard ratios for second job exposure measures were determined by assigning values of 0 (zero) to each physical measure for those workers who did *not* have a second job outside of their participating company.

When treated as continuous variables, years employed on the second job (HR = 1.08, p = 0.04), showed evidence of an association, and hours per week spent working the second job (HR = 1.01, p = 0.10), and Borg-Hours on the second job (HR = 1.001, p = 0.10) showed suggestive evidence of association with incident cases of any LBP. However, typical Borg CR-10 rating for the second job by itself showed no evidence of association with the incidence of any LBP (p = 0.78) (Table 3.23). In the adjusted model, none of these measures showed any significance (p ≥ 0.22) (Table 3.24).

When treated as categorical variables, working more than three years on a second job showed evidence of association with the incidence of any LBP when compared with working between > 0.5 and ≤ 3 years on a second job (HR = 3.82, p = 0.03). However, working less than or equal to 0.5 years on a second job also showed suggestive evidence of association with the incidence of any LBP when compared with > 0.5 to ≤ 3 years working on a second job (HR = 2.01, p = 0.17) (Table 3.26). In the adjusted model, working more than three years showed an association with the incidence of any LBP (adjusted HR = 3.82, p = 0.03). Similarly, working less than or equal to 0.5 years showed suggestive evidence of association with the incidence of any LBP (adjusted HR = 2.01, p = 0.17) (Table 3.26).

When categorized, working more than 20 hours per week on a second job showed an association with incidence of any LBP when compared with working less than or equal to 20 hours per week on a second job (HR = 2.47, p = 0.02) (Table 3.26). In the adjusted model, working more than 20 hours per week showed suggestive evidence of association with the incidence of any LBP (adjusted HR = 1.92, p = 0.16) (Table 3.26).

When categorized, more than 60 Borg-hours of exposure per week on a second job showed an association with the incidence of any LBP when compared with less than or equal to 60 Borg-hours of exposure (HR = 2.757, p = 0.03). In the adjusted model, there was suggestive evidence of association between Borg-hours/week greater than 60 and the incidence of any LBP (adjusted HR = 2.18, p = 0.19) (Table 3.26).

Table 3.25: Categorical Analyses for Participating Workers' Prior Work Exposure

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Peak Borg Rating	*Model:*	*436*	---	---	*0.047*	*422*	---	---	*0.141*
	≤ 1	28	1.000	---	---	28	1.000	---	---
	> 1 - ≤ 3	105	2.089	0.890 – 4.903	0.091	102	1.791	0.757 – 4.236	0.184
	> 3 - ≤ 7	268	2.493	1.097 – 5.669	0.029	259	1.819	0.790 – 4.189	0.160
	> 7	35	1.314	0.468 – 3.692	0.604	33	0.898	0.308 – 2.621	0.844

Table 3.26: Categorical Analyses for Participating Workers' Second Job Exposure

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Years on Second Job (Years)	*Model:*	*459*	---	---	*0.074*	*443*	---	---	*0.194*
	≤ 0.5	428	2.013	0.751 – 5.456	0.167	414	2.013	0.747 – 5.427	0.167
	> 0.5 - ≤ 3.0	17	1.000	---	---	17	1.000	---	---
	> 3	14	3.816	1.153 – 12.725	0.029	12	3.816	1.149 – 12.679	0.029
Hours Worked/Week (hours/week)	*Model:*	*462*	---	---	*0.019*	*446*	---	---	*0.158*
	≤ 20	453	1.000	---	---	439	1.000	---	---
	> 20	9	2.472	1.160 – 5.265	0.019	7	1.918	0.777 – 4.734	0.158
Borg-Hours	*Model:*	*462*	---	---	*0.026*	*446*	---	---	*0.186*
	≤ 60	456	1.000	---	---	442	1.000	---	---
	> 60	6	2.757	1.132 – 6.715	0.026	4	2.178	0.688 – 6.897	0.186

Current Employment - Worker Level:
Typical days worked per week showed suggestive evidence of a protective association with incident cases of any LBP (HR = 0.66, p = 0.10) (Table 3.27). When adjusted for covariates, there was evidence of association between typical days worked per week and incident cases of any LBP (adjusted HR = 0.55, p = 0.03) (Table 3.28). An adjusted hazard ratio of 0.55 showed that the association was protective, i.e. greater number of days worked per week lowered the risk. Maximum days worked per week, typical hours worked per week, and maximum number of hours worked per week showed no evidence of association with incident cases of any LBP (p = 0.33).

When treated as continuous variables, worker Borg CR-10 rating at the beginning of the work shift and worker Borg CR-10 rating for the end of the work shift showed no evidence association with incident cases of LBP (p > 0.23). However, the difference between those ratings (Delta Borg = Borg End – Borg Beginning) did show suggestive evidence of association with any LBP incident cases (HR = 1.06, p = 0.17) (Table 3.27). However, when adjusted for covariates, delta Borg showed no evidence of association with incident cases of any LBP (p = 0.24) (Table 3.28).

When divided into different categories, Borg ratings showed a linear trend up to an increase in rating of 5.0 (Table 3.29). There was suggestive evidence of association between workers' delta Borg ratings between and incident cases of any LBP. Those categories were: > 0 to ≤ 3 (HR = 1.3, p = 0.13), > 3 to ≤ 4 (HR = 1.55, p = 0.17), or > 4 to ≤ 5 (HR = 1.69, p = 0.10) for univariate analysis; and ratings greater than 0 to less than or equal to 3 (adjusted HR = 1.27, p = 0.17) and ratings greater than 4 to less than or equal to 5 (adjusted HR = 1.53, p = 0.19) for adjusted analysis. However, in the adjusted model, there was no evidence of association between delta Borg ratings and incident cases of any LBP for ratings greater than 3 but less than or equal to 4 (p = 0.31) and ratings greater than 5 (p = 0.63) (Table 3.29).

When treated as a continuous variable, the maximum weight handled during the work shift showed suggestive evidence of association with the incidence of any LBP, in univariate analysis (HR = 1.004, p = 0.17) (Table 27), but no evidence in the adjusted analysis (p = 0.34) (Table 3.28). When divided into three categories (≤ 35 lbs, >35 and ≤ 50lbs, >50 lbs), lifting/lowering of maximum weight > 50 lbs showed suggestive evidence of association with the incidence of any LBP, both in univariate analysis (HR = 1.351, p = 0.09) and adjusted analysis (adjusted HR = 1.27, p =0.20) (Table 3.29).

The minimum vertical hand location while handling the maximum weight showed evidence of association with any LBP incident cases, both in univariate and adjusted analysis (adjusted HR = 1.01, p < 0.01) (Tables 3.27 and 3.28). This showed that the risk increased with an increase in vertical location. Therefore, when divided into different vertical heights (≤ 5", > 5 and 27", > 27 and ≤ 32" (reference), >32 and ≤52" and > 52" from floor), minimum vertical location showed suggestive evidence of association with the incidence of any LBP for the category ≤ 5" (HR = 2.04, p = 0.12) and evidence of association for height > 52 " (HR = 2.73, p ≤ 0.01) (Table 3.29). In the adjusted model,

there was suggestive evidence of association for height ≤ 5" LBP (adjusted HR = 2.09 p = 0.11), and evidence of association for height > 52" (adjusted HR = 2.66, p ≤ 0.01) with the incidence of any LBP (Table 3.29).

The maximum horizontal distance of the hands from L_5/S_1 disc when handling the maximum weight showed no evidence of association of with incidence of nay LBP (p = 0.79) (Table 3.27).

Table 3.27: Continuous, Univariate Hazard Ratios for Exposure at the Worker (Position) Level

Variable	n	$\overline{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Duration of Exposure Variables						
Typical Hours/Week (Hours/Week)						
Non-Cases	273	40.33 (± 4.66)	8 - 56	1.00	-	-
Cases	172	40.25 (± 2.46)	29 - 50	0.98	0.95 - 1.02	0.40
Maximum Hours/Week (Hours/Week)						
Non-Cases	273	47.33 (± 8.71)	8 - 82	1.00	-	-
Cases	172	47.07 (± 8.52)	30 - 78	0.99	0.97 - 1.01	0.33
Typical Days/Week (Days/Week)						
Non-Cases	274	5.00 (± 0.39)	3 - 7	1.00	-	-
Cases	171	4.97 (± 0.34)	4 - 7	0.66	0.40 - 1.08	0.10
Maximum Days/Week (Days/Week)						
Non-Cases	274	5.54 (± 0.64)	3 - 7	1.00	-	-
Cases	172	5.56 (± 0.65)	4 - 7	1.000	0.79 - 1.27	1.00
Intensity of Exposure Variables						
Borg CR-10 Rating-Beginning of Shift						
Non-Cases	261	1.95 (± 1.96)	0 - 8	1.00	-	-
Cases	171	1.80 (± 1.67)	0 - 8	1.000	0.92 - 1.09	0.99
Borg CR-10 Rating-End of Shift						
Non-Cases	261	3.29 (± 2.30)	0 - 10	1.00	-	-
Cases	171	3.43 (± 1.91)	0 - 10	1.04	0.97 - 1.12	0.23
Delta Borg						
Non-Cases	261	1.34 (± 1.98)	-8 - 9	1.00	-	-
Cases	171	1.63 (± 1.74)	-3 - 7	1.06	0.98 - 1.14	0.17
Maximum Weight (lbs)						
Non-Cases	277	39.55 (± 26.77)	0.20 - 132	1.00	-	-
Cases	179	42.24 (± 27.37)	1.00 - 132	1.000	0.998 - 1.009	0.17
Maximum Horizontal Distance (in)						
Non-Cases	277	19.38 (± 5.39)	3.65 - 36.00	1.00	-	-
Cases	179	19.59 (± 5.21)	9.00 - 32.5	0.99	0.97 - 1.02	0.79
Minimum Vertical Location (inches)						
Non-Cases	277	29.45 (± 14.27)	-0.5 - 73.7	1.00	-	-
Cases	179	33.73 (± 15.69)	-1.1 - 75	1.01	1.003 - 1.02	0.009

78

Table 3.28: Continuous, Adjusted Hazard Ratios for Exposure at the Worker (Position) Level

Variable	n	$\overline{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Duration of Exposure Variables						
Typical Days/Week (Days/Week)						
Non-Cases	268	5.00 (± 0.39)	3.00-7.00	1.00	-	-
Cases	166	4.96 (± 0.30)	4.00-6.00	0.55	0.33 - 0.93	0.03
Intensity of Exposure Variables						
Delta Borg						
Non-Cases	255	1.33 (± 1.94)	-8.00-9.00	1.00	-	-
Cases	165	1.66 (± 1.74)	-3.00-7.00	1.05	0.97 - 1.14	0.24
Maximum Weight (lbs)						
Non-Cases	270	38.80 (± 25.74)	0.20-132.00	1.00	-	-
Cases	171	41.93 (± 27.74)	1.00-132.00	1.000	0.10 - 1.01	0.34
Minimum Vertical Location (inches)						
Non-Cases	270	29.25 (± 14.17)	-0.50-73.70	1.00	-	-
Cases	171	33.52 (± 15.63)	-1.10-75.00	1.01	1.00 - 1.03	0.007

Table 3.29: Categorical, Univariate Analyses for Participating Workers' Current Job Exposure at the Worker Level

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Delta Borg	*Model:*	*433*	---	---	*0.208*	*420*	---	---	*0.002*
	≤ 0	159	1.000	---	---	152	1.000	---	---
	> 0 - ≤ 3	214	1.299	0.929 – 1.817	0.127	210	1.272	0.899 – 1.799	0.174
	> 3 - ≤ 4	25	1.554	0.832 – 2.903	0.166	24	1.408	0.726 – 2.729	0.311
	> 4 - ≤ 5	24	1.685	0.902 – 3.147	0.102	24	1.537	0.813 – 2.909	0.186
	> 5	11	0.528	0.129 – 2.165	0.375	10	0.705	0.170 – 2.926	0.630
Maximum Weight (lbs)	*Model:*	*457*	---	---	*0.164*	*441*	---	---	*0.331*
	≤ 35	217	1.000	---	---	213	1.000	---	---
	> 35 - ≤ 50	122	0.975	0.680 – 1.397	0.890	117	0.963	0.664 – 1.396	0.843
	>50	118	1.351	0.953 – 1.915	0.091	111	1.273	0.881 – 1.840	0.199
Minimum Vertical Location (inches)	*Model:*	*457*	---	---	*0.010*	*441*	---	---	*0.003*
	≤ 5	13	2.043	0.833 – 5.013	0.119	13	2.088	0.846 – 5.150	0.110
	> 5 - ≤ 27	158	0.980	0.551 – 1.744	0.945	154	0.985	0.554 – 1.751	0.959
	> 27 - ≤ 32	49	1.000	---	---	49	1.000	---	---
	> 32 - ≤ 52	210	1.224	0.702 – 2.135	0.476	200	1.194	0.686 – 2.077	0.531
	> 52	27	2.729	1.367 – 5.448	0.004	25	2.664	1.336 – 5.312	0.005

Job Level - Job Physical Exposure Measures:
When treated as continuous measures, lifting frequencies both for the typical job (HR = 1.03, p = 0.09) and for the highest job (job performed with the highest lifting frequency) (HR = 1.04, p = 0.05) showed evidence of association with the incidence any LBP (Table 3.30). In the adjusted model, lifting frequency for the highest job (adjusted HR = 1.03, p = 0.07) and the typical job (adjusted HR 1.03, p = 0.17) showed suggestive evidence of association with any LBP incidence (Table 3.31).

Lifting frequencies greater than 4 lifts per minutes showed suggestive evidence of association with incident cases of any LBP when compared with lifting frequencies less than or equal to four lifts per minute both for the highest job (HR = 1.32, p = 0.07) and the peak job (HR – 1.34, p = 0.07) (Table 3.30). When adjusted for covariates, lifting frequency greater than 4 lifts/min showed suggestive evidence of association with the incidence of any LBP both for the highest job adjusted HR = 1.32, p = 0.08) and for the typical job (adjusted HR – 1.28, p = 0.15) (Table 3.31).

When treated as continuous variable, lifting frequency for lifts performed at or below 30 inches (workers with no lifts below 30 inches assigned a value of 0 lifts/minute) showed no evidence of association with the incidence of any LBP for both the highest and the peak jobs (p > 0.38) (Table 3.30).

Table 3.30: Continuous Variable, Univariate Hazard Ratios for Highest and Typical Job Worker Exposure

Variable	n	$\overline{X}$ ($\pm$ SD)	Range	Hazard Ratio	95% C.I.	p-value
Highest Job						
Lifting Frequency (lifts/min)						
Non-Cases	275	3.37 ($\pm$ 3.27)	0 - 15.8	1.00	-	-
Cases	177	4.01 ($\pm$ 4.65)	0 - 35.67	1.04	0.10 - 1.07	0.05
Lifting Frequency for Lifts < 30"						
Non-Cases	275	1.44 ($\pm$ 2.11)	0 - 15	1.00	-	-
Cases	177	1.42 ($\pm$ 2.16)	0 - 13.47	1.01	0.95 - 1.08	0.72
% of Time Spent Back bent > 20°						
Non-Cases	238	17.91 ($\pm$ 19.32)	0 - 80	1.00	-	-
Cases	152	20.43 ($\pm$ 20.11)	0 - 92	1.01	0.10 - 1.01	0.12
TWA Borg CR-10						
Non-Cases	240	2.88 ($\pm$ 1.69)	0 - 8.46	1.00	-	-
Cases	148	2.97 ($\pm$ 1.35)	0 - 6.9	1.06	0.96 - 1.17	0.22
Peak Activity Rating (Borg CR-10)						
Non-Cases	258	3.81 ($\pm$ 1.96)	0 - 10	1.00	-	-
Cases	164	3.96 ($\pm$ 1.77)	0 - 10	1.06	0.98 - 1.15	0.16
Peak Task Rating (Borg CR-10)						
Non-Cases	251	4.54 ($\pm$ 2.1)	0 - 10	1.00	-	-
Cases	161	4.53 ($\pm$ 1.93)	0 - 10	1.02	0.94 - 1.10	0.71
Typical Job						
Lifting Frequency (lifts/min)						
Non-Cases	275	2.67 ($\pm$ 3.02)	0 - 15.8	1.00	-	-
Cases	177	3.22 ($\pm$ 3.96)	0 - 26.5	1.03	0.99 - 1.07	0.09
Lifting Frequency for Lifts ≤ 30"						
Non-Cases	275	1.03 ($\pm$ 1.87)	0 - 15	1.00	-	-
Cases	177	1.1 ($\pm$ 2.02)	0 - 13.47	1.03	0.96 - 1.11	0.38
% of Time Spent Back bent > 20°						
Non-Cases	230	15.9 ($\pm$ 17.92)	0 - 80	1.00	-	-
Cases	149	18.61 ($\pm$ 19.39)	0 - 92	1.01	1.00 - 1.02	0.06
TWA Borg CR-10						
Non-Cases	236	2.55 ($\pm$ 1.59)	0 - 8.46	1.00	-	-
Cases	143	2.64 ($\pm$ 1.31)	0 - 6.9	1.07	0.96 - 1.19	0.22
Peak Activity Rating (Borg CR-10)						
Non-Cases	256	3.5 ($\pm$ 1.89)	0 - 10	1.00	-	-
Cases	163	3.64 ($\pm$ 1.68)	0 - 10	1.07	0.98 - 1.16	0.12
Peak Task Rating (Borg CR-10)						
Non-Cases	248	4.25 ($\pm$ 2.12)	0 - 10	1.00	-	-
Cases	160	4.22 ($\pm$ 1.84)	0 - 9	1.01	0.94 - 1.09	0.77

Table 3.31: Continuous, Adjusted Hazard Ratios for Highest and Typical Job Worker Exposure

Variable	n	$\bar{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Highest Job						
Lifting Frequency (lifts/min)						
Non-Cases	268	3.40 (± 3.30)	0.00-15.80	1.00	-	-
Cases	170	3.98 (±4.71)	0.00-35.67	1.03	0.997 - 1.07	0.07
% Of Time Spent Back bent > 20°						
Non-Cases	234	18.04 (± 19.32)	0.00-80.00	1.00	-	-
Cases	146	20.45 (±20.24)	0.00-92.00	1.01	0.10 - 1.02	0.13
Peak Activity Rating (Borg CR-10)						
Non-Cases	235	2.90 (± 1.70)	0.00-8.46	1.00	-	-
Cases	143	2.91 (± 1.32)	0.00-6.76	1.04	0.96 - 1.13	0.39
Typical Job						
Lifting Frequency (lifts/min)						
Non-Cases	268	2.67 (± 3.05)	0.00-15.80	1.00	-	-
Cases	170	3.25 (± 4.01)	0.00-26.50	1.03	0.989 - 1.07	0.17
% Of Time Spent Back bent > 20°						
Non-Cases	227	15.91 (± 17.90)	0.00-80.00	1.00	-	-
Cases	144	18.60 (± 19.42)	0.00-92.00	1.01	0.999 - 1.02	0.10
Peak Activity Rating (Borg CR-10)						
Non-Cases	232	2.57 (± 1.59)	0.00-8.46	1.00	-	-
Cases	138	2.63 (± 1.25)	0.00-6.50	1.05	0.96 - 1.14	0.31

Percentage of time spent with the trunk flexed more than 20° showed suggestive evidence of association with the incidence of any LBP both for the typical job (HR = 1.01, p = 0.06) and the highest job (HR = 1.01, p = 0.12). The highest job was the job with the greatest percentage of time with the trunk flexed more than 20°. In the adjusted model, the percentage of time spent with the trunk flexed greater than 20° showed suggestive evidence for both the highest job (adjusted HR = 1.01, p = 0.13) and typical job (adjusted HR = 1.01, p = 0.10) (Table 3.31).

More than 15% of time spent with the trunk flexed ≥ 20° showed no evidence of association with the incidence of any LBP for either the highest job (p = 0.27) or the typical job (HR = 1.22, p = 0.21) (Tables 3.32 and 3.33).

When treated as a continuous variable, the peak activity Borg CR-10 rating (across the five activity categories: material handling, assembly, fork-truck driving, paperwork and resting/waiting) showed suggestive evidence of association with the incidence of any LBP both for the highest job (HR = 1.06, p = 0.16) and the typical job (HR = 1.07, p = 0.12) (Tables 3.32 and 3.33). When adjusted for covariates, there was no association between the peak activity Borg CR-10 rating and the incident cases of any LBP for either the highest job or the typical job (p ≥ 0.31) (Table 3.31).

Table 3.32: Categorical Analyses for General 'Highest' Job Variables

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Lifting Frequency (lifts/min)	*Model:*	*453*	---	---	*0.071*	*438*	---	---	*0.079*
	≤ 4	291	1.000	---	---	282	1.000	---	---
	> 4	162	1.319	0.977 – 1.781	0.071	156	1.321	0.968 – 1.804	0.079
% of Time Spent Back Bent ≥ 20°	*Model:*	*462*	---	---	*0.274*	---	---	---	---
	≤ 15	282	1.000	---	---	---	---	---	---
	> 15	180	1.178	0.878 – 1.580	0.274	---	---	---	---
TWA Borg CR-10	*Model:*	*389*	---	---	*0.029*	*378*	---	---	*0.115*
	≤ 0.7	28	1.000	---	---	27	1.000	---	---
	> 0.7 - ≤ 2.0	93	3.071	1.090 – 8.656	0.034	91	2.728	0.965 – 7.707	0.058
	> 2.0	268	3.692	1.361 – 10.014	0.010	260	2.897	1.062 – 7.900	0.038

Table 3.33: Categorical Analyses for General 'Typical' Job Variables

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Lifting Frequency (lifts/min)	*Model:*	*453*	---	---	*0.072*	*438*	---	---	*0.146*
	≤ 4	334	1.000	---	---	323	1.000	---	---
	> 4	119	1.342	0.974 – 1.849	0.072	115	1.281	0.918 – 1.787	0.146
% of Time Spent Back Bent ≥ 20°	*Model:*	*462*	---	---	*0.190*	*346*	---	---	*0.208*
	≤ 15	311	1.000	---	---	299	1.000	---	---
	> 15	151	1.223	0.905 – 1.653	0.190	147	1.221	0.894 – 1.667	0.208
TWA Borg CR-10	*Model:*	*380*	---	---	*0.068*	*370*	---	---	*0.216*
	≤ 0.7	34	1.000	---	---	33	1.000	---	---
	> 0.7 - ≤ 2.0	112	2.038	0.914 – 4.544	0.082	107	1.893	0.844 – 4.248	0.121
	> 2.0	234	2.408	1.117 – 5.190	0.025	230	1.994	0.921 – 4.314	0.080

When treated as a continuous variable, time-weighted average worker Borg CR-10 rating (TWA Borg), calculated by multiplying Borg rating by percentage of time in the five activity categories (material handling, assembly, fork-truck driving, paperwork and resting/waiting), showed no evidence of association with incident cases of any LBP for either the highest job (p=0.22) or the typical job (p = 0.22). Borg TWA ratings were categorized into three categories: less than or equal to 0.7 (reference), greater than 0.7 and less than or equal to 2.0 (TWA1), and greater than 2.0 (TWA2). For the highest job, univariate analysis showed evidence of association for both TWA1 (HR = 3.07, p = 0.03) and TWA2 (HR = 3.69, p = 0.01) with the incidence of any LBP (Table 3.32). Similarly, for the typical job, there was suggestive evidence of association for TWA1 (HR = 2.04, p = 0.08) and evidence of association for TWA2 (HR = 2.41, p = 0.03) with the incidence of any LBP (Table 3.33). In the adjusted model, there was suggestive evidence of association between workers' TWA Borg ratings and the incidence of any LBP both for the highest and the typical jobs (Tables 3.32 and 3.33). For the highest job, workers TWA1 and TWA2 had an adjusted HR of 2.73 (p = 0.06) and 2.9 (p = 0.04), respectively (Table 3.32). Similarly, for the typical job, TW1 and TWA2 had an adjusted HR of 1.89 (p = 0.12) and 1.99 (p = 0.08), respectively (Table 3.33).

When treated as a continuous variable, worker peak Borg CR-10 ratings for the single most difficult task performed all showed no evidence of association with incident cases of any LBP for neither the "typical", nor the "highest" exposure job (p ≥ 0.22). (Table 3.30)

Revised NIOSH Lifting Equation:
When treated as a continuous variable, the Composite Lifting Index (CLI) showed evidence of association with incident cases of any LBP both for the highest job (HR = 1.04, p < 0.01) and the typical job (HR = 1.04, p ≤ 0.01) (Table 3.34). When adjusted for covariates, the CLIs for both highest job (adjusted HR = 1.04, p < 0.01) and the typical job (adjusted HR = 1.03, p = 0.01) showed evidence of association with incident cases of any LBP (Table 3.35).

CLIs were also calculated using only those lifts/lowers with origin or destination at a height of 30 inches or less from the floor. When treated as continuous variables, these CLIs also showed evidence of an association with LBP for both highest job (HR = 1.04, p = 0.09) and the typical job (HR = 1.03, p = 0.14) (Table 3.34). In the adjusted model, CLI showed suggestive evidence for the highest job (HR = 1.04, p = 0.13) and no evidence of association with the incidence of any LBP for the typical job (p = 0.21) (Table 3.35). It should be noted that for these analyses workers who performed a job(s) that did not have lifting at a height less than or equal to 30 inches from the floor were assigned a very low cumulative lifting index value of 0.25.

Table 3.34: Continuous, Univariate Hazard Ratios for Highest Job and Typical Job Revised NIOSH Lifting Equation CLI

Variable	n	$\overline{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Highest Job						
CLI						
Non-Cases	275	3.02 (± 3.02)	0.25 - 29.3	1.00	-	-
Cases	177	4.17 (± 7.14)	0.25 - 56.99	1.04	1.01 - 1.06	0.001
CLI for Lifts/Lowers < 30"						
Non-Cases	275	2.06 (± 1.88)	0.25 - 13.31	1.00	-	-
Cases	177	2.44 (± 3.63)	0.25 - 33.9	1.04	0.99 - 1.08	0.09
Typical Job						
CLI_						
Non-Cases	275	2.75 (± 3.02)	0.25 - 29.3	1.00	-	-
Cases	177	3.82 (± 7.19)	0.25 - 56.99	1.04	1.01 - 1.06	0.003
CLI for Lifts/Lowers < 30"						
Non-Cases	275	1.84 (± 1.91)	0.25 - 13.31	1.00	-	-
Cases	177	2.19 (± 3.65)	0.25 - 33.9	1.03	0.98 - 1.08	0.14

Table 3.35: Continuous, Adjusted Hazard Ratios for Highest Job and Typical Job Revised NIOSH Lifting Equation CLI

Variable	n	X (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Highest Job						
CLI						
Non-Cases	268	3.00 (± 3.05)	0.25-29.30	1.00	-	-
Cases	170	4.22 (± 7.27)	0.25-56.99	1.04	1.01 - 1.06	0.002
CLI for Lifts/Lowers < 30"						
Non-Cases	221	2.44 (± 1.87)	0.25-13.31	1.00	-	-
Cases	141	2.88 (± 3.91)	0.25-33.90	1.04	0.99 - 1.08	0.13
Typical Job						
CLI						
Non-Cases	268	2.73 (± 3.05)	0.25-29.30	1.00	-	-
Cases	170	3.87 (± 7.32)	0.25-56.99	1.03	1.01 - 1.06	0.01
CLI for Lifts/Lowers < 30"						
Non-Cases	205	2.32 (± 1.95)	0.25-13.31	1.00	-	-
Cases	132	2.75 (± 4.04)	0.25-33.90	1.03	0.98 - 1.08	0.21

The Revised NIOSH Lifting Equation suggests that a job with a lifting index less than or equal to one poses low risk of injury to a worker while a lifting index greater than three poses significantly elevated risk of injury to a worker. To test these established guidelines, analyses were performed to compare the following categories: less than or equal to 1.0, greater than 1.0 to less than or equal to 3.0, and greater than 3.0. In addition, binary tests of less than or equal to three versus greater than three were tested.

Both the CLI and CLI for lifts less than or equal to 30 inches from the floor were tested against each of the categories.

In univariate analysis, CLI greater than 3.0 showed evidence (HR = 1.46, p = 0.01) for the highest job and suggestive evidence (HR = 1.33, p = 0.07) of association for the typical job with the incidence of LBP when compared to CLI less than or equal to 3.0 (Tables 3.36 and 3.37). When adjusted for covariates, results were similar to those from univariate analyses. CLI greater than 3.0 showed evidence (adjusted HR = 1.4, p = 0.04) for the highest job and suggestive evidence (adjusted HR = 1.25, p = 0.19) of association with the incidence of LBP for the typical job (Tables 3.36 and 3.37).

Similar analyses (CLI > 3.0 against CLI ≤ 3.0) were performed for lifts and lowers where the workers hands were at a height less than or equal to 30 inches from the floor. In univariate analyses, there was suggestive evidence of association with the incidence of any LBP for the highest job (HR = 1.39, p = 0.05) and no evidence for the typical job (p > 0.26). (Tables 3.36 and 3.37). For the highest job, the adjusted model also showed suggestive evidence of association with the incidence of LBP (adjusted HR = 1.32, p = 0.13) (Table 3.36).

In univariate analysis for the highest job, CLI greater than 3.0 also showed suggestive evidence of association with the incidence of LBP when compared to the less than or equal to 1.0 group (HR = 1.32, p = 0.18). However, there was no evidence of association for CLI greater than 1.0 to less than or equal to 3.0 for incidence of any (p = 0.48) (Table 3.36). The adjusted model for the highest job showed no evidence of association between CLI and the incidence of any LBP (p ≥ 0.28) (Table 3.36). For the typical job, there was no evidence of association between CLI and incident cases of any LBP when treating CLI ≤ 1.0 as reference group (p ≥ 0.31).

Similar results were obtained for lifts/lowers at heights less than or equal to 30". For the highest job, CLI greater than 3.0 showed suggestive evidence of association with incidence of LBP when compared to CLI ≤ 1.0 (HR = 1.32, p = 0.18). However, there was no evidence of association for CLI greater than 1.0 to less than or equal to 3.0 for the incidence of any LBP (p = 0.52) (Table 3.36). For the typical job, there was no evidence of association between CLI and incident cases of any LBP (p ≥ 0.26) (Table 3.37).

Revised NIOSH Lifting Equation - Different CLI Categories
(Reference Group 0.8 > CLI ≤ 1.1):
In addition to using the established guidelines of 1.0 and 3.0 for lifting index categories, cases and non-cases were plotted against CLI and, based on visual evidence, five score categories were assigned. These CLI categories were: ≤ 0.8, > 0.8 to ≤ 1.1, >1.1 to ≤ 3.0, > 3.0 to ≤ 6.0 and >6.0. There were an unusual number of cases occurring with very low CLI scores, ≤ 0.8. For this reason, the range of greater than 0.8 to less than or equal to 1.1 was assigned as the reference group. Using these CLI categories, CLI greater than 3.0 to less than or equal to 6.0 (HR = 1.87 p = 0.15) and greater than 6.0 (HR = 2.16, p = 0.10) showed suggestive evidence of association with the incidence of any LBP for the highest job. CLI less than or equal to 0.8 and greater than 1.1 to less than or equal to 3.0

showed no evidence of association with incidence of any LBP (p ≥ 0.30). There was a trend between CLI and hazard ratio for CLI > 1.1 (Table 3.36). In the adjusted model for the highest job, CLIs in certain categories showed suggestive evidence of association with incident cases of any LBP. These categories were CLI ≤ 0.8 (adjusted HR = 1.9, p = 0.19), 3.0 > CLI ≤ 6.0 (adjusted HR = 2.06, p = 0.13) and CLI > 6.0 (adjusted HR= 2.3, p = 0.10). There was no evidence of association with the incidence case any LBP for the category 1.1 > CLI ≤ 3.0; however, there was evidence of a positive trend for CLI categories greater than 1.1 to greater than 6.0 (Table 3.36).

For the typical job, CLI, scores greater than 6.0 showed suggestive evidence of association with the incidence of any LBP when compared with scores between greater than 0.8 and less than or equal to 1.1 (HR = 1.80, p = 0.12). All other CLI categories showed no evidence of association with incident cases of any LBP (p ≥ 0.36). There was a trend between CLI and hazard ratio for CLI > 1.1 (Table 3.37). In the adjusted model for the typical job, there was no evidence of association between CLI and incident cases of LBP (p ≥ 0.20) (Table 3.37).

Similar analyses were performed for lifts/lowers where the hands were at height of less than or equal to 30 inches from the floor at either the origin or the destination. For the highest job, there was suggestive evidence for CLI greater than 1.1 and less than or equal to 3.0 (HR = 2.62, p = 0.06) and evidence (HR = 3.95, p ≤ 0.01) of association for CLI greater than 3 and less than or equal to 6.0) and the incidence of any LBP. There was no evidence of association between CLI greater than 6 and the incidence of any LBP (p = 0.28) (Table 3.36). For the typical job, there was evidence of association between CLIs and the incidence of any LBP for CLI greater than 1.1 and less than or equal to 3.0 (HR = 3.07, p ≤ 0.02) and CLI greater than 3 and less than or equal to 6.0 (HR = 3.75, p ≤ 0.01) There was no evidence of association between CLI greater than 6 and the incidence of any LBP (p = 0.22) (Table 3.37). However, both for the highest (HR = 2.90, p = 0.04) and the typical job HR = 2.98, p ≤ 0.02) scores less than or equal to 0.8 also showed evidence of association with the incidence of any LBP (Table 3.37).

Results from the adjusted models for CLIs for lifts/lowers at heights less than or equal to 30" were similar to those from univariate analyses. In the adjusted model for the highest job), there was evidence for CLI less than or equal to 0.8 (adjusted HR = 3.45, p = 0.04), LI greater than 1.1 and less than or equal to 3.0 (adjusted HR = 3.16, p = 0.05) and CLI greater than 3 and less than or equal to 6.0 (adjusted HR = 4.44, p ≤ 0.01), and suggestive evidence(adjusted HR = 2.57, p = 0.20) of association for CLIs greater than 6 and the incidence of any LBP (Table 3.37). Similarly, for the typical job, there was evidence of association for CLI less than or equal to 0.8 (adjusted HR = 3.08, p ≤ 0.03), CLI greater than 1.1 and less than or equal to 3.0 (adjusted HR = 3.23, p ≤ 0.02), and CLI greater than 3 and less than or equal to 6.0 (adjusted HR = 3.57, p ≤ 0.02) and the incidence of any LBP. There was no evidence of association between CLI greater than 6 and the incidence of any LBP (p = 0.22) (Table 3.37).

Table 3.36: Categorical Analyses for 'Highest' Job Revised NIOSH Lifting Equation Variables

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
CLI	*Model*	*453*	--	--	*0.036*	*438*	--	--	*0.075*
	≤1	84	1.000	--	--	84	1.000	--	--
	>1 - <3	201	0.860	0.568 – 1.302	0.477	195	0.804	0.529 – 1.224	0.310
	≥3	168	1.318	0.881 – 1.973	0.180	159	1.205	0.795 – 1.828	0.380
CLI	*Model*	*453*	--	--	*0.013*	*438*	--	--	*0.038*
	<3	285	1.000	--	--	279	1.000	--	--
	≥3	168	1.459	1.084 – 1.964	0.013	159	1.396	1.018 – 1.913	0.038
CLI	*Model*	*453*	--	--	*0.095*	*438*	--	--	*0.147*
	≤ 0.8	72	1.582	0.660 – 3.794	0.304	72	1.900	0.732 – 4.930	0.187
	> 0.8 - ≤1.1	21	1.000	--	--	19	1.000	--	--
	>1.1 - <3	192	1.261	0.545 – 2.915	0.588	188	1.426	0.569 – 3.578	0.449
	≥3 - <6	124	1.865	0.805 – 4.324	0.146	116	2.060	0.814 – 5.211	0.127
	≥6	44	2.155	0.865 – 5.368	0.099	43	2.326	0.853 – 6.339	0.099
CLI for Lifts/Lowers ≤30"	*Model*	*453*	--	--	*0.129*	*438*	--	--	*0.268*
	≤1	157	1.000	--	--	152	1.000	--	--
	>1 - <3	191	0.893	0.633 – 1.262	0.523	185	0.906	0.636 – 1.290	0.584
	≥3	105	1.306	0.897 – 1.902	0.164	101	1.252	0.846 – 1.853	0.261
CLI for Lifts/Lowers ≤30"	*Model*	*453*	--	--	*0.054*	*438*	--	--	*0.125*
	<3	348	1.000	--	--	337	1.000	--	--
	≥3	105	1.386	0.995 – 1.931	0.054	101	1.316	0.927 – 1.870	0.125
CLI for Lifts/Lowers ≤30"	*Model*	*453*	--	--	*0.042*	*438*	--	--	*0.094*
	≤ 0.8	140	2.900	1.054 – 7.981	0.039	137	3.447	1.076 – 11.042	0.037
	> 0.8 - ≤1.1	25	1.000	--	--	23	1.000	--	--
	>1.1 - <3	183	2.621	0.955 – 7.188	0.061	177	3.155	0.988 – 10.078	0.053
	≥3 - <6	89	3.950	1.418 – 11.005	0.009	85	4.444	1.363 – 14.485	0.013
	≥6	16	2.076	0.558 – 7.727	0.276	16	2.569	0.605 – 10.908	0.201

Table 3.37: Categorical Analyses for 'Typical Job' Revised NIOSH Lifting Equation Variables

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
CLI	*Model:*	*453*	--	--	*0.118*	*438*	--	--	*0.246*
	≤ 1	111	1.000	--	--	109	1.000	--	--
	> 1 - < 3	202	0.823	0.566 – 1.196	0.307	197	0.811	0.553 – 1.189	0.283
	≥ 3	130	1.180	0.807 – 1.727	0.393	132	1.091	0.729 – 1.631	0.672
CLI	*Model:*	*453*	--	--	*0.068*	*438*	--	--	*0.188*
	< 3	313	1.000	--	--	306	1.000	--	--
	≥ 3	140	1.332	0.979 – 1.813	0.068	132	1.246	0.898 – 1.728	0.188
CLI	*Model:*	*453*	--	--	*0.198*	*438*	--	--	*0.387*
	≤ 0.8	91	1.306	0.669 – 2.550	0.435	89	1.335	0.656 – 2.715	0.426
	> 0.8 - ≤ 1.1	31	--	--	--	29	1.000	--	--
	>1.1 - <3	191	1.022	0.539 – 1.938	0.947	188	1.034	0.526 – 2.033	0.923
	≥ 3 - < 6	100	1.358	0.701 – 2.630	0.364	93	1.299	0.642 – 2.630	0.467
	≥ 6	40	1.804	0.858 – 3.793	0.120	39	1.684	0.756 – 3.754	0.202
CLI for Lifts/Lowers ≤30"	*Model:*	*453*	--	--	*0.531*	--	--	--	--
	≤ 1	197	1.000	--	--	--	--	--	--
	> 1 - < 3	163	1.024	0.731 – 1.434	0.892	--	--	--	--
	≥ 3	93	1.235	0.842 – 1.811	0.280	--	--	--	--
CLI for Lifts/Lowers ≤30"	*Model:*	*453*	--	--	*0.264*	--	--	--	--
	< 3	360	1.000	--	--	--	--	--	--
	≥ 3	93	1.222	0.859 – 1.739	0.264	--	--	--	--
CLI for Lifts/Lowers ≤30"	*Model:*	*453*	--	--	*0.080*	*438*	--	--	*0.184*
	≤ 0.8	176	2.977	1.202 – 7.373	0.018	172	3.078	1.119 – 8.471	0.030
	> 0.8 - ≤ 1.1	32	--	--	--	30	1.000	--	--
	>1.1 - <3	152	3.070	1.232 – 7.648	0.016	147	3.230	1.167 – 8.942	0.024
	≥ 3 - < 6	77	3.754	1.470 – 9.588	0.006	73	3.569	1.248 – 10.205	0.018
	≥ 6	16	2.161	0.625 – 7.465	0.223	16	2.309	0.609 – 8.747	0.218

Biomechanical Measures:

When treated as continuous variables, for the highest job, there was evidence of association for minimum percent capable population (HR = 0.996, p = 0.05); and suggestive evidence for cumulative compressive force per minute (CF_{cum}) (HR = 1.000, p = 0.13), peak compressive force multiplied by lifting frequency ($CF_{max}*F$) (HR = 1.000, p = 0.16) and cumulative flexion/extension moment per minute (HR = 1.000, p = 0.20) with the incidence of any LBP (Table 3.38). When adjusted for covariates, there was suggestive evidence of association for cumulative compressive force per minute (CF_{cum}) (adjusted HR = 1.000, p = 0.15) and percent capable population (adjusted HR = 0.997, p = 0.15) with the incidence of any LBP. In the adjusted model, there was no evidence of association for peak compressive force for lift/lower tasks multiplied by lifting frequency for the highest job ($CF_{max}*F$) and total flexion/extension moment per minute with the incidence of any LBP (p ≥ 0.26). Neither peak compressive force, average compressive force per exertion, nor flexion/extension moment showed evidence of association with any LBP incident cases (p ≥ 0.23) (Table 3.40). None of the biomechanical measures for typical job showed evidence of association with incident cases of any LBP (p ≥ 0.25) (Tables 3.39).

Compressive Force:

NIOSH has suggested that L_5S_1 compressive force less than or equal to 770 lbs poses low risk of injury to workers. Further, NIOSH suggests that L5/S1 disc compressive force greater than 1,430 lbs poses high risk to workers. These guidelines were used to perform categorical analyses for peak compressive force for both highest and typical jobs performed by workers. When cases and non-cases were graphed against the compressive force, the histogram revealed an usually high number of cases with very low peak compressive force (<80 lbs). Therefore, Maximum compressive forces were divided into four categories: ≤ 80 lbs, > 80 to ≤ 770 lbs, > 770 to ≤ 1430, and > 1430 lbs with >80 to ≤ 770 as reference.

In univariate analysis for the highest job, there was suggestive evidence of association with the incidence of any LBP for maximum compressive force ≤ 80 lbs (HR = 2.48, p = 0.08), evidence for maximum compressive force greater than 770 to less than or equal to 1,430 lbs (HR = 1.38, p = 0.04), and no evidence for maximum compressive force than 1,430 lbs (p = 0.97) (Table 3.41). For the typical job, the results were similar to those for the highest job. For the typical job, there was evidence of association with the incidence of any LBP for maximum compressive force ≤ 80 lbs (HR = 1.987, p ≤ 0.01), suggestive evidence for maximum compressive force greater than 770 to less than or equal to 1,430 lbs (HR = 1.25, p = 0.16), and no evidence for maximum compressive force than 1,430 lbs (p = 0.97) (Table 3.42).

In the adjusted model, for the highest job, maximum compressive force less than or equal to 80 lbs (adjusted HR = 2.41, p = 0.09) and greater than 770 to less than or equal to 1,430 lbs (adjusted HR = 1.25, p = 0.18) showed suggestive evidence of association with the incidence of any LBP (Table 3.41). There was no evidence of association with the incidence of any LBP for maximum compressive force greater than 1,430 lbs (p = 0.97) (Table 3.41). For the typical job, there was no evidence of association between maximum

compressive force and the incidence of any LBP (p ≥ 0.51) except the lowest category of maximum compressive force of less than 80 lbs (adjusted HR = 2.05, p ≤ 0.01) (Table 3.42).

Table 3.38: Continuous, Univariate Hazard Ratios for Highest Job Biomechanical Measures

Variable	n	$\overline{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Max. Compressive Force (lbs)						
Non-Cases	259	742.62 (± 278.48)	74 - 1655	1.00	-	-
Cases	168	750.85 (± 299.13)	50 - 1421	1.000	1.00 - 1.001	0.34
Max. Comp. Force x Frequency (CF_{max}*F) (lbs/min)						
Non-Cases	259	1814.68 (± 1994)	0.87 - 14672.89	1.00	-	-
Cases	168	2172.9 (± 2506.59)	2.25 - 13484.75	1.000	1.00 - 1.00	0.16
Average Compressive Force/Exertion (lbs/exertion)						
Non-Cases	259	511.94 (± 192.07)	74 - 1450.9	1.00	-	-
Cases	168	508.41 (± 206.98)	49 - 1148.5	1.000	0.999 - 1.001	0.57
Cumulative Compressive Force/min (lbs-sec/min)						
Non-Cases	259	2131.93 (± 1996.93)	3.27 - 8744.92	1.00	-	-
Cases	168	2455.69 (± 2632.84)	0 - 17084.01	1.000	1.00 - 1.00	0.13
Max. Flexion/Extension Moment (in-lbs)						
Non-Cases	259	1709.26 (± 715.49)	6.1 - 3690	1.00	-	-
Cases	168	1750.24 (± 800.42)	6.4 - 3690	1.000	1.00 - 1.00	0.23
Cumulative Flexion/Extension Moment (in-lbs-sec./min)						
Non-Cases	259	2720.38 (± 3066.95)	0.61 - 18979.06	1.00	-	-
Cases	168	3104.46 (± 3308.69)	0.64 - 18330.56	1.000	1.00 - 1.00	0.20
Minimum % Capable Population (%)						
Non-Cases	259	50.39 (± 34.58)	0 - 99	1.00	-	-
Cases	168	46.05 (± 35.74)	0 - 99	0.996	0.99 - 1.00	0.05

Table 3.39: Continuous, Univariate Hazard Ratios for Typical Job Biomechanical Measures

Variable	n	$\overline{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Max. Compressive Force (lbs)						
Non-Cases	259	692.98 (± 271.13)	74 - 1655	1.00	-	-
Cases	168	678.32 (± 279.51)	50 - 1421	1.000	0.999 - 1.00	0.98
Max. Comp. Force x Frequency (CF_{max}*F) (lbs/min)						
Non-Cases	259	1469.58 (± 1969.24)	0.87 - 14672.89	1.00	-	-
Cases	168	1751.49 (± 2535.34)	1.94 - 13484.75	1.000	1.00 - 1.00	0.29
Average Compressive Force/Exertion (lbs/exertion)						
Non-Cases	259	482.42 (± 187.91)	74 - 1450.9	1.00	-	-
Cases	168	463.67 (± 192.85)	49 - 1125	1.000	0.999 - 1.001	0.69
Cumulative Compressive Force/min (lbs-sec/min)						
Non-Cases	259	1517.07 (± 1656.44)	3.27 - 8744.92	1.00	-	-
Cases	168	1638.37 (± 2062.48)	0 - 12280.64	1.000	1.00 - 1.00	0.60
Max. Flexion/Extension Moment (in-lbs)						
Non-Cases	259	1594.92 (± 713.92)	6.1 - 3690	1.00	-	-
Cases	168	1573.06 (± 747.94)	6.4 - 3690	1.000	1.00 - 1.00	0.84
Cumulative Flexion/Extension Moment (in-lbs-sec./min)						
Non-Cases	259	2210.41 (± 3050.44)	0.61 - 18979.06	1.00	-	-
Cases	168	2428.74 (± 3314.83)	0.64 - 18330.56	1.000	1.00 - 1.00	0.48
Minimum % Capable Population (%)						
Non-Cases	259	56.72 (± 34.84)	0 - 99	1.00	-	-
Cases	168	54.82 (± 35.58)	0 - 99	0.998	0.99 - 1.00	0.25

Cumulative Compressive Force:
Cumulative compressive force minute was categorized into three categories: ≤ 400, >400 to ≤ 670, > 670 to ≤ 4000, and > 4000 lbs-sec/min with > 400 to ≤ 670 as reference. In the univariate analysis, for the highest job, cumulative compressive force per minute greater than 4,000 lbs-sec showed suggestive evidence of association with incidence of any LBP (HR = 1.79, p = 0.06). There was no evidence of association with the incidence of any LBP for other categories of cumulative compressive force per minute (p $\geq$ 0.32) (Table 3.41). For typical job all categories of cumulative compressive force per minute showed suggestive evidence of association with the incidence of any LBP: ≤ 400 lbs-sec (HR = 1.78, p = 0.11), > 670 to ≤ 4000 (HR = 1.63, p = 0.17), and > 4000 (HR = 1.81, p = 0.14) (Table 3.42).

In the adjusted model, for the highest job, there was suggestive evidence of association between cumulative compressive of greater than 4000 lbs-sec/minute and the incidence

93

of any LBP (adjusted HR = 1.69, p = 0.11) and no evidence for the other two categories (p ≥0.29) (Table 3.41). For the typical job, cumulative compressive force greater than 670 to less than or equal to 4,000 lbs-sec/min (adjusted HR = 1.81, p = 0.13) and greater than 4,000 lbs-sec/min (adjusted HR = 2.02, p = 0.12) showed suggestive evidence of association with the incidence of any LBP; and evidence of association between cumulative compressive force less than or equal to 400 lbs-sec /min and the incidence of any LBP (adjusted HR = 2.24, p = 0.05) (Table 3.42).

Table 3.40: Continuous, Adjusted Hazard Ratios for Highest Job Biomechanical Measures

Variable	n	$\overline{X}$ (± SD)	Range	Hazard Ratio	95% C.I.	p-Value
Max. Comp. Force x Frequency $(CF_{max}*F)$ (lbs/min)						
Non-Cases	252	743.98 (± 280.24)	74.00-1655.00	1.00	-	-
Cases	161	749.67 (± 303.62)	50.00-1421.00	1.00	1.00 - 1.00	0.26
Cumulative Compressive Force/min (lbs-sec/min)						
Non-Cases	252	2158.53 (± 2016.49)	3.27-8744.92	1.00	-	-
Cases	161	2463.34 (± 2653.51)	0.00-17084.01	1.00	1.00 - 1.00	0.15
Cumulative Flexion Extension Moment (in-lbs-sec min)						
Non-Cases	252	2739.77 (± 3099.79)	0.61-18979.06	1.00	-	-
Cases	161	3123.02 (± 3359.80)	0.64-18330.56	1.00	1.00 - 1.00	0.28
Minimum % Capable Population (%)						
Non-Cases	252	50.55 (± 34.53)	0.00-99.00	1.00	-	-
Cases	161	47.57 (±35.55)	0.00-99.00	1.00	0.992 - 1.00	0.15

Minimum Percent Capable:
For the minimum percent capable population two binary categorical analyses were performed: (i) less than 75% (reference group) vs. greater than or equal to 75 percent capable and (ii) less than 90% (reference group) vs. greater than or equal to 90 percent capable for both the highest and the typical jobs. For the highest job, accommodating both greater than or equal to 75% of the population (HR = 0.80, p = 0.18) and greater than or equal to 90% of the population (HR = 0.71, p = 0.12) showed suggestive evidence of protective association with the incidence for any LBP (Table 3.41). For the typical job, there was no evidence of association between percent capable population and incident cases of any LBP (p ≥ 0.26) (Table 3.42).

When adjusted for covariates, for the highest job, there was no evidence of association with the incidence of any LBP for percent capable ≥ 75% (p = 0.35); however, there was suggestive evidence for percent capable ≥ 90% (adjusted HR = 0.757, p = 0.20) (Table 3.41).

94

Cumulative Moments:
Cumulative flexion/extension moments per minute were categorized into three
categories: < 7000, > 7000 to ≤ 10000, and > 10000 in-lbs-sec/min with ≤ 7000 as
reference group. In univariate analysis, for the highest job, cumulative flexion/extension
moments greater than 7,000 to less than or equal to 10,000 in-lbs-sec/min showed
evidence of association with the incidence of any LBP (HR = 2.44, p ≤ 0.01); but there
was no evidence of association for cumulative flexion/extension moments greater than
10,000 in-lbs-sec/min (p – 0.64) (Table 3.41). Results for typical job were similar to
those for the highest job. For the typical job, cumulative flexion/extension moment,
moments greater than 7,000 to less than or equal to 10,000 in-lbs-sec/min showed
evidence of association with the incidence of any LBP (HR = 2.32, p = 0.01). However,
cumulative moments greater than 10,000 in-lbs-sec/min showed no evidence of
association (p – 0.75) (Table 3.42).

In the adjusted model, there was suggestive evidence of association for cumulative
flexion/extension moment greater than 7,000 to less than or equal to 10,000 in-lbs –
sec/min for the highest job (adjusted HR = 2.34, p = 0.06) and evidence of association for
the typical job (adjusted HR – 2.25, p = 0.02) (Tables 3.41 and 3.42). Moments greater
than 10,000 in-lbs showed no evidence of association with the incidence of any LBP both
for the highest job (p – 0.69) and the typical job (p = 0.84) (Tables 3.41 and 3.42).

Table 3.41: Categorical Analyses for 'Highest' Job Biomechanical Measures

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Max. Compressive Force (lbs)	*Model:*	*428*	---	---	*0.092*	*413*	---	---	*0.258*
	≤ 80	5	2.475	0.906 – 6.766	0.0773	5	2.408	0.873 – 6.645	0.090
	> 80 - ≤ 770	226	1.000	---	---	217	1.000	---	---
	>770 - ≤ 1,430	194	1.384	1.019 – 1.881	0.038	188	1.247	0.901 – 1.727	0.184
	> 1,430	3	0.000	0.000 – 9999	0.972	3	0.000	0.000 – 9999	0.973
Cumulative Compressive Force / Minute (lbs-sec/min)	*Model:*	*428*	---	---	*0.289*	*413*	---	---	*0.362*
	≤ 400	75	1.303	0.772 – 2.199	0.322	74	1.314	0.778 – 2.310	0.291
	> 400 - ≤ 670	76	1.000	---	---	71	1.000	---	---
	> 670 - ≤ 4,000	247	1.177	0.757 – 1.830	0.469	238	1.148	0.723 – 1.822	0.558
	> 4,000	30	1.792	0.968 – 3.320	0.0635	30	1.686	0.895 – 3.175	0.106
Cumulative Flexion/Extension Moment (in-lbs-sec/min)	*Model:*	*428*	---	---	*0.010*	*413*	---	---	*0.019*
	≤ 7,000	391	1.000	---	---	376	1.000	---	---
	> 7,000 - ≤ 10,000	17	2.436	1.351 – 4.391	0.003	17	2.336	1.275 – 4.282	0.006
	>10,0000	20	0.833	0.390 – 1.777	0.636	20	0.856	0.339 – 1.836	0.690
Minimum % Capable Population (%)	*Model:*	*428*	---	---	*0.179*	*413*	---	---	*0.353*
	< 75	283	1.000	---	---	270	1.000	---	---
	≥ 75	145	0.801	0.579 – 1.107	0.179	143	0.855	0.615 – 1.189	0.353
Minimum % Capable Population (%)	*Model:*	*428*	---	---	*0.117*	*413*	---	---	*0.203*
	< 90	356	1.000	---	---	343	1.000	---	---
	≥ 90	72	0.711	0.465 – 1.088	0.117	70	0.757	0.493 – 1.163	0.203

Table 3.42: Categorical, Analyses for 'Typical Job' Biomechanical Measures

Variable	Category	Univariate Model				Adjusted Model			
		n	Hazard Ratio	95% C.I.	p-Value	n	Hazard Ratio	95% C.I.	p-Value
Max. Compressive Force (lbs)	*Model:*	*462*	---	---	*0.055*	*446*	---	---	*0.066*
	≤ 80	39	1.987	1.194 – 3.305	0.008	38	2.049	1.213 – 3.464	0.007
	> 80 - ≤ 770	271	1.000	---	---	260	1.000	---	---
	>770 - ≤ 1,430	149	1.250	0.913 – 1.710	0.164	145	1.117	0.801 – 1.560	0.514
	> 1,430	3	0.000	0.000 – 9999	0.971	3	0.000	0.000 – 9999	0.972
Cumulative Compressive Force / Minute (lbs-sec/min)	*Model:*	*428*	---	---	*0.432*	*413*	---	---	*0.208*
	≤ 400	131	1.775	0.878 – 3.590	0.110	128	2.238	1.018 – 4.920	0.045
	> 400 - ≤ 670	37	1.000	---	---	35	1.000	---	---
	> 670 - ≤ 4,000	216	1.625	0.817 – 3.232	0.166	206	1.813	0.834 – 3.938	0.133
	> 4,000	44	1.814	0.821 – 4.011	0.141	44	2.015	0.843 – 4.814	0.115
Cumulative Flexion/Extension Moment (in-lbs-sec/min)	*Model:*	*428*	---	---	*0.045*	*413*	---	---	*0.065*
	≤ 7,000	396	1.000	---	---	381	1.000	---	---
	> 7,000 - ≤ 10,000	13	2.324	1.185 – 4.559	0.014	13	2.247	1.131 – 4.465	0.021
	>10,0000	19	0.886	0.415 – 1.890	0.754	19	0.923	0.430 – 1.978	0.840
Minimum % Capable Population (%)	*Model:*	*428*	---	---	*0.260*	---	---	---	---
	< 75	237	1.000	---	---	---	---	---	---
	≥ 75	191	0.839	0.618 – 1.139	0.260	---	---	---	---
Minimum % Capable Population (%)	*Model:*	*428*	---	---	*0.482*	---	---	---	---
	< 90	328	1.000	---	---	---	---	---	---
	≥ 90	100	0.878	0.612 – 1.261	0.482	---	---	---	---

4. Discussions

4.1 Hypotheses and Aims:
This research was undertaken to test the following two hypotheses:

Hypothesis 1: There are significant relationships between quantitative Job Physical Exposures and the subsequent risk for low back pain (LBP) in a cohort.

Hypothesis 2: There are significant relationships between quantitative Job Physical Exposures and subsequent risk of low back impairments (e.g. diminished range of motion) and LBP measures of severity (e.g. medication use, lost or restricted workdays) in a cohort.

We have successfully tested hypothesis 1. We have collected data to test hypothesis 2 and have begun data analyses. However, due to the enormous amount of effort and time required to analyze all data only results for any low back pain (LBP) incident cases are provided in this report. We are analyzing data on LBP severity measures. These include: LBP cases with medication use, LBP cases with light/modified duty, LBP cases with lost workdays, and sciatica cases. In addition we plan to analyze recurrent cases of LBP.

We have completed the following aims of the study (Chapter 1). Our goal was to follow 670 workers with an average follow up time of 24 months (Aim 1a). We have follow up data for 610 workers totaling 1033 person-years (average follow-up time of 20.3 months). A total of 759 workers were enrolled in the study with baseline health data collected on 733 workers, baseline job physical exposure data collected on 673 workers and both health and job baseline data collected on 647 workers. A significant number of workers quit their jobs (Figure 3.1) prior to follow-up data collection. We tried to replace lost workers, however due to the enormous amount of time and effort required to replace workers with new workers and, in some cases, new companies we were not always successful. (In this regard, we found a total study time of three years was grossly inadequate for this multi-center prospective cohort study. It takes substantially more time and effort to seek participation of companies, enroll subjects, collect data, and analyze data than we anticipated.) Nearly all-participating workers were followed quarterly for job physical exposure and monthly for health outcomes; changes in their exposure and outcomes were recorded. We have successfully quantified job physical exposures as outlined in aim 1b. We have successfully analyzed physical exposure using the Revised NIOSH Lifting Equation and the 3-D Static Strength Biomechanical Model (3D-SSPP). At present it has not been possible to analyze physical exposure using maximum acceptable weights and forces and Lifting TLV due to large variation in workers' physical exposure (job rotation and variation in physical exposure within a job). We have successfully classified job physical exposure into low, medium and high exposure categories as well as additional categories where applicable (Aim 1d).

Throughout the study job physical exposure teams were blinded to health data teams and similarly health data teams were blinded to job physical exposure teams (Aim2).

Questionnaire data, structured interviews, and physical examinations were given on all subjects at baseline (n =733) (Aim 2a). We monitored the cohort (n= 610) and recorded relevant changes in low back health status and rendered structured interviews and physical examinations to those with either new LBP symptoms or changes in symptoms (Aim 2b). Nearly all participants in Utah and Wisconsin were given exit questionnaires, structured interviews and physical examinations at the termination of the study (Am 2c). Those subjects in Texas were not given exit interviews due to a lack of resources.

We have successfully measured the prevalence of prior LBP, LBP, sciatica, low back impairments, LBP-related restricted duty, and healthcare utilization at baseline (Aim 3a). We followed the cohort (n =610) monthly to determine incidence rates of LBP, sciatica and low back severity (Aims 3b, 3c and 3d). We have evaluated the relationship between job physical exposure and any LBP incident cases (Aim 3e). As stated earlier we have collected data and have begun analysis of data to study relationships between job physical exposure and LBP severity (LBP with medication use, LBP cases with light/modified duty, LBP cases with lost workdays and sciatica incident cases) (Aim 3e).

4.2 Preliminary Findings:

It should be recognized that we are dealing with a very large database, with data collected and analyzed by three different teams in three different states. Also, since job physical exposure and health outcome assessment teams were separate and blinded to each other it required merging of job physical exposure and health assessment data. We have made sincere efforts to determine the accuracy of our data and correct errors in our database. However, at the time of writing this report, we continue to find errors in our database and it would require substantially more time and effort to determine the accuracy of our data with reasonable certainty. Therefore, this report must be viewed as preliminary and our findings reported here are ubject to change should we find substantial errors in our database.

4.3 Association Between Non-Physical Factors and Incidence of any LBP:

Univariate comparisons were made between the LBP outcome variables and non-physical variables in order to identify relevant covariates.

Age, gender, obesity, tobacco use are generally believed to be risk factors for low back pain. Miranda et al (2002) studied a cohort of 2077 workers and concluded that greater age, mental stress, smoking of long duration, and work related twisting of the trunk increased the risk of incidental sciatic pain. This study found no evidence to support these findings. However the LBP outcomes are different in the two studies (sciatica versus any LBP. This study did not find evidence of association between incident cases of any LBP and any of the demographic variables studied. Thus, there was no evidence of association between age, gender, BMI and pack-years smoked and incidence of any LBP.

Exercise/physical activity has been thought of as a panacea for prevention and treatment of LBP (ACOEM 2007). Miranda et al. (2002) reported that joggers had a lower risk for incidental sciatic pain, but a higher risk for persistent symptoms. Further, waking was

positively associated. In this stud, there was no evidence of association between any of the hobbies and physical exercises studied and the incidence of any LBP. Once again, the LBP outcomes were not the same in the two studies. Lack of evidence of association between hobbies/physical exercises and the incidence of any LBP found in this study is consistent with the findings of Van Nieuwenhuvse et al. (2006), who reported that physical factors during leisure time were not predictive of LBP lasting seven or more consecutive days.

In this study, there was suggestive evidence of association between total vehicle miles traveled/day and incidence of any LBP (p = 0.06) and time to commute to work one way and incidence of any LBP (p = 0.09). It may be that these two variables are correlated.

This studied confirmed a relationship between measures of workplace support and job enjoyment (modified APGAR) and subsequent risk of any LBP. Similarly, this study confirmed a relationship between measures of depression (modified Zung scale) and subsequent risk of LBP. It also suggests anxiety is a risk for LBP Nervous-Edge-Tense composite). All three psychosocial scales studied (modified Work APGAR (p < 0.01), modified Zung depression scale (p< 0.01) and composite of edge-nervous-tense scale (p = 0.02)) showed evidence of association with incidence of any LBP. Among individual psychosocial questions not included in the three scales, certain categories of 'felt mentally exhausted', 'felt physically exhausted', 'felt uneasy' and 'control over work pace' showed potential evidence of association with incidence of any LBP (p < 0.20); and certain categories of 'having family problems', 'felt depressed' and control over variety of tasks showed evidence of association with incidence of any LBP (p < 0.05).

Based on a review of relevant studies published between 1990 and 2002, Hartvigsen et al. (2004) concluded that: (i) there was strong evidence of no association between social support at work and stress at work and consequences of LBP, (ii) no conclusions could be drawn regarding perception of work and consequences of LBP, (iii) there was moderate evidence for no association between LBP and perception of work, organizational aspects of work, and social support at work, and (iv) there was insufficient evidence for a positive association between stress at work and LBP. Hoogendoorn et al. (2000) restricted their review to only those studies with a cohort (11 studies) or case-control design (2 studies). The authors concluded that (i) there was strong support for low workplace social support and low job satisfaction in the work place as risk factors for back pain, (ii) there was insufficient evidence for high work pace, high qualitative demands, low job content, low job control, and psychosocial factors in the private life, and (iii) the combined evaluation of job content and job control, both aspects of decision latitude, led to a strong evidence of a role for low job decision latitude. Davis and Heaney (2000) reviewed 66 articles and concluded that psychosocial characteristics were related to some LBP outcomes and that job dissatisfaction and job stress were more consistently related to LBP than workload, lack of influence over work and quality of relationships with coworkers. From the past literature, it appears that depression (Schneider et al. 2005, Power et al. 2001) and job dissatisfaction (Hoogendoorn et al. 2000, Davis and Heaney 2000, Krause et al. (1998 and Papaageorgiou et al. 1997) appear to more commonly associated with increased risk for LBP.

100

A wide variety of instruments have been used for collection of data on work related psychosocial factors, many of which had not undergone any kind of validation Hartvigsen et al. (2004). Similarly, different measures of LBP outcomes have been used to study relationships between psychosocial; factors and LBP, and this makes it difficult to compare results reported in this study with those reported in LBP literature. It appears that while there is evidence for an effect of work-related psychosocial factors, the evidence for the role of specific factors has not been established (Hoogendoorn et al. 2000).

Recognizing that the above limitations may affect direct comparisons, the findings of this study are consistent with those reported by Clavs et al. (2007), Miranda et al. (2002), Kerr et al. (2001), Hoogendoorn et al. (2001), Thorbiornsson et al. (2000) and Krauuse et al. (1998). For example, Clavs at al. (2007) concluded that psychosocial factors both work and non-work related constituted non-negligible risks for the development of LBP. In this study, low decision attitude and low social support at work significantly increased the risk for LBP in men. Similarly, Hoogendoorn et al. (2001) reported that low social support, from either supervisors or coworkers, appeared to be a risk factor for low back pain.

This study found that the LBP is a dynamic process with high rates for prevalence, incidence and recurrence. In this study the recovery from any LBP was not high, as nearly one out of four workers never had a pain free period of 90 days.

Practically, all measures of past history of LBP studied showed evidence of association with incidence of any LBP. More than three separate lost- time episodes (HR = 2.63, p ≤ 0.01), pinched nerve/sciatica (HR = 2.48, p ≤ 0.01), changed job because of LBP (HR = 2.23, p ≤ 0.02), missed work because of LBP (HR = 2.19, p ≤ 0.01), ever been on light/modified duty (HR = 2.07, p ≤ 0.01), saw a healthcare provider (HR = 2.07, p ≤ 0.01) and ever used medicine to treat LBP (HR = 2.03, p ≤ 0.01) showed the strongest evidence of association with any LBP incidence cases. Other measures of past history of LBP with evidence of association with incidence of any LBP included received workers' compensation for back injuries, received workers' compensation for any injury, continuous duration of any LBP lasting at least 7 days and past diagnosis of low back strain/sprain by a healthcare provider.

These findings are consistent with those reported in the literature that previous history of LBP is a significant risk factor for new or continued LBP (Brage et al. 2007, Tubach et al 2002) and Bigos et al. (1991). The incidence rate reported in this study is a little higher than the yearly incidence 20% to 28% among scaffolders reported by Elders and Burdorf (2004).

There was no evidence of association between medical history, other than LBP, and incidence of any LBP. This study did not find any evidence of association between diabetes, thyroid, high blood pressure, high cholesterol or broken bones and incident cases of any LBP. Other medical history variables such as diagnosis of scoliosis,

101

Heberden's or Bouchard's nodes, inflammatory arthropathy, osteoporosis, chronic fatigue, irritable bowel syndrome, fibromyalgia, myofascial pain syndrome, gout, and kidney failure had very small sample size and, therefore; were not considered as possible risk factors.

Similarly, none of the physical examination findings showed any evidence of association with incidence of any LBP. These included patellar reflex, Achilles reflex and applying pressure on SI joint and signs of rheumatoid arthritis.

4.4 Association between Physical Factors and Incidence of any LBP:

The hypothesis regarding the role of job physical risk factors were assessed using unadjusted and adjusted Cox regression models. Adjusted hazard ratios were determined for those continuous and categorical job physical exposure measures that showed evidence of association with incident cases of any LBP ($p \leq 0.20$). The adjusted model included age, BMI, gender, psychosocial factors (composite APGAR), and past history of any low back pain (one or more episodes of low back pain lasting one or more days) as covariates. Age, gender and BMI were included because these are traditionally used as covariates in musculoskeletal disorder epidemiological studies even though none of these variables showed evidence of association with incidence of any LBP.

Job physical exposure measures included (i) prior work history, (ii) second job, and (iii) current job. Close to forty-four percent of workers in the cohort had job rotation, i.e., performing two or more jobs. There is no clear guidance in the literature on how to quantify physical exposure when a worker performs two or more jobs. Therefore, for the purpose of this report, job physical exposure was expressed in two different ways: (i) exposure from the job that produced highest physical stress of interest, 'highest job,' and (ii) the job that a worked performed most of the time, 'typical job'. Those job physical exposures that could be measured for the entire work shift such as Borg ratings, number of days worked, maximum number of hours worked, etc. were quantified at the worker level.

When job physical exposures were expressed as continuous variables, adjusted models showed evidence of association with certain physical exposure measures. These included total days worked per week ($p = 0.03$), minimum vertical height when lifting/lowering maximum weights, lifting frequency for the highest job, Composite Lifting Index for the highest job ($p = 0.002$) and Composite Lifting Index for the typical job ($p = 0.01$). Percent of time spent with trunk bent greater than $20°$ showed suggestive evidence of association with incidence of any LBP ($p = 0.10$). However, the hazard ratios were too small to be meaningful for practical applications.

Major findings when job physical exposures were considered as categorical variables in the adjusted Cox regression model are summarized in Tables 4.1 to 4.4 and are discussed below.

4.4.1. Prior Work History:
Prior peak Borg Ratings (CR10) showed suggestive evidence of association with incidence of any LBP ($p = 0.18$ for $1 > CR10 \le 3$ and $p = 0.16$ for $3 > CR10 \le 7$) (Table 4.1).

4.4.2. Second Job:
There was evidence of association between more than three years working on a second job and incidence of any LBP ($p = 0.03$), and there was suggestive evidence of association between less than or equal to 0.5 year on second job and incidence of any LBP ($p = 0.17$). There was suggestive evidence of association for working more than 20 hours per week ($p = 0.16$) or for greater than 60 Borg-hours ($p = 0.19$) on second job with incident cases of any LBP (Table 4.1).

While prior work history and having a second as a potential risk factors for LBP are important findings in the context of this study, it is difficult to assess their overall importance due to lack of quantitative data on these factors in the literature.

Table 4.1: Adjusted Analyses for Previous Exposure and Second Job Exposure Measures

Variable	Category	n	Hazard Ratio	95% C.I.	p-Value
Previous Exposure Measures					
	Model:		---	---	0.141
	≤ 1		1.000	---	---
Peak Borg Rating	> 1 - ≤ 3		1.791	0.757 – 4.236	0.184
	> 3 - ≤ 7		1.819	0.790 – 4.189	0.160
	> 7		0.898	0.308 – 2.621	0.844
Covariates					
Age (continuous)		422	0.999	0.986 – 1.012	0.879
BMI (continuous)		422	1.000	0.975 – 1.025	0.985
Gender (ref: males)		422	0.750	0.536 – 1.050	0.094
APGAR Composite (continuous)		422	1.076	1.025 – 1.129	0.003
Previous LBP Lasting > 1 Day (ref: no)		422	1.608	1.141 – 2.266	0.007
Second Job Measures					
	Model:	443	---	---	0.194
Years on Second Job (Years)	≤ 0.5	414	2.013	0.747 – 5.427	0.167
	> 0.5 - ≤ 3.0	17	1.000	---	---
	> 3	12	3.816	1.149 – 12.679	0.029
Covariates					
Age (continuous)		443	1.002	0.989 – 1.015	0.789
BMI (continuous)		443	1.006	0.981 – 1.031	0.649
Gender (ref: males)		443	0.799	0.574 – 1.110	0.181
APGAR Composite (continuous)		443	1.077	1.027 – 1.129	0.002
Previous LBP Lasting > 1 Day (ref: no)		443	1.619	1.165 – 2.252	0.004
	Model:	446	---	---	0.158
Hours Worked/Week	< 20	439	1.000	---	---
(hours/week)	> 20	7	1.918	0.777 – 4.734	0.158
Covariates					
Age (continuous)		446	1.001	0.988 – 1.014	0.158
BMI (continuous)		446	1.004	0.980 – 1.029	0.726
Gender (ref: males)		446	0.811	0.585 – 1.124	0.208
APGAR Composite (continuous)		446	1.076	1.026 – 1.128	0.002
Previous LBP Lasting ≥ 1 Day (ref: no)		446	1.637	1.180 – 2.271	0.003
	Model:	446	---	---	0.186
Borg-Hours	< 60	442	1.000	---	---
	> 60	4	2.178	0.688 – 6.897	0.186
Covariates					
Age (continuous)		446	1.001	0.988 – 1.014	0.848
BMI (continuous)		446	1.003	0.979 – 1.028	0.805
Gender (ref: males)		446	0.805	0.581 – 1.116	0.193
APGAR Composite (continuous)		446	1.079	1.029 – 1.131	0.002
Previous LBP Lasting ≥ 1 Day (ref: no)		446	1.628	1.173 – 2.258	0.004

4.4.3. Current Job (Worker Level):

There was suggestive evidence of association for certain levels of delta Borg ratings (an increase in Borg rating for low back from beginning of shift to end of shift) with incidence of any LBP. These categories were: (i) $0 >$ delta Borg ≤ 3 and (ii) $4 >$ delta Borg ≤ 5 ($p \leq 0.19$). Lifting maximum weights at near floor level (vertical height ≤ 5") (p

= 0.11) showed suggestive evidence of association and lifting at a greater than 52" (p < 0.01) showed evidence of association with incidence of any LBP (Table 4.2).

Table 4.2: Adjusted, Analyses for Job Physical Exposure Measures at the Worker Level

Variable	Category	n	Hazard Ratio	95% C.I.	p-Value
Highest Job					
	Model:	*438*	---	---	*0.079*
Lifting Frequency (lifts/min)	< 4	282	1.000	---	---
	> 4	156	1.321	0.968 – 1.804	0.079
Covariates					
Age (Continuous)		438	1.002	0.990 – 1.016	0.711
BMI (Continuous)		438	1.003	0.978 – 1.028	0.829
Gender (ref: male)		438	0.786	0.565 – 1.094	0.153
APGAR Composite (continuous)		438	1.075	1.024 – 1.128	0.003
Previous LBP Lasting ≥ 1 Day (ref: no)		438	1.600	1.149 – 2.227	0.005
	Model:	*378*	---	---	*0.115*
TWA Borg CR-10	≤ 0.7	27	1.000	---	---
	> 0.7 – < 2.0	91	2.728	0.965 – 7.707	0.058
	> 2.0	260	2.897	1.062 – 7.900	0.038
Covariates					
Age (Continuous)		378	1.002	0.988 – 1.016	0.799
BMI (Continuous)		378	1.007	0.981 – 1.033	0.608
Gender (ref: male)		378	0.637	0.437 – 0.928	0.019
APGAR Composite (continuous)		378	1.075	1.021 – 1.131	0.006
Previous LBP Lasting ≥ 1 Day (ref: no)		378	1.811	1.240 – 2.646	0.002
Typical Job					
	Model:	*438*	---	---	*0.146*
Lifting Frequency (lifts/min)	< 4	323	1.000	---	---
	> 4	115	1.281	0.918 – 1.787	0.146
Covariates					
Age (Continuous)		437	1.003	0.990 – 1.016	0.703
BMI (Continuous)		437	1.003	0.979 – 1.028	0.781
Gender (ref: male)		437	0.797	0.573 – 1.108	0.177
APGAR Composite (continuous)		437	1.072	1.022 – 1.125	0.004
Previous LBP Lasting ≥ 1 Day (ref: no)		437	1.573	1.130 – 2.189	0.007
	Model:	*370*	---	---	*0.216*
TWA Borg CR-10	≤ 0.7	33	1.000	---	---
	> 0.7 – ≤ 2.0	107	1.893	0.844 – 4.248	0.121
	> 2.0	230	1.994	0.921 – 4.314	0.080
Covariates					
Age (Continuous)		370	1.002	0.988 – 1.017	0.736
BMI (Continuous)		370	1.005	0.978 – 1.032	0.726
Gender (ref: male)		370	0.674	0.461 – 0.984	0.041
APGAR Composite (continuous)		370	1.082	1.027 – 1.140	0.003
Previous LBP Lasting ≥ 1 Day (ref: no)		370	1.786	1.213 – 2.629	0.003

4.4.4. Current Job (Job Level):

There was suggestive evidence that lifting/lowering more than 4 times/min is associated with incidence of any LBP (p = 0.08 for the highest job and p = 0.15 for the typical job). For the highest job, there was evidence that time weighted Borg-CR 10 rating (TWA Borg) of more than 2 was associated with incidence of any LBP (p = 0.04), and similar suggestive evidence for the typical job TWA Borg (p = 0.08). There was suggestive evidence that TWA Borg of greater than 0.7 and less than or equal to 2 was associated with incidence of any LBP for both the highest job (p = 0.06) and the typical job (p = 0.12).

Biomechanical Measures:

This study found no evidence of association between peak compressive force and incidence of any LBP, nor peak moment and incidence of any LBP. Thus, this study could not support the findings reported in the literature that peak compressive force and peak moments are associated with increased risk of incidence of any LBP (Chaffin and Park 1973, Herrin et al 1986, Marras et al. 1993). However, there was evidence of association between cumulative trunk flexion/extension moment of between greater 7000 in-lbs-sec/min and less than or equal to 10,000 in-lbs-sec/min and incidence of any LBP for both the highest job (p < 0.01) and the typical job (p = 0.02) (Table 4.3). The findings that cumulative moments both on the highest and typical jobs were associated are consistent with those reported by (Norman et al. 1998). Similarly, there was suggestive evidence that the cumulative compressive force was associated with incidence of any LBP for both the highest job (p = 0.11) and the typical job (p = 0.12). These findings are consistent with those reported by Kumar 1990 and Norman et al. 1998).

Repeated sub failure loads lead to tissue fatigue. This reduces the tissue failure tolerance (Adams and Hutton 1985, Brinckmann et al. 1988, McGill 1997). Norman et al. (1998) determined the relative importance of modeled peak spine loads, hand loads, trunk kinematics and cumulative spine loads as predictors of reported low back pain. These physical exposures were analyzed on 130 randomly selected controls and 104 cases. The authors identified four independent risk factors: integrated lumbar moment over a shift, usual hand force, peak shear force at L4/L5 and peak trunk velocity. In the multivariate logistics the odds ratios (ORs) for these four factors were 4.5, 10.5, 4.7 and 5.8. Substitution of compressive force or moment for shear force did not appreciable change odds ratios. Workers in the top 25% of loading exposure on all four risk factors had a more than six fold increase in the risk of reporting low back pain than those in the bottom 25%. The study concluded that cumulative biomechanical variables are important risk factors in the reporting of LBP.

Revised NIOSH Lifting Equation:

The Recommended Weight Limit is designed to protect workers from musculoskeletal injuries to low back and upper extremity (shoulder, elbow and wrist). In general, based upon biomechanical principles, it is believed that the risk of an injury is much greater to upper extremity when loads are lifted/lowered at approximately higher than knuckle height. Similarly, risk of injury to low back is much greater than that to upper extremity when loads are lifted/lowered at lower heights. Therefore, when analyzing lifting and

106

lowering tasks using the Revised NIOSH Lifting Equation we chose only those lift and lowers that had either origin, destination or both at or below 30" height. It is recognized that 30" height is not a fixed marker and may depend upon the worker and other characteristics of a job.

When cases and non-cases were plotted against Composite Lifting Index (CLI), we noticed that the ratio of cases to non-cases was high for low values of Composite Lifting Index (CLI $\leq$ 0.8). Therefore, in the adjusted Cox regression model five different categories of Composite Lifting Index were considered ($\leq$ 0.8, > 0.8 to $\leq$ 1.1, > 1.1 to $\leq$ 3.0, > 3.0 to $\leq$ 6.0 and >6.0). Cut off limit of about 1 and 3 are based on recommendations from the Revised NIOSH Lifting Equation. The category with the Composite Lifting Index between greater than 0.8 and less than or equal to 1.1 served as the reference group. Analyses based on these categories showed that there is evidence of association between Composite Lifting Index and incident cases of any LBP for all categories of Composite Lifting index (p $\leq$ 0.05) except the highest group (CLI > 6, p $\geq$ 0.20) (Table 4.4).

Table 4.3: Adjusted Analyses for Biomechanical Measures

Variable	Category	n	Hazard Ratio	95% C.I.	p-Value
Highest Job					
	Model:	*413*	---	---	*0.362*
Cumulative Compressive	≤ 400	74	1.314	0.778 – 2.310	0.291
Force / Minute	> 400 - ≤ 670	71	1.000	---	---
(lbs-sec/min)	> 670 - < 4,000	238	1.148	0.723 – 1.822	0.558
	> 4,000	30	1.686	0.895 – 3.175	0.106
Covariates					
Age (Continuous)		413	1.002	0.989 – 1.015	0.788
BMI (Continuous)		413	0.998	0.972 – 1.023	0.850
Gender (ref: male)		413	0.811	0.575 – 1.144	0.233
APGAR Composite (continuous)		413	1.073	1.020 – 1.128	0.006
Previous LBP Lasting ≥ 1 Day (ref: no)		413	1.547	1.101 – 2.176	0.012
	Model:	*413*	---	---	*0.019*
Cumulative Flexion/Extension	< 7,000	376	1.000	---	---
Moment (in-lbs-sec/min)	> 7,000 - ≤ 10,000	17	2.336	1.275 – 4.282	0.006
	>10,0000	20	0.856	0.339 – 1.836	0.690
Covariates					
Age (Continuous)		413	1.004	0.991 – 1.018	0.525
BMI (Continuous)		413	0.999	0.973 – 1.024	0.911
Gender (ref: male)		413	0.812	0.575 – 1.147	0.237
APGAR Composite (continuous)		413	1.069	1.018 – 1.124	0.008
Previous LBP Lasting ≥ 1 Day (ref: no)		413	1.541	1.096 – 2.167	0.013
Typical Job					
	Model:	*413*	---	---	*0.208*
Cumulative Compressive	≤ 400	128	2.238	1.018 – 4.920	0.045
Force / Minute	> 400 - ≤ 670	35	1.000	---	---
(lbs-sec/min)	> 670 - < 4,000	206	1.813	0.834 – 3.938	0.133
	> 4,000	44	2.015	0.843 – 4.814	0.115
Covariates					
Age (Continuous)		413	1.004	0.990 – 1.017	0.592
BMI (Continuous)		413	0.998	0.973 – 1.024	0.869
Gender (ref: male)		413	0.804	0.569 – 1.134	0.213
APGAR Composite (continuous)		413	1.068	1.016 – 1.122	0.010
Previous LBP Lasting ≥ 1 Day (ref: no)		413	1.567	1.114 – 2.203	0.010
	Model:	413	---	---	0.065
Cumulative Flexion/Extension	≤ 7,000	381	1.000	---	---
Moment (in-lbs-sec/min)	> 7,000 - ≤ 10,000	13	2.247	1.131 – 4.465	0.021
	>10,0000	19	0.923	0.430 – 1.978	0.840
Covariates					
Age (Continuous)		413	1.002	0.989 – 1.016	0.763
BMI (Continuous)		413	0.997	0.972 – 1.023	0.827
Gender (ref: male)		413	0.788	0.559 – 1.110	0.173
APGAR Composite (continuous)		413	1.073	1.021 – 1.129	0.006
Previous LBP Lasting ≥ 1 Day (ref: no)		413	1.571	1.117 – 2.210	0.009

Table 4.4: Adjusted Analysis for CLI Measures*

Variable	Category	n	Hazard Ratio	95% C.I.	p-Value
Highest Job					
	Model:	*438*	---	---	*0.094*
	< 0.8	137	3.447	1.076 – 11.042	0.037
CLI for Lifts/Lowers ≤ 30"	> 0.8 - < 1.1	23	1.000	---	---
	>1.1 - <3	177	3.155	0.988 – 10.078	0.053
	> 3 - < 6	85	4.444	1.363 – 14.485	0.013
	≥ 6	16	2.569	0.605 – 10.908	0.201
Covariates					
Age (Continuous)		438	1.002	0.989 – 1.015	0.749
BMI (Continuous)		438	1.003	0.978 – 1.028	0.841
Gender (ref: male)		438	0.861	0.615 – 1.205	0.382
APGAR Composite (Continuous)		438	1.072	1.021 – 1.125	0.005
Previous LBP Lasting > 1 Day (ref: no)		438	1.542	1.105 – 2.151	0.012
Typical Job					
	Model:	*438*	---	---	*0.184*
	< 0.8	172	3.078	1.119 – 8.471	0.030
CLI for Lifts/Lowers < 30"	> 0.8 - < 1.1	30	1.000	---	---
	>1.1 - <3	147	3.230	1.167 – 8.942	0.024
	≥ 3 - < 6	73	3.569	1.248 – 10.205	0.018
	≥ 6	16	2.309	0.609 – 8.747	0.218
Covariates					
Age (Continuous)		438	1.001	0.988 – 1.014	0.862
BMI (Continuous)		438	1.004	0.979 – 1.029	0.768
Gender (ref: male)		438	0.846	0.605 – 1.183	0.329
APGAR Composite (Continuous)		438	1.071	1.021 – 1.124	0.005
Previous LBP Lasting > 1 Day (ref: no)		438	1.523	1.091 – 2.127	0.013

*Hazard ratios and p-values were very comparable for both analyses with all eligible workers and analyses with only those workers who lifted at or below 30-inch heights. Analyses for all eligible workers are shown in this table.

We could not find any study in the literature that has considered lifts/lowers at or below 30" height in the published literature. Other studies have studied relationship between the Revised NIOSH Lifting Equation and LBP without dividing Lifting Indices into different height ranges. These studies have reported significant relationships between Lifting Index and risk of LBP (Wang et al. 1998, Marras et al. 1999a, Waters et al. 1999). When limited to 30" vertical height our results are consistent with those reported in the literature, though the results in the literature are not limited to 30 inch height. Marras et al. (1999a) evaluated the validity and effectiveness of the Revised NIOSH Lifting Equation on 353 industrial jobs representing more than 21 million person-hours of exposure. The results indicated that the NIOSH Lifting Equation was predictive of low back injuries and resulted in an odds ratio of 3.1. Waters found that as the LI increased from 1.0 to 3.0, the odds ratio for low-back pain increased (Waters et al. 1999). Interestingly, the odds ratio was higher when the LI was between 2.0 and 3.0 (2.45) than when the LI was greater than 3.0 (1.45).

It was of interest to determine why the lowest group (CLI ≤ 0.8) had a higher ratio of cases to non-cases when compared to the reference group. A preliminary analysis

showed that the maximum weight lifted in this group of workers had a mean of 16.2 lbs and much lower than the maximum weights lifted in all other categories of the Composite Lifting Index (Table 4.5). Similarly, lifting frequency in this category of Composite Lifting Index was lower than that in any other category (Table 4.5). Strength requirements were relatively low as a greater percent of workers (mean = 71.8%) were capable of lifting and lowering loads as compared to any other category of Composite Lifting Index (Table 4.5). In general, biomechanical stresses (peak compressive force, average compressive force, cumulative compressive force, peak moment on L_5/S_1 disc and cumulative moment at L_5/S_1 disc) were lower in this group of workers (Table 4.5). Thus, it appears that the strength requirements of jobs, biomechanical stresses and physical fatigue (weight x frequency) were lower in this group of workers than those in other categories of CLI. These are the measures of physical exposure that have shown to be associated with the increased risk of reported LBP in the literature. Thus, it appears that factors other than job physical factors might have been responsible for the large number of incidences of any LBP in this group of workers. However, This group of workers did spend a greater percent of time with their trunk flexed more than 20° when compared to the reference group (Table 4.5). The percent of time with trunk flexed more than 20° for those in the CLI less than or equal to 0.8 group was comparable to the percent of time with trunk flexed more than 20° for those in the CLI greater than 1.1 to less than or equal 3.0 group. Percent of time spent with flexed trunk has been reported to be risk factor (Punnett et al. 1991, Hoogendoorn et al. (2000), and is not accounted for in the Revised NIOSH Lifting Equation.

Regarding amount of time spent with trunk flexion as a risk factor, Punnett et al. (1991) conducted a case-referent (95 cases and 124 referents) study in an automobile assembly plant to evaluate the effect of trunk posture on reported low-back pain. The authors reported that back disorders were associated with mild trunk flexion (OR = 4.9), severe trunk flexion (OR = 5.7), and trunk twist or lateral bend (OR = 5.9). Hoogendoorn et al. (2000) reported on the results of a 3-year prospective study of 861 workers employed in 34 companies. Physical workload was assessed by analyses of video-recordings. The authors concluded that trunk flexion and rotation and lifting of loads were moderate risk factors for low back pain. Those workers who worked with trunk flexion $\geq 60°$ for more than 5% of the working time (RR = 1.5), trunk rotation $\geq 30°$ for more than 10% of working time (RR = 1.3) and lifted load ≥ 25 kg more than 15 times per working day (RR = 1.6) were at an increased risk of low back pain.

It should be noted that some of the workers in the group with CLI ≤ 0.8 had clerical and supervisory roles with random job physical demands. In spite of our sincere efforts, often it was not possible to observe and document those random physical exposure demands. It is possible that undocumented job physical exposures were high and might have resulted in the misclassification of some of the workers in this group.

There are other, non-current job related inconsistencies with the workers represented in the CLI ≤ 0.8 group. For example, the group of workers with CLI ≤ 0.8 had been on their second jobs for greater number of years than any other group of workers (Table 4.6). They also had a greater number of hours/week worked on their second jobs as compared

110

to any other group except the highest exposure group (CLI > 6.0) (Table 4.6). The workers in the group with CLI ≤ 0.8 had relatively higher scores on all three psychosocial scales (APGAR, Zung and edge-nervous-tense scales) than those in any other groups (Table 4.6). In terms past LBP history, we reviewed two of the many variables: (i) single longest duration of LBP ever and (ii) and most recent single longest duration of LBP prior at baseline. Both of these measures of past history of LBP were extremely high in this group of workers when compared to those in any other group (Table 4.6).

In summary, based upon a preliminary analysis it appears that job physical demands (including strength, biomechanical stresses and physical fatigue) were relatively low for those workers with LI ≤ 0.8. With the possible exception of percent of time spent with trunk flexed more than 20°, physical factors on their current jobs do not appear to be associated with their LBP. On the other hand, workers in this group had relatively higher psychosocial scores on all three scales and substantially higher measures of history of LBP. They also had relatively greater number of years and hours on their second jobs than the workers in most or all other CLI groups. Some of these factors not associated with job physical demands on their current jobs may be responsible for the relatively large number of incidences of any LBP reported by this group.

When considering the highest exposure group (CLI > 6.0), the sample size for the group was only 16 and may be responsible for the inconsistent results when compared to the other CLI groups. In this group the maximum weight lifted was 48 lbs (Table 4.5). This was higher than the weight lifted by those workers with CLI greater than 1.1 and less than equal to 3.0. Lifting frequency was substantially higher in this group than any other group (Table 4.5). Percent capable population was low (37.7% capable, Table 4.5). Cumulative compressive force and cumulative moment at L_5/S_1 disc were the highest in this group (Table 4.5). Similarly, peak compressive force and peak flexion/extension moment at L_5/S_1 disc were the second highest for the workers in this group as compared to for those in other groups (Table 4.5). Since the physical exposure measures for this group are the highest for this group, it seems possible that self-selection of workers may be partially responsible for relatively low hazard ratios found in this group of workers.

Workers in this group also had the second lowest longest duration of episode of low back pain ever as compared to the workers in other groups (Table 4.6). The workers in this group also had the lowest scores on all three psychosocial scales (APGAR, Zung and edge-nervous-tense scales, Table 4.6).

Table 4.5: Comparison of Select Job Physical Exposure Measures (Mean Values) with CLI scores for Lifts ≤ 30 Inches.

CLI <30" for *Highest* Job	Maximum Weight Lifted (lbs)	Time Spent, Back Bent >20° (%)	Lifting Frequency (lifts/min)	Lifting Frequency ≤30" (lifts/min)	Minimum Capable Population (%)	Peak L_5S_1 Compressive Force (lbs)	Cumulative L_5S_1 Compressive Force (lbs-sec/min)	Peak Flexion/Extension Moment (in-lbs)	Cumulative Flexion / Extension Moment (in-lbs-sec/min)
Highest Job*									
≤ 0.8	16.2	16.3	2.5	0.8	71.8	6.9	1,420	1,311	1,673
> 0.8, < 1.1	27.7	8.8	2.5	0.9	62.3	5.2	1,466	1,363	1,466
> 1.1, < 3	40.5	19.2	3.4	1.7	41.0	6.4	2,538	1,834	2,612
> 3, < 6	66.7	26.2	3.6	2.0	27.2	6.1	2,772	2,412	3,989
> 6	48.3	13.8	8.6	6.3	37.7	3.9	3,446	2,143	7,690
Typical Job									
≤ 0.8		15.9	2.4	0.7	75.6	6.9	1,203	1,244	1,451
> 0.8, < 1.1		8.8	2.0	0.9	65.8	5.2	1,206	1,320	1,429
> 1.1, < 3		15.0	2.2	1.0	54.2	6.4	1,407	1,619	1,649
> 3, < 6		25.0	3.0	1.6	33.3	6.1	2,077	2,254	3,437
> 6		12.5	8.4	6.2	38.1	3.9	3,446	2,081	7,418

* Workers used in the typical CLI categories are from the highest CLI job. Workers Job Physical Exposure Measures for both their highest and typical jobs are based on those workers who were in the highest CLI job.
Measures expressed at the worker (position) level are listed under highest job.

Table 4.6: Comparison of Select Mean Second Job Exposure Measures, History of Low Back Pain Measures, and Psychosocial Measures with Categories of CLI scores for Lifts ≤ 30" for the Highest Job

CLI <30" for *Highest* Job	Years Working Second Job (years)	Hours / Week Working Second Job (hrs/week)	Duration of Longest Episode of Low Back Pain (days)	Duration of Most Recent Episode of Low Back Pain (days)	APGAR (index)	Zung (index)	Tense/Edge/Nervous (index)
≤ 0.8	0.73	2.20	148.4	216.4	5.0	6.9	2.9
> 0.8, < 1.1	0.48	1.80	5.8	8.3	3.9	5.2	2.6
> 1.1, < 3	0.28	1.10	29.3	8.8	4.4	6.4	2.6
> 3, < 6	0.17	0.97	67.8	24.9	4.7	6.1	2.5
> 6	0.13	2.50	8.2	11.3	3.8	3.9	1.9

* Workers used in the typical CLI categories are from the highest CLI job. Workers Job Physical Exposure Measures for both their highest and typical jobs are based on those workers who were in the highest CLI job.
Measures expressed at the worker (position) level are listed under highest job.

112

4.5   Complex Jobs and Job Rotation:

Nearly 44% of workers had job rotation and they rotated between up to 11 jobs. This percentage of workers is comparable to that reported by Jorgensen et al. (2005) who conducted a web-based questionnaire to survey job rotation practices from Midwest US manufacturing companies and reported that 42.7% of the companies used job rotation. Due to a lack of clearly established guidelines or metrics to account for variation in biomechanical exposure from job rotation it has not been possible to integrate physical exposures to the workers over their entire work shifts (Dempsey 1999, Mathiassen 2006). This raises the issue of how to integrate the stresses to the worker across multiple jobs for an entire work shift.

We did analyze peak compressive force and peak flexion/extension trunk moment at L_5/S_1 disc. While we were unable to analyze cumulative compressive force and moment for the entire work shift due to time constraints, we plan to accomplish this in the near future. Regarding the Revised NIOSH Lifting Equation, at present there are no clear guidelines to integrate physical exposure from the entire work shift when a worker performs more than one job. We are in the process of developing a methodology to integrate physical exposure from the entire work shift into a meaningful Cumulative Lifting Index and will also test the methodology proposed by Waters (2007).

Nearly all of the jobs in this study were complex jobs and many of those were part of a job rotation. The most common methods used to reconcile variation in physical exposure within a job cycle are to quantify all job physical demands throughout the cycle based on: peak exposure, average exposure, time or frequency weighted average exposure or cumulative workload. Herrin et al. (1986) concluded that averaging or pooling of stressful and non-stressful tasks tended to obscure the differences between jobs that contributed most to overexertion injuries. Dempsey (1999) and Garg and Kapellusch (2008) reviewed various methods of aggregating multiple tasks into a single exposure metric and found problems with all existing methods. Straker et al. (1996, 1997a, 1997b) compared risk assessed in single manual handling tasks with those in combination tasks using different job evaluation criteria that included maximum acceptable weights, ratings of perceived discomfort and exertion, heart rate, and biomechanical measures. The authors concluded that the use of a single task to estimate the risk in combination tasks was unacceptable. Further, the best predictor in one situation may not be the best predictor in a different situation.

4.6   LBP Outcome and Ineligibles:

As previously stated only the 'any LBP' outcome is presented in this report. This definition is based on a very low threshold of LBP level (first event of *any* LBP lasting at least one day) and a fairly high threshold to become eligible to report the occurrence of 'any LBP' (must be pain free for 90 consecutive days). As such, there were 148 (24.3%) participants who were ineligible to become an incident case (The workers never went pain free for 90 days during follow-up). Thus, we were unable to use data on nearly one out of four subjects who participated in this study. These ineligible subjects may have had an impact on the relationship between job physical exposure and risk of any LBP. We plan to study those ineligible subjects as well as other measures of LBP such as LBP

113

with a minimum pain intensity of 5, LBP lasting at least 3 consecutive days or combination of both as well as relaxing the requirement of a 90 day continuous pain free period that was established a priori. Sample size may dictate what LBP intensity and LBP lasting a minimum number of consecutive days can be studied as we may not have enough power due to small sample size.

4.7 Other Confounders:

We adjusted our model for age, BMI, gender, composite APGAR and one or more episodes of low back pain lasting one or more days as covariates. We were unable to study co-linearity between different measures of past history of LBP nor determine which is the best measure(s) of past history of LBP to include in the adjusted model due to time constraints. Similarly, we were unable to study co-linearity between our three psychosocial scales and determine which is the best scale(s) to include in the adjusted model due to time constraints. As reported we found that some measures of physical exposures on workers' second jobs, Borg-hours from prior history of work and total miles traveled per day may be potential confounders. These measures have not been explored for their inclusion in the adjusted model; again due to time constraints.

4.8 Conclusions:

Based on adjusted models, this study found evidence of association between Composite Lifting Index for those lifts and lowers with their origin, destination or both at or below 30" height and incidence of any LBP, both for the highest and the typical jobs. Similarly this study found evidence of association between cumulative flexion/extension moment at the $L5/S_1$ disc and incidence of any LBP for both the highest and the typical jobs. There was potential evidence of association between cumulative compressive at the $L5/S_1$ disc and incidence of any LBP for both the highest and the typical jobs. There was evidence of association between workers' TWA Borg ratings and incidence of LBP for the highest job, and suggestive evidence for the typical job. There was potential evidence of association between more than 4 lifts/min and incidence of any LBP for both the highest and the typical job.

The adjusted model showed that there is potential evidence of association between certain measures of physical exposure on workers' second jobs and incidence of any LBP. These measures included years on second job, hours worked per week on second job and Borg-hours on second job. Similarly, there was potential evidence of association between peak Borg rating on prior jobs and incidence of any LBP.

Among non-physical factors, univariate analyses showed evidence of association between several measures of past history of LBP and incidence of any LBP. Similarly, the three psychosocial scales studied (modified APGAR, modified Zung and edge-nervous-tense composite scale) showed evidence of association between these scale scores and incidence of any LBP.

Except for total miles traveled/day and one way commuting time to work, there was no evidence of association between any of the demographic variables, anthropometric

114

measures, different hobbies, different physical exercises or medical history other than LBP and incidence 0f any LBP.

The results reported here should be viewed as preliminary as we are continuing to analyze data and correct errors as we find them. Also, we need to study and address other confounders for incident cases of any LBP.

5. References:

1. Adams, M.A. and Hutton, W.C., 1985, Gradual disc prolapse. *Spine*, 10(6): 524-531.

2. Bigos, S.J., Battie, M.C., Spengler, DM, Fisher LD, Fordyce, WE, Hansson, TH Nachemson, Al, Wortley, PT, ., 1991, A prospective study of work perceptions and psychosocial factors affecting report of back injury. Spine, 16(1):1-6.

3. Brage S, Sandanger I, and Nygård J.F. (2007). Emotional distress as a predictor for low back disability: a prospective 12-year population-based study. *Spine, 32(2)*, 269-274.

4. Brinckmann, P., Biggermann, M., and Hilweg, D., 1988, Fatigue fracture of human lumbar vertebrae. Clinical Biomechanics (Bristol, Avon) 3 (Suppl. 1): S1-S23.

5. Chaffin, D.B., Park, K.S., 1973, A longitudinal study of low back pain as associated with occupational lifting factors. *Am. Ind. Hyg. Assoc. J.* 34: 513-525.

6. Clays, E., De Bacquer, D., Leynen, F., Kornitzer, M., Kittel, F., and De Backer, G. (2007). The impact of psychosocial factors on low back pain: longitudinal results from the Belstress study. *Spine, 32(2)*, 262-268

7. Cox DR. (1972) Regression models and life tables (with discussion). *J Roy Statist Soc B*; 34: 187-220.

8. Dempsey, P.G, 1999, Utilizing criteria for assessing multiple-task manual materials handling jobs. *Int. J. of Industrial Ergonomics*, 24: 405-416.

9. Elders L.A and Burdorf A. (2004). Prevalence, incidence, and recurrence of low back pain in scaffolders during a 3-year follow up study. *Spine, 29(6)*, 101-106.

10. Davis K.G. and Heaney C.A. (2000). The relationship between psychosocial work characteristics and low back pain: underlying methodological issues. *Clin Biomech (Bristol, Avon), 15(6)*, 389-406.

11. Fleming TR, Harrington DP (1991). Counting Processes & Survival Analysis. New York: John Wiley & Sons.

12. Garg, A, Kapellusch, JM (2008), Applications of biomechanics for prevention of work related musculoskeletal disorders. *Ergonomics, In Press*

13. Hartvigsen, J., Lings S, Leboeuf-Yde C, and Bakketeig L. (2004). Psychosocial factors at work in relation to low back pain and consequences of low back pain; a systematic, critical review of prospective cohort studies. *Occup. Environ. Med., 61(1),* e2.

14. Herrin, G.D., Jaraieidi, M., and Anderson, C.K., 1986, Prediction of overexertion injuries using biomechanical and psychophysical models. *Am. Ind. Hyg. Assoc. J.,* 47 (6): 322 - 330.

15. Hoogendoorn W.E., van Poppel M.N., Bongers B.W., and Bouter L.M. (2000). Systematic review of psychosocial factors at work and private life as risk factors for back pains. *Spine, 23(16),* 2114-2125.

16. Hoogendoorn W.E., Bongers P.M., de Vet H.C., Houtman I.L., Ariëns G.A., van Mechelen W., and Bouter L.M. (2001). Psychosocial work characteristics and psychological strain in relation to low-back pain. *Scand. J. Work Environ. Health, 27(4),* 258-267.

17. Jorgensen, M., Davis, K. Kotowski, S., Aedla, P., and Dunning, K., 2005, Characteristics of job rotation in the Midwest US manufacturing sector. *Ergonomics,* 48 (15): 1721-1733.

18. Kaplan EL, Meier P. (1958) Nonparametric estimator from incomplete observations. *J Amer Statist Assoc;* 53: 457-81.

19. Kerr M.S., Frank J.W., Shannon H.S., Norman R.W., Wells R.P., Neumann W.P., Bombardier C., and Ontario Universities Back Pain Study Group. Biomechanical and psychosocial risk factors for low back pain at work. *Am J Public Health, 91(7),* 1069-1075.

20. Krause N, Ragland D.R, Fisher J, and Syme S.L. (1998). Psychosocial job factors, physical workload, and incidence of work-related spinal injury: A 5-year prospective study of urban transit operators. *Spine, 23(23),* 2507-2516.

21. Kumar, S., 1990, Cumulative load as a risk factor for back pain. *Spine,* 15(2): 1311-1316.

22. Marras, W.S., Fine, L.J., Ferguson, S.A. and Waters, T.R.,1999, The effectiveness of commonly used lifting assessment methods to identify industrial jobs associated with elevated risk of low-back disorders. *Ergonomics* 42(1): 229-245.

23. Marras, W.S., Lavender, S.A., Leurgans, S.E., Rajulu, S.L., Allread, W.G., Fathallah, F.A., Ferguson, S.A., 1993, The roll of dynamic three-dimensional trunk motion in occupationally-related low back disorders. *Spine* 18(5): 617-628.

24. Mathiassen, S.E., 2006, Diversity and variation in biomechanical exposure: what is it and why would we like to know? *Appl. Ergon.*, 37(4): 419-427.

25. McGill, S.M., 1997, Biomechanics of low back injury: Implications on current practice and the clinic. *J. Biomechanics*, 30(5): 465-475.

26. Miranda H., Viikari-Juntura E., Martikainen R., Takala E.P, & Riihimäki, H. (2002). Individual factors, occupational loading, and physical exercise as predictors of sciatic pain. *Spine, 27(10),* 1102-1109.

27. Norman, R., Wells, R., Neumann, P., Frank, J., Shannon, H., Kerr, M., and the Ontario Universities Back Pain Study Group, 1998, A comparison of peak vs. cumulative physical work exposure risk factors for the reporting of low back pain in the automotive industry. *Clinical Biomechanics*, 13: 561-573.

28. Papageorgiou A.C., Macfarlane, G.J., Thomas E, Croft P.R, Jayson M.I, and Silman A.J. (1997). Psychosocial factors in the workplace—do they predict new episodes of low back pain? Evidence from the South Manchester Back Pain Study. *Spine, 22(10),* 1137-1142.

29. Power C, Frank J, Hertzman C, Schierhout G, Li L. Predictors of low back pain onset in a prospective British study. *Am J Public Health* 2001; 91:1671-1678.

30. Punnett, L., Fine, L.J., Keyserling, W.M., Herrin, G.D., and Chaffin, D.B., 1991, Back disorders and nonneutral trunk postures of automobile assembly workers. *Scand J Work Environ Health*, 17(5): 337-346.

31. Rubin DB. (1976) Inference and missing data. *Biometrika*; 63:581-92.

32. Schneider S, Schmitt H, Zoller S, Schiltenwolf M. Workplace stress, lifestyle and social factors as correlates of back pain: a representative study of the German working population. *Int Arch Occup Environ Health* 2005; 78:253-269.

33. Straker, L.M., Stevenson, M.G., and Twomey, L.T., 1996, A comparison of risk assessment of single and combination manual handling tasks: 1. Maximum acceptable weight measures. *Ergonomics,* 39(1): 128-140.

34. Straker, L.M., Stevenson, M.G., and Twomey, L.T., 1997a. A comparison of risk assessment of single and combination manual handling tasks: 2. Discomfort, rating of perceived exertion and heart rate measures. *Ergonomics,* 40(6): 656-669.

35. Straker, L.M., Stevenson, M.G., Twomey, L.T., and Smith, L.M., 1997b. A comparison of risk assessment and single an combination manual handling tasks: 3. Biomechanical measures. *Ergonomics,* 40: 708-728.

36. Thorbjörnsson C.B., Alfredsson L., Fredriksson K., Michélsen H., Punnett L., Vingård E., Torgén M., and Kilbom A. (2000). Physical and psychosocial factors related to low back pain during a 24-year period. A nested case-control analysis. *Spine, 25(3),* 369-374.

37. Tubach F., Leclerc A., Landre M.F., and Pietri-Taleb F. Risk factors for sick leave due to low back pain: a prospective study. *J. Occup. Environ. Med., 44(5),* 457-458.

38. Van Nieuwenhuyse, A., Somville, P.R., Crombez, G., Burdorf, A., Verbeke, G., Johannik, K., Van den Bergh, O., Masschelein, R., Mairiaux, P., Moens, G.F.; BelCoBack Study Group. (2006). The role of physical workload and pain related fear in the development of low back pain in young workers: evidence from the BelCoBack Study; result after one year of follow up. *Occup. Environ Med. 63(1),* 45-52

39. Wang, M.J.J., Garg, A., Chang, Y.C., Shih, Y.C., Yeh, W.Y., and Lee, C.L., 1998, The relationship between low back discomfort ratings and the NIOSH Lifting Index. *Human Factors,* 40(3): 509-515.

40. Waters TR, Baron SL, Piacitelli LA, Anderson VP, Skov T, Haring-Sweeney M, Wall DK, Fine LJ. Evaluation of the Revised NIOSH Lifting Equation: A cross-sectional epidemiologic study. *Spine* 1999, 24(4): 386-395

41. Waters, TR, Lu, L., Occhipinti, E. (2007). New procedures for assessing sequential manual lifting job using the Revised NIOSH Lifting Equation, *Ergonomics 50(11),* 1-10.

This page is intentionally blank

120

APPENDIX A

An Ergonomic-Epidemiologic Study of the Low Back: Baseline Questionnaire

Directions:

Please answer each question by pointing the arrow with the mouse and clicking with you index finger to either mark "yes" or "no" or to fill in a blank. If you need help or have any questions please ask one of our research assistants. We're happy to help!

An Ergonomic-Epidemiologic Study of the Low Back:
Baseline Questionnaire

1. Your Company's name: _____

2. Department: _____

3. Job Title: _____

4. Age (in tenths) _____ . _____ years (calculated on the computer)

5. Gender: _____ Male _____ Female

6. How long have you worked for <<company name>>? _____ years _____ months

7. How long have you worked at your current job? _____ years _____ months

8. Altogether, approximately how many miles do you travel in a car or bus on an average day? _____ miles

9. Altogether, approximately how many minutes do you spend traveling one way to your job on an average day? _____ Hours _____ Minutes

10. Do you walk on a regular basis **at least twice a month** outside of work? _____ Yes _____ No

   a. If yes,

Type of Exercise	Number of months per year	Average number of times per week	Average number of minutes each time
Walking	Months	Per week	Minutes

   b. Do you do any other exercise outside of work (for example, bicycling, basketball, skiing, or swimming) at least twice a month? _____ Yes _____ No
   If no, skip to question 11.

   a. Which of the following types of exercise (outside of work) do you do?

Type of Exercise	Yes	No	Number of months per year	Average number of times per week	Average number of minutes each time
Aerobics, Jazzercise			Months	Per week	Minutes
Running, Jogging			Months	Per week	Minutes
Bowling			Months	Per week	Minutes
Bicycling			Months	Per week	Minutes
Swimming			Months	Per week	Minutes
Weight Lifting			Months	Per week	Minutes
Baseball			Months	Per week	Minutes
Basketball			Months	Per week	Minutes
Football			Months	Per week	Minutes
Soccer			Months	Per week	Minutes
Racquetball			Months	Per week	Minutes
Handball			Months	Per week	Minutes
Tennis			Months	Per week	Minutes
Snow Skiing or Snowboarding			Months	Per week	Minutes
Water Skiing or Wave Runner			Months	Per week	Minutes
Hunting			Months	Per week	Minutes
Fishing			Months	Per week	Minutes
Martial Arts (Karate, Judo, etc.)			Months	Per week	Minutes
Other (please list)			Months	Per week	Minutes
Other (please list)			Months	Per week	Minutes

11. Altogether, outside of work, approximately how much time in a usual day do you spend sitting down (e.g. watching TV, reading, using a computer, and/or going to the movies, etc...)? _____ hours _____ min. per day

12. Outside or work do you participate in any activities or hobbies (for example, gardening, snow shoveling, car maintenance or doing housework, etc.) on a regular basis, at least twice a month?

If no, skip to question 13.

Type of Hobby	Yes	No	Number of months per year	Average number of times per week	Average number of minutes each time
Yoga / martial arts / relaxation therapy			Months	Per week	Minutes
Gardening, Landscaping			Months	Per week	Minutes
Snow Shoveling			Months	Per week	Minutes
Maintenance (e.g. car or engine repair), Mechanical Work			Months	Per week	Minutes
Driving a motorcycle or ATV			Months	Per week	Minutes
Snowmobiling			Months	Per week	Minutes
Building and/or repairing furniture or woodworking			Months	Per week	Minutes
Remodeling or building a home			Months	Per week	Minutes
Housework (mopping, cleaning, dusting, etc)			Months	Per week	Minutes
Knit, sewing, needlepoint, crocheting. Or arts and crafts			Months	Per week	Minutes
Other (please specify)			Months	Per week	Minutes
Other (please specify)			Months	Per week	Minutes

13. Have you ever been told by a physician that you have any of the following:

   a. Diabetes: ___ Yes ___ No
       Approximately how many years ago was this diagnosed? _____Years

       With which of the following are you treating the Diabetes?
                                             ____ Insulin
                                             ____ Pills / Oral Agents
                                             ____ Both Insulin and Pills

                                             ____ Diet only (no insulin or
              pills)

   b. Chronic Fatigue Syndrome?   ___ Yes ___ No

   c. Irritable Bowel Syndrome?   ___ Yes ___ No

   d. Thyroid problem: ___ Yes ___ No

   e. Gout: ___ Yes ___ No

   f. Kidney Failure: ___ Yes ___ No

   g. High Blood Pressure: ___ Yes ___ No

   h. High cholesterol (Laboratory test result over 200 mg/dL) ___ Yes ___ No

   i. Hernia (Abdominal or Inguinal hernia, **does not** include herniation of disk
       in neck or back):
       _____Abdominal (Belly Button)
       _____Inguinal (Groin)
       _____Both

14. Have you ever been diagnosed with any other problems?
   a. Other:_____(please specify) ___ Yes ___ No
   b. Other:_____(please specify) ___ Yes ___ No
   c. Other:_____(please specify) ___ Yes ___ No
   d. Other:_____(please specify) ___ Yes ___ No
   e. Other :_____(please specify) ___ Yes ___ No
   f. Other:_____(please specify) ___ Yes ___ No

15. How often do you have back pain and/or back stiffness when getting out of bed in the morning?

_____ Never

_____ Seldom

_____ Often

_____ Always

16. How often do you get back pain and/or back stiffness when driving or riding in a car within 1 hour?

_____ Never

_____ Seldom

_____ Often

_____ Always

17. What is the most you weighed in your life, excluding pregnancy? _____ lbs.

18. What was your weight when you were 20 years old? _____ lbs.

19. Marital Status:

_____ Never married (Single)

_____ Married

_____ Divorced

_____ Separated

_____ Widowed/Widowered

20. What is the highest grade in school that you completed?

_____ 8th grade or less

_____ Some high school

_____ High school graduate or GED

_____ Some college

_____ College graduate (Bachelor's Degree or higher)

21. Have you ever smoked tobacco?

_____ Never

_____ Yes, current

_____ Yes, but smoked in the past

If never, go to question 22…otherwise

How old were you when you started smoking? _____ *years old*

How old were you when you quit smoking? _____ *years old*

On average, how many cigarettes did you smoke per day? _____ *Cigarettes per day*

22. In the past, have you ever had a problem with alcohol? _____ Yes _____ No

a. If yes, approximately how many years ago? _____ Years

23. What is your race/ethnicity is (if you wish to select more than one please either contact a research assistant or select "Other and type in your choices):

_____ Caucasian or White
_____ Hispanic or Latino
_____ African American or Black
_____ Asian
_____ Pacific Islander or Native Hawaiian
_____ Native American or Alaskan Native
_____ Other (please specify)_____
_____ Decline to answer this question.

24. For women only:
Are you currently:

a. Pregnant? ____ Yes ____ No
    i. If yes, when is your due date _____/_____/_____
                                       Month   Day   Year

b. How many times have you been pregnant? _____

c. How many children have you given birth to? _____

25. How many brothers do you have (biological)? _____

26. How many sisters do you have (biological)? _____

27. Has any one in your family (blood relatives only) ever had a pinched nerve, Sciatica, or Lumbar Radiculopathy in the lower back? _____ Yes _____ No

    a. If yes, write in how many of each

Biological Sister(s)		Biological Brother(s)	
Biological Mother		Biological Father	

28. Has any one in your family (blood relatives only) ever been diagnosed Cervical Radiculopathy or a pinched nerve in the neck? _____ Yes _____ No

    a. If yes, write in how many of each

Biological Sister(s)		Biological Brother(s)	
Biological Mother		Biological Father	

128

29. How often do you have family problems that irritate or bother you?

_____ Never

_____ Sometimes

_____ Often

_____ Always

30. How often during the past month have you felt uneasy?

_____ Never

_____ Sometimes

_____ Often

_____ Always

31. How well do you sleep at night?

_____ Very well

_____ Well

_____ Fair

_____ Poorly

_____ Very poorly

32. How often during the past month have you felt "on the edge"?

_____ Never

_____ Sometimes

_____ Often

_____ Always

33. How often during the past month have you felt tense?

_____ Never

_____ Sometimes

_____ Often

_____ Always

34. How often during the past month has your sleep been restless?

_____ Never

_____ Sometimes

_____ Often

_____ Always

35. How often are you physically exhausted after work?

_____ Never

_____ Sometimes

_____ Often

_____ Always

36. How often are you <u>mentally</u> exhausted after work?

    ____ Never
    ____ Sometimes
    ____ Often
    ____ Always

37. How often during the past month have you felt "down", blue or depressed?

    ____ Never
    ____ Sometimes
    ____ Often
    ____ Always

38. How often during the past month have you felt nervous or anxious?

    ____ Never
    ____ Sometimes
    ____ Often
    ____ Always

The next group of questions pertain to feelings you have concerning your job.

39. All in all, how satisfied are you with your job?

    ____ Very satisfied
    ____ Somewhat Satisfied
    ____ A little satisfied
    ____ Not at all satisfied

40. My job requires working very fast.

    ____ Strongly agree
    ____ Agree
    ____ Disagree
    ____ Strongly Disagree

41. My job requires working very hard (physically).

    ____ Strongly agree
    ____ Agree
    ____ Disagree
    ____ Strongly Disagree

42. I am NOT asked to do an excessive amount of work.

    ____ Strongly agree
    ____ Agree
    ____ Disagree
    ____ Strongly Disagree

43. I have enough time to get the job done.

_____ Strongly agree

_____ Agree

_____ Disagree

_____ Strongly Disagree

44. I am free from conflicting demands that others make.

_____ Strongly agree

_____ Agree

_____ Disagree

_____ Strongly Disagree

45. How much influence or control do you have over the variety of tasks you perform?

_____ Very Much

_____ Much

_____ Moderate Amount

_____ A Little

_____ Very Little

46. How much influence or control do you have over the order in which you perform tasks at work?

_____ Very Much

_____ Much

_____ Moderate Amount

_____ A Little

_____ Very Little

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

_____ Very Much

_____ Much

_____ Moderate Amount

_____ A Little

_____ Very Little

48. How much influence or control do you have over the extent to which you can work ahead and take a short break during work hours?

_____ Very Much

_____ Much

_____ Moderate Amount

_____ A Little

_____ Very Little

49. How firm or hard is the mattress you sleep on?
 _____ Hard
 _____ Medium
 _____ Soft

50. On average, about how many total hours of sleep do you get per night (don't count time you are laying awake or trying to fall asleep)?
 I average _____ total hours of sleep per night

51. Please look at the sleep positions below. Choose and rank up to two that are closest to the positions you think you use at night. If A, B, or C is selected, please indicate which side you sleep on.
 _____ 1st most common _____ right side _____ left side _____ both equally
 _____ 2nd most common _____ right side _____ left side _____ both equally
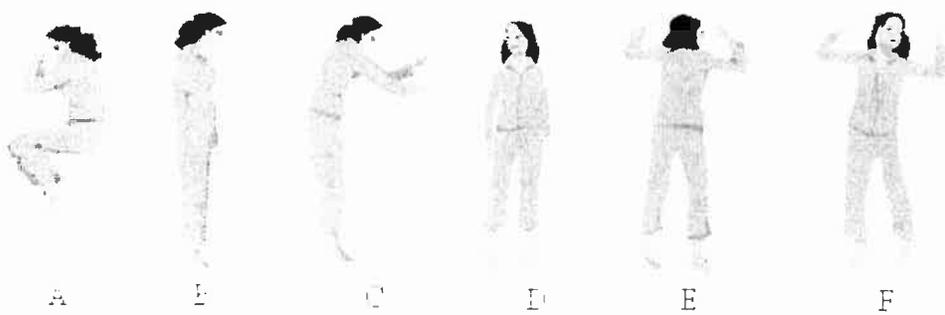
A   B   C   D   E   F

Modified Work APGAR

Please place a checkmark in the box corresponding with how you feel about each of the following statements.

		Almost always	Some of the time	Hardly ever
52.	I am satisfied that I can turn to a fellow worker for help if something is troubling me.			
53.	I am satisfied with the way my fellow workers talk things over with me and share problems with me.			
54.	I am satisfied that my fellow workers accept and support my new ideas and thoughts.			
55.	I am satisfied with the way my fellow workers respond to my emotions, such as anger, sorrow, or laughter.			
56.	I am satisfied with the way my fellow workers and I share time together.			
57.	I enjoy the tasks involved in my job.			
58.	I am satisfied with how well I get along with my closest or immediate supervisor.			

Modified Zung Depression Index

Please indicate for each of the following questions which answer best describes how you have been feeling recently.	Rarely or none of the time (less than 1 day per week)	Some or little of the time (1–2 days per week)	A moderate amount of time (3–4 times per week)	Most of the time (5–7 days per week)
59. I feel downhearted and sad				
60. I feel that nobody cares				
61. I get tired for no reason				
62. I feel that I am useful and needed				
63. I am still able to enjoy those things I used to				
64. I eat as much as I used to				
65. I am more irritable than usual				
66. I feel hopeful about the future				

Thank you for completing the questionnaire.

133

Plant: _____
Subject ID # _____
Date: _____
Time: _____
Examiner 1: _____
Examiner 2: _____

Back Baseline Structured Interview (to be completed on a laptop computer)

1. Have you ever been told by a health care professional (medical doctor/chiropractor) that you have any of the following:

   a. Rheumatoid arthritis, Lupus, or another inflammatory arthritis (not typical Osteoarthritis or Degenerative Arthritis). ___ Yes ___ No
   Approximately how many years ago was this diagnosed? _____ Years

   b. Osteoarthritis or Degenerative Arthritis ___ Yes ___ No

      i. If yes, what joints have been affected? (check all that apply)

☑	Body Part	Which side is affected?			Approximately how many years ago was this diagnosed?
		Right	Left	Both	
☐	Fingers				Years
☐	Wrists				Years
☐	Elbows				Years
☐	Shoulders				Years
☐	Neck				Years
☐	Upper Back				Years
☐	Middle Back				Years
☐	Low Back				Years
☐	Hips	☐	☐	☐	Years
☐	Knees	☐	☐	☐	Years
☐	Ankles	☐	☐	☐	Years
☐	Toes	☐	☐	☐	Years

134

c. Fibromyalgia? ___ Yes ___ No

d. Myofascial Pain Syndrome? ___ Yes ___ No

e. Infection in the back bone (Osteomyelitis). ___ Yes ___ No
What bone(s) were infected:_____(please specify)

f. Osteoporosis:_____ (please specify) ___ Yes
___ No
Please specify what bones were
osteoporotic_____

g. Have you ever had a broken bone or fracture? ___ Yes ___ No

If yes, which bone(s) did you fracture?

Body Part	Check if yes	Right	Left	Bilateral
Foot / Ankle				
Calf / Tibia / Fibula (Lower Leg)				
Thigh / Femur				
Coccyx (Tail Bone)				
Pelvis				
Low Back / Lumbar Spine				
Middle Back / Thoracic Spine				
Neck / Cervical Spine				
Head / Skull				
Sternum (Breast Bone)				
Rib (s)				
Collar Bone / Clavicle				
Upper Arm / Humerus				
Lower Arm / Radius / Ulna				
Wrist				
Finger(s)				

2. Have you **EVER** had an accident or sudden injury to your Neck, Middle, or Lower Back (such as a motor vehicle accident, whiplash, sports injury, fracture, slip, trip, or fall)? ___Yes ___ No

   a. If yes, please give year(s) of each:

Body Part	Approx. Year(s)	Did it occur at work?	Cause (check all that apply)		
Neck		☐ Yes ☐ No ☐ Unsure	☐ MVA ☐ Unsure	☐ Sports ☐ Other_____	☐ Slip, Trip, Fall
Middle Back		☐ Yes ☐ No ☐ Unsure	☐ MVA ☐ Unsure	☐ Sports ☐ Other_____	☐ Slip, Trip, Fall
Lower Back		☐ Yes ☐ No ☐ Unsure	☐ MVA ☐ Unsure	☐ Sports ☐ Other_____	☐ Slip, Trip, Fall

3. Have you ever had surgery on your neck, back, legs, or feet? _____ Yes _____No
   a. If yes, in what body part did you have surgery on?

	Surgery		Describe
Type of Surgery	Yes	No	
Neck			☐ Disk Removal ☐ Vertebral Fusion ☐ Other (specify)
Middle Back			☐ Disk Removal ☐ Vertebral Fusion ☐ Other (specify)
Low Back			☐ Disk Removal ☐ Vertebral Fusion ☐ Laminectomy ☐ Other (specify)
Hip			☐ Hip Replacement ☐ Other (specify)
Knee			☐ Cartilage Removed ☐ Ligament Repair ☐ Knee Replacement ☐ Other (specify)
Foot			☐ Bunions / Corns / Calluses ☐ Other (specify)

4. Have you **ever** been told by a health care professional (physican, chiropractor, etc.) that you have any of the following:

Disorder	Yes	No		Right	Left	Unsure
Neck Strain, Neck Sprain						
Pinched Nerve in the Neck (Cervical Radiculopathy)						
Bulging Disk in the Neck						
Degenerative Spine/Disk disease in the neck (Cervical)						
Lower Back Pain, Lower Back Strain, Lower Back Sprain						
Pinched nerve in the lower back (Sciatica)						
Sacroiliac Joint Dysfunction, Sacroiliitis						
Bulging Disk in the Lower Back						
Degenerative Spine/Disk disease in the low back (Lumbar)						
Spondylolisthesis						
Spina bifida						
Scoliosis						
Problem with Lower Spine / Vertebral Bone Alignment						
Other						
Other						
Other						

The following questions ask about your history of LOW BACK PAIN in your life.

5. Have you EVER had pain in your **Low Back Pain** that **lasted at least 7 days**?

             _____Yes _____No

If answer to question 5 is yes, skip to question 6.

    a. Have you EVER had pain in your **Low Back Pain** that **lasted at least 3 days**?

             _____Yes _____No

If answer to question 5a is no, skip to question 11.

6. About how old were you when you first experienced **Low Back Pain** that lasted at least (3 or 7 depending on question 5) days?

     _____ years old

7. How many episodes of **Low Back Pain** have you <u>ever</u> had lasting at least (3 or 7) days? _____ episodes

   a. Approximately how many of those episodes (answer from #7) lasting at least (3 or 7) days do you estimate were work-related? _____ episodes

   b. How long ago was your **most recent** episode of **Low Back Pain** lasting at least (3 or 7) days?
     _____ Years _____ Months _____ Weeks _____ Days

   c. How long did that **most recent** episode lasting at least (3 or 7) days last?
     _____ Years _____ Months _____ Weeks _____ Days

8. What was the worst **Low Back Pain** you ever experienced? (please refer to pain scale below) .

_____/10
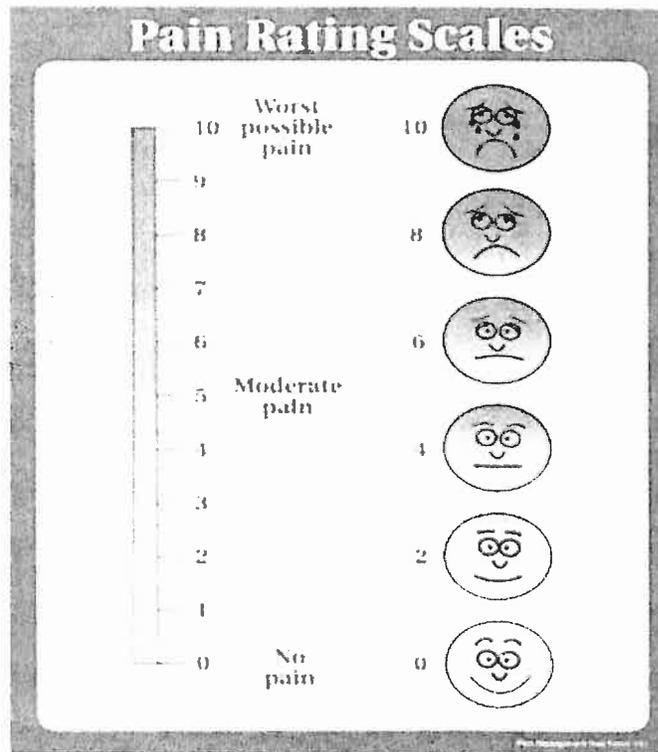
9. How long was the longest episode of **Low Back Pain** that you EVER experienced?
     _____ Months _____ Weeks _____ Days

10. Which of the following treatments or tests have you EVER had for **Low Back**? (check all that apply)

Treatment option	Yes	No	Approximate number of appointments or times
Medical Doctor (M.D.) or Doctor of Osteopathy (D.O.)			Appts.
Chiropractor			Appts.
Physical Therapy (P.T.)			Appts.
Massage Therapist			Appts.
Plain X-Ray			x-ray series
Magnetic Resonance Image (MRI)			MRI scans
Computed Tomography Imaging (CT Scan, CAT Scan)			CT scans
Over the Counter Medications (e.g. Tylenol, Aspirin, Advil, etc.)			Courses of medication
Prescription Non-Narcotic Medications (e.g. prescription of Ibuprophen/Motrin, Vioxx, Celebrex, etc.)			Rx
Prescription of Narcotic Medications (e.g. Lortab, Tylenol with Codeine, Vicodin, etc.)			Rx
Epidural Cortisone Injections			Injx
Work Hardening			Rx for WH
Back Belt / Back Braces			Back Belt / Braces
I don't recall			
No Treatment			

If "Yes" to question 5 then participants will not see questions 11.

11. Have you ever had **Low Back Pain** that lasted **at least 24 hours**? _____ Yes _____ No

    a. If yes, did you see a doctor (MD, DO, or Chiropractor) for these back pain(s)? _____ Yes _____ No

If answer to question 11 is "No", skip to question 15.

12. Not including car or other accidents, did you ever miss work because of **Low Back Pain** you thought was from work?

                                        _____Yes _____No

   a. If yes, approximately how many days have you missed for **Low Back Pain** altogether? _____ days

   b. What was the longest period of time you missed work because of **Low Back Pain**?

       ____ Months ____Weeks ____Days

   c. Did you report the **Low Back Pain** to your employer?

       ____ Yes _____ No

13. Not including car or other accidents, have you ever been on light / restricted / modified duty to **Low Back Pain**?

                                          _____Yes _____No

   a. If yes, approximately how many days have you been on light / restricted / modified duty for **Low Back Pain** altogether?

                     ____ Months ____Weeks ____Days

   b. What was the longest period of time you were on light / restricted / modified duty for **Low Back Pain**?

                     ____ Months ____Weeks ____Days

14. Not including car or other accidents have you ever changed jobs because of **Low Back Pain** other than temporary assignments?

    _____Yes _____No

The following questions ask about your history of MIDDLE BACK PAIN in your life.

15. Have you EVER had pain in your **Middle Back Pain** that **lasted at least 3 days**?

                         ____Yes _____No

    If answer to question 14 is no, skip to question 23.

16. About how old were you when you first experienced **Middle Back Pain** that lasted at least 3 days?

    _____years old

17. How many episodes of **Middle Back Pain** have you ever had lasting at least 3 days?
_____episodes

    a. Approximately how many of those (answer from #16) episodes lasted at least 7 days?
_____episodes

    b. Approximately how many of those episodes (answer from #16 A) lasting at least 7 days do you estimate were work-related? _____episodes

18. What was the worst **Middle Back Pain** you ever experienced? (please refer to pain scale below)

_____/10

Pain Rating Scales
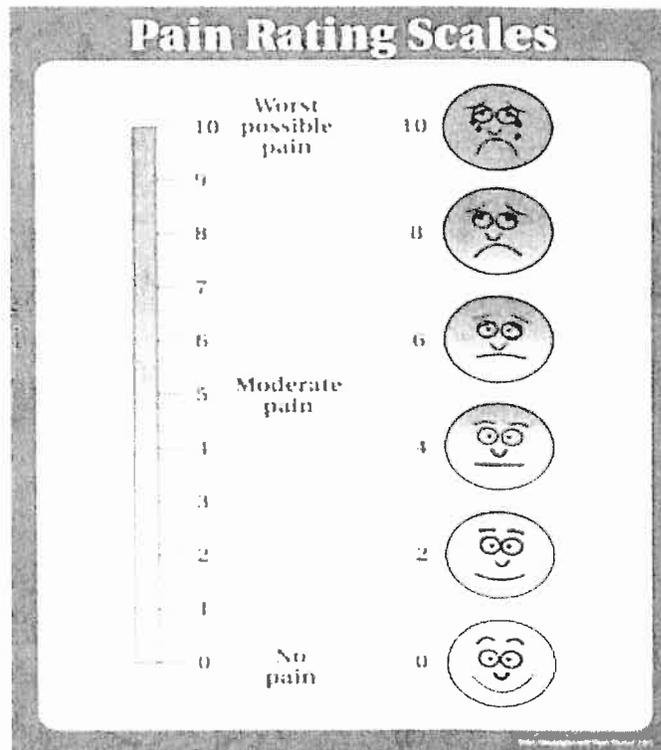
How long was the longest episode of **Middle Back Pain** that you EVER experienced?
_____ Months _____ Weeks _____ Days

19. Which of the following treatments or tests have you EVER had for **Middle Back**? (check all that apply)

Treatment option	Yes	No	Approximate number of appointments or times
Medical Doctor (M.D.) or Doctor of Osteopathy (D.O.)			Appts.
Chiropractor			Appts.
Physical Therapy (P.T.)			Appts.
Massage Therapist			Appts.
Plain X-Ray			x-ray series
Magnetic Resonance Image (MRI)			MRI scans
Computed Tomography Imaging (CT Scan, CAT Scan)			CT scans
Over the Counter Medications (e.g. Tylenol, Aspirin, Advil, etc.)			Courses of medication
Prescription Non-Narcotic Medications (e.g. prescription of Ibuprophen/Motrin, Vioxx, Celebrex, etc.)			Rx
Prescription of Narcotic Medications (e.g. Lortab, Tylenol with Codeine, Vicodin, etc.)			Rx
Epidural Cortisone Injections			Injx
Work Hardening			Rx for WH
Back Belt / Back Braces			Back Belt / Braces
I don't recall			
No Treatment			

20. Not including car or other accidents, did you ever miss work because of **Middle Back Pain** you thought was from work?

_____ Yes _____ No

a. If yes, approximately how many days have you missed for **Middle Back Pain** altogether? _____ days

b. What was the longest period of time you missed work because of **Middle Back Pain**?
_____ Months _____ Weeks _____ Days

c. Did you report the **Middle Back Pain** to your employer?
_____ Yes _____ No

142

21. Not including car or other accidents, have you ever been on light / restricted / modified duty to **Middle Back Pain**?

_____Yes _____No

   a. If yes, approximately how many days have you been on light / restricted / modified duty for **Middle Back Pain** altogether?

_____ Months _____Weeks _____Days

   b. What was the longest period of time you were on light / restricted / modified duty for **Middle Back Pain**?

_____ Months _____Weeks _____Days

Not including car or other accidents have you ever changed jobs because of **Middle Back Pain** other than temporary assignments?

_____Yes _____No

The following questions ask about your history of NECK PAIN in your life.

22. Have you EVER had pain in your **Neck Pain** that **lasted at least 3 days**?

_____Yes _____No

If answer to question 23 is no, skip to question 32.

23. About how old were you when you first experienced **Neck Pain** that lasted at least 3 days?

_____ years old

24. How many episodes of **Neck Pain** have you <u>ever</u> had lasting at least 3 days?

_____episodes

   a. Approximately how many of those (answer from #25) episodes lasted at least 7 days?

_____episodes

   b. Approximately how many of those episodes (answer from #25 A) lasting at least 7 days do you estimate were work-related? _____episodes

   c. How long ago was your **most recent** episode of **Neck Pain** lasting at least 7 days?
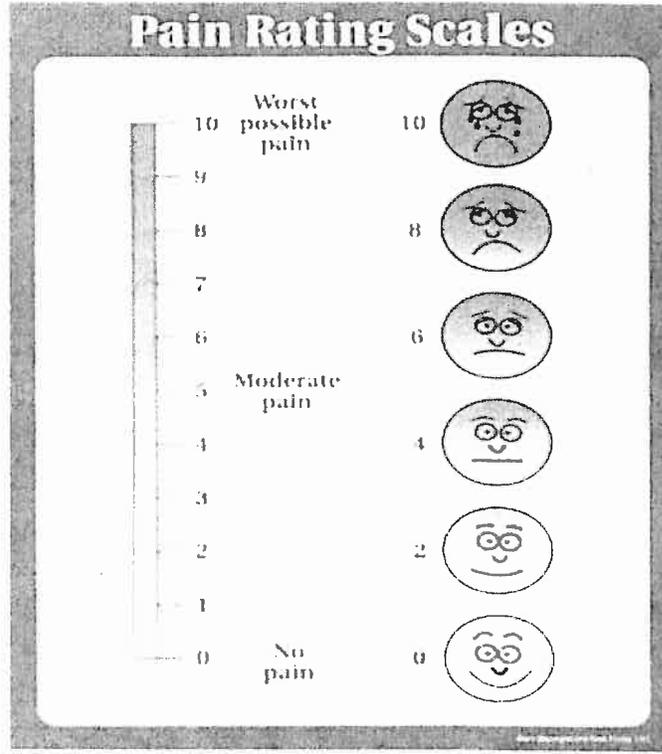
_____ Years _____ Months _____ Weeks _____ Days

   d. How long did that **most recent** episode lasting at least 7 days last?

_____ Years _____ Months _____Weeks _____Days

25. What was the worst **Neck Pain** you ever experienced? (please refer to pain scale below)

_____/10

How long was the longest episode of **Neck Pain** that you EVER experienced?
_____ Months _____Weeks _____Days

26. Which of the following treatments or tests have you EVER had for **Neck Pain**?
(check all that apply)

Treatment option	Yes	No	Approximate number of appointments or times
Medical Doctor (M.D.) or Doctor of Osteopathy (D.O.)			Appts.
Chiropractor			Appts.
Physical Therapy (P.T.)			Appts.
Massage Therapist			Appts.
Plain X-Ray			x-ray series
Magnetic Resonance Image (MRI)			MRI scans
Computed Tomography Imaging (CT Scan, CAT Scan)			CT scans
Over the Counter Medications (e.g. Tylenol, Aspirin, Advil, etc.)			Courses of medication
Prescription Non-Narcotic Medications (e.g. prescription of Ibuprophen/Motrin, Vioxx, Celebrex, etc.)			Rx
Prescription of Narcotic Medications (e.g. Lortab, Tylenol with Codeine, Vicodin, etc.)			Rx
Epidural Cortisone Injections			Injx
Work Hardening			Rx for WH
Back Belt / Back Braces			Back Belt / Braces
I don't recall			
No Treatment			

27. Not including car or other accidents, did you ever miss work because of **Neck Pain** you thought was from work?
_____Yes _____No

a. If yes, approximately how many days have you missed for **Neck Pain** altogether?
_____ days

b. What was the longest period of time you missed work because of **Neck Pain**?
_____ Months _____Weeks _____Days

c. Did you report the **Neck Pain** to your employer?
_____ Yes _____ No

28. Not including car or other accidents, have you ever been on light / restricted / modified duty to **Neck Pain**?

_____ Yes _____ No

a. If yes, approximately how many days have you been on light / restricted / modified duty for **Neck Pain** altogether?

_____ Months _____ Weeks _____ Days

b. What was the longest period of time you were on light / restricted / modified duty for **Neck Pain**?

_____ Months _____ Weeks _____ Days

29. Not including car or other accidents have you ever changed jobs because of **Neck Pain** other than temporary assignments? _____ Yes _____ No

30. PAIN ASSESSMENT

At the current time or at any time in the **past month** have you had any pain, ache, and/or burning, in any of the following body parts? (check all that apply and refer to the body diagram so the worker can note <u>all</u> areas that apply).

Body part	Yes	No	Pain / Ache / Burning in this body part	Average Pain Severity Rating (0-10)	Current (today) Pain / Ache / Burning Symptoms	Total Pain Duration (could be >30 days... e.g. 365 for 1 year)
Neck (A)					☐Yes ☐No	Days
Shoulder(s)						
Interscapular (F)			☐Yes ☐No		☐Yes ☐No	Days
R. Nape of the Neck (C)			☐Yes ☐No		☐Yes ☐No	Days
R. Periscapular (G)			☐Yes ☐No		☐Yes ☐No	Days
R. Shoulder (Glenohumeral) (H)			☐Yes ☐No		☐Yes ☐No	Days
R. Upper Arm (K)			☐Yes ☐No		☐Yes ☐No	Days
L. Nape of the Neck (B)			☐Yes ☐No		☐Yes ☐No	Days
L. Periscapular (E)			☐Yes ☐No		☐Yes ☐No	Days
L. Shoulder (Glenohumeral) (D)			☐Yes ☐No		☐Yes ☐No	Days
L. Upper Arm (I)			☐Yes ☐No		☐Yes ☐No	Days
Middle Back (J)			☐Yes ☐No		☐Yes ☐No	Days
Lower Back						
Lumbar Immediately Paraspinal (M)			☐Yes ☐No		☐Yes ☐No	Days
R. Lumbar (N)			☐Yes ☐No		☐Yes ☐No	Days
L. Lumber (L)			☐Yes ☐No		☐Yes ☐No	Days
R. Gluteal (P)			☐Yes ☐No		☐Yes ☐No	Days
L. Gluteal (O)			☐Yes ☐No		☐Yes ☐No	Days
Legs						
R. Thigh (R)			☐Yes ☐No		☐Yes ☐No	Days
L. Thigh (Q)			☐Yes ☐No		☐Yes ☐No	Days
R. Upper Calf (T)			☐Yes ☐No		☐Yes ☐No	Days
L. Upper Calf (S)			☐Yes ☐No		☐Yes ☐No	Days
R. Lower Calf/foot (V)			☐Yes ☐No		☐Yes ☐No	Days
L. Lower Calf/foot (U)			☐Yes ☐No		☐Yes ☐No	Days

Need to fill out pain diagram

a. If yes, which of the above, if any, were from an accident (e.g. a car accident, slip, trip, fall, etc.)?

31. Have you ever had pain in the lower back or buttock that traveled down a leg into a calf?
_____ Yes _____ No _____ Right _____ Left _____ Both at the same time _____ Both legs at different times

   a. If yes, at it's longest, approximately how long did this type of pain last (mark only if pain in that leg)?
   Right: ___ Days ___ Weeks ___ Months ___ Years **Left:** ___ Days ___ Weeks ___ Months ___ Years

32. Did you have numbness and/or tingling in either of your legs **in the past month**?
Yes _____ No _____
   a. If yes, please mark where in the table below (mark all that apply).

	Yes	No	Left	Right
Thigh (Q & R)				
Lateral Calf (W & Z)				
Medial Calf (X & Y)				
Foot				
Toes				

33. Did the tingling and/or numbness occur at the same time as low back pain? Yes _____ No _____

34. Did the tingling and/or numbness occur only with sitting on a leg and causing it to "fall asleep"?
Yes _____ No _____

35. Have you ever received workers compensation for time off work for a work related injury, whether for the back or any other part of the body? _____ Yes _____ No
   a. If yes, was it for a back related injury? _____ Yes _____ No

Structured Interview Low Back Pain Diagram #1
Typical Low Back Pain in the past month

This is to be completed by anyone indicating pain in Lumbar Immediately Paraspinal **(M)**, Right Lumbar **(N)** Left Lumber **(L)**, Right Gluteal **(P)**, and/or Left Gluteal **(O)**

36. **Circle** the area of the low back where you typically experienced pain **in the past month**.

37. **Mark with an "X"** on the diagram where you experienced the **WORST** pain.

Back Vital Statistics Data Collection

Plant: _____

Subject ID # _____

Date: _____

1. Heart Rate _____ beats/min

2. Blood Pressure _____ mmHg / _____ mmHg
   Systolic   Diastolic

Test	Yes	No
R. Foot Only Toe Raise 10 Times (able to complete task?)		
L. Foot Only Toe Raise 10 Times (able to complete task?)		
Heel Walk 5 Paces on each leg (able to complete task?)		
Toe Walk 5 Paces on each leg (able to complete task?)		

3. Gait (10 paces) __ Normal __ Antalgic
   __ Other describe: _____

4. Chest Circumference _____ cm

5. Waist Circumference _____ cm

6. Hip Circumference _____ cm

7. Measured Middle Finger fingertip to floor distance (knees locked, without shoes)

Finger	Neutral Upright	Lateral Flexion	Forward Spinal Flexion
Right (cm)			
Left (cm)			

8. Goniometer measurements (landmarks are greater Trochanter to the posterior acromion process and middle knee joint)
   a. Neutral   _____ degrees
   b. Full Flexion   _____ degrees
   c. Full Extension   _____ degrees

9. Measured Weight (Without Shoes) _____.__ kg

10. Measured Height (Without Shoes) _____.__ cm

11. Shoulder Width (Lateral Posterior Acromion process tip to Lateral P. Acromion process) _____ cm

12. Hip to Shoulder length (Lateral Iliac crest to Posterior Acromion Process) _____ cm

13. Upper Arm length (Posterior Acromion Process to Upper Olecranon Process) _____ cm

14. Lower Arm length (Upper Olecranon Process to distal 3rd MCP joint) _____ cm

150

15. Horizontal Arm Length (<u>Horizontal</u> From Posterior Acromion to distal 3rd MCP Joint) _____ cm

16. Elbow Height (Upper Olecranon Process to floor, **with shoes**) _____ cm

17. Knee Height (Upper patella to floor, **with shoes**) _____ cm

Back Physical Examination Form (all physicals)

Plant: _____

Subject ID # _____

Date: _____

Body region	Sign	1st Examiner		2nd Examiner	
		+ Present	**–** Absent	**+** Present	**–** Absent
Neck (seated)	R. Spurlings (Right Neck Rotation)				
	L. Spurlings (Left Neck Rotation)				
	Abnormal Cervical ROM (Flexion less than 2 cm from the sternum)				
	Evidence of Neck Surgery / Scar (Anterior or Posterior)				
	Superficial Neck Tenderness				
	General Overreaction to Examination				
Neck (seated)	Simulated Axial Loading				
Back (seated)	Simulated Axial Loading				

Lumbar Back	**Seated Physical Exam Maneuver**	**+** Present	**–** Absent	**+** Present	**–** Absent
	R. "+" **Seated** Straight Leg Raise (Leg Pain below the knee not hamstring tightness, 60° or less)				
	L. "+" **Seated** Straight Leg Raise (Leg Pain below the knee not hamstring tightness, 60° or less)				

Seated Test	1st Examiner	2nd Examiner
R. Patellar Tendon Reflex Grade (0 - 4+)		
L. Patellar Tendon Reflex Grade (0 - 4+)		
R. Achilles Tendon Reflex Grade (0 – 4+)		
L. Achilles Tendon Reflex Grade (0 – 4+)		
R. Extensor Hallicus Muscle Strength Grade (1-5 / 5)	/ 5	/ 5
L. Extensor Hallicus Muscle Strength Grade (1-5 / 5)	/ 5	/ 5

Lumbar Back	Physical Exam Maneuver	+ Present	– Absent	+ Present	– Absent
(recumbent)	R. "+" **Recumbent** Straight Leg Raise (Leg Pain, ≤ 60°)				
	L. "+" **Recumbent** Straight Leg Raise (Leg Pain, ≤ 60°)				
	R. Sacroiliac Joint Stress Test				
	L. Sacroiliac Joint Stress Test				
(standing)	Simulated Rotation (20 to 30 degrees)				
	General Overreaction to Low Back Examination				
	Superficial Low Back Tenderness				
	Evidence of back surgery / scar				

Neck Pain Tender Point Evaluation

Directions: Using 4 kg of force, evaluate all tender points, checking all points where "**pain**" is indicated. **Circle the <u>MOST PAINFUL</u>** of all tender points in the neck (if any).

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Left Sub-Occipital Muscle
Insertions "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Right Sub-Occipital Muscle
Insertions "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Left Middle Upper Trapezius "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Right Middle Upper Trapezius "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Left Levator Scapulae "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Right Levator Scapulae "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
Left Rhomboid
Major "**Pain**"

___/___
1ˢᵗ Ex.   2ⁿᵈ Ex
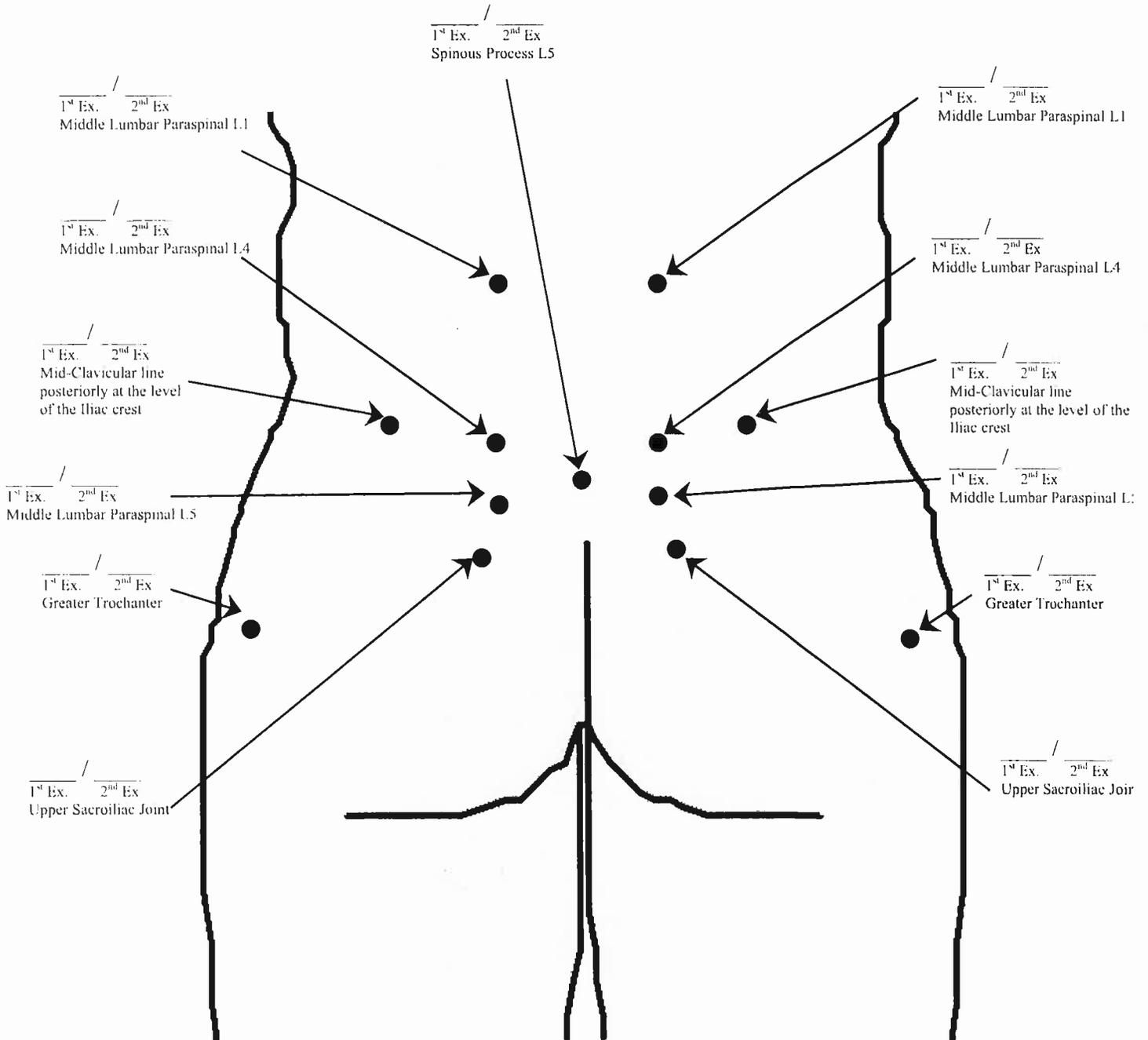Right Rhomboid
Major "**Pain**"

153

Low Back Pain Tender Point Evaluation

Directions: Using 4 kg of force, evaluate all tender points, checking all points where **"pain"** is indicated. **Circle the <u>MOST PAINFUL</u>** of all tender points in the Low Back (if any).

____ / ____
1st Ex.   2nd Ex
Spinous Process L5

____ / ____
1st Ex.   2nd Ex
Middle Lumbar Paraspinal L1

____ / ____
1st Ex.   2nd Ex
Middle Lumbar Paraspinal L4

____ / ____
1st Ex.   2nd Ex
Mid-Clavicular line posteriorly at the level of the Iliac crest

____ / ____
1st Ex.   2nd Ex
Middle Lumbar Paraspinal L5

____ / ____
1st Ex.   2nd Ex
Greater Trochanter

____ / ____
1st Ex.   2nd Ex
Upper Sacroiliac Joint

____ / ____
1st Ex.   2nd Ex
Middle Lumbar Paraspinal L1

____ / ____
1st Ex.   2nd Ex
Middle Lumbar Paraspinal L4

____ / ____
1st Ex.   2nd Ex
Mid-Clavicular line posteriorly at the level of the Iliac crest

____ / ____
1st Ex.   2nd Ex
Middle Lumbar Paraspinal L5

____ / ____
1st Ex.   2nd Ex
Greater Trochanter

____ / ____
1st Ex.   2nd Ex
Upper Sacroiliac Joint

154

18. Signs of Rheumatoid Arthritis _____ Yes _____ No

19. Heberden's Nodes _____ Yes _____ No
    If yes, which joint(s)_____

20. Bouchard's Nodes _____ Yes _____ No
    If yes, which joint(s)_____

Other findings in the physical exam (e.g. Sensory Exam If

Body Part	Test performed	Positive finding	Negative finding	Examiner 1st	2nd

Indicated):

<u>Overall Diagnostic Impression</u>

(check appropriate boxes)

	Yes	No
Past history of **Right** sciatica Right		
Past history of **Left** sciatica		
Current history of **Right** sciatica (**L5 Nerve Root**) Right		
Current history of **Left** sciatica (**L5 Nerve Root**)		
Current history of **Right** sciatica (**S1 Nerve Root**) Right		
Current history of **Left** sciatica (**S1 Nerve Root**)		
Past history of Low Back Pain lasting at least 7 days		
Current history of Low Back Pain lasting at least 7 days		
Other (describe)		

Gender: _____
Date: _____
Last Visit Date : _____
Days Since Last Visit: _____
Time: _____
Plant: _____
Subject ID: _____

Low Back Pain Monthly Questionnaire (to be completed on a laptop computer)

1. Absent _____ Yes _____ No

If Yes, Why is the participant absent? (Please circle all that apply).
Ill / sick, Vacation, FMLA, Surgery / Medical Appt, Laid off, Terminated, Quit,
Declined Participation, Declined participation (this month only),
OTHER....

If quit, terminated, or laid off, when was their last day here?

_____
MM / DD / YYYY

2. **Last time we were here you had pain in**:
All areas of pain from previous month will be checked and previous pain rating present.

☑	Body Part	Previous Pain Rating	Did it go away?	Is it the same?	Present Pain Rating?	Percent of days you have pain?	If the pain stopped how many days ago did it stop?
☐	Lumbar Immediately Paraspinal (M)		Yes /No	Yes /No			
☐	R. Lumbar (N)		Yes /No	Yes /No			
☐	L. Lumbar (L)		Yes /No	Yes /No			
☐	R. Gluteal (P)		Yes /No	Yes /No			
☐	L. Gluteal (O)		Yes /No	Yes /No			
☐	R. Thigh (R)		Yes /No	Yes /No			
☐	L. Thigh (Q)		Yes /No	Yes /No			
☐	R. Upper Calf (T)		Yes /No	Yes /No			

	Body Part					
☐	L. Upper Calf (S)		Yes /No	Yes /No			
☐	R. Lower Calf/foot (V)		Yes /No	Yes /No			
☐	L. Lower Calf/foot (U)		Yes /No	Yes /No			

3. **Last time we were here you had numbness and tingling in:**
   Previous percent of days will be filled in.

☑	Body Part	Previous % of days	Did it go away?	Is it the same?	Precent of days you have N/T?	Does the N/T occur at the same time as the low back pain?
☐	R. Thigh (R)		Yes / No			Yes / No
☐	R. Lateral Calf (Z)		Yes / No			Yes / No
☐	R. Medial Calf (Y)		Yes / No			Yes / No
☐	R. Foot (S)		Yes / No			Yes / No
☐	R. Toes (U)		Yes / No			Yes / No
☐	L. Thigh (Q)		Yes / No			Yes / No
☐	L. Lateral Calf (W)		Yes / No			Yes / No
☐	L. Medial Calf (X)		Yes / No			Yes / No
☐	L. Foot (T)		Yes / No			Yes / No
☐	L. Toes (V)		Yes / No			Yes / No

4. Do you have any <u>NEW PAIN</u> since your last follow-up ___ days ago in your

Body part	Pain / Ache / Burning in this body part	Average Pain Severity Rating (0-10)	Current (today) Pain / Ache / Burning Symptoms	Total Pain Duration
Lumbar Immediately Paraspinal (M)	☐Yes ☐No		☐Yes ☐No	Days
R. Lumbar (N)	☐Yes ☐No		☐Yes ☐No	Days
L. Lumber (L)	☐Yes ☐No		☐Yes ☐No	Days
R. Gluteal (P)	☐Yes ☐No		☐Yes ☐No	Days
L. Gluteal (O)	☐Yes ☐No		☐Yes ☐No	Days

Legs				
R. Thigh **(R)**	☐Yes ☐No		☐Yes ☐No	Days
L. Thigh **(Q)**	☐Yes ☐No		☐Yes ☐No	Days
R. Upper Calf **(T)**	☐Yes ☐No		☐Yes ☐No	Days
L. Upper Calf **(S)**	☐Yes ☐No		☐Yes ☐No	Days
R. Lower Calf/foot **(V)**	☐Yes ☐No		☐Yes ☐No	Days
L. Lower Calf/foot **(U)**	☐Yes ☐No		☐Yes ☐No	Days

PLEASE FILL OUT PAIN DIAGRAM FOR YOUR NEW LOW BACK

5. What do you think caused this New Pain?
   _____ Unsure
   _____ Accident outside of work (slip, trip, fall, MVA, etc.)
   _____ Something outside of work (NOT an accident)
   _____ Accident at work (slip, trip, fall, MVA, etc.)
   _____ Something at work (Not an accident)
   _____ Relapse or aggrivation of previously reported pain

6. When did the Pain occur?
   (Don't answer if cause ="Unsure"
   _____ Sudden (within 30 minutes)
   _____ Same dau (after 30 mimutes)
   _____ Next day or after
   _____ Don't Know

7. Did a job evaluation team study the part of your job related to when/where you were injured?
   _____ Yes
   _____ No
   _____ Not Applicable

8. Do you have any new NUMBNESS/TINGLING in your:

☑	Body Part	Number of days you have had N/T.	How often do you have N/T upon awakening in the morning?	How often do you have N/T at night
☐	R. Thigh (R)			
☐	R. Lateral Calf (Z)			
☐	R. Medial Calf (Y)			
☐	R. Foot (S)			
☐	R. Toes (U)			
☐	L. Thigh (Q)			
☐	L. Lateral Calf (W)			
☐	L. Medial Calf (X)			
☐	L. Foot (T)			
☐	L. Toes (V)			

9. What do you think caused this NUMBNESS/TINGLING?
_____ Unsure
_____ Accident outside of work (slip, trip, fall, MVA, etc.)
_____ Something outside of work (NOT an accident)
_____ Accident at work (slip, trip, fall, MVA, etc.)
_____ Something at work (Not an accident)
_____ Relapse or aggrivation of previously reported pain

10. When did the Numbness/Tingling occur?
(Don't answer if cause ="Unsure"
_____ Sudden (within 30 minutes)
_____ Same dau (after 30 mimutes)
_____ Next day or after
_____ Don't Know

11. Does the N/T occur at the same time as the low back pain?

         _____Yes

         _____No

12. Since your follow-up ____ days ago, have you been on light duty because of Low Back Pain?

         _____Yes

         _____No

If yes, How many days ago or what day did you <u>begin</u> light duty?

_____   _____

month   day   year   days ago

When did you end or will you end working light duty?

_____

month   day   year

13. Since your last follow-up ____ days ago, have you had any lost duty days due to Low Back Pain?

         _____Yes

         _____No

If Yes, How many lost duty days did you have?

         _____days

14. Are you taking any medication or getting any treatment for your pain or numbness/tingling?

_____ Yes

_____ No

If YES, What types of treatment are you using?

☑	Mid-Back	Yes / No
☐	Back Surgery	
☐	Injection in the back	
☐	Back Brace	
☐	Chiropractor	
☐	Physician	
☐	PT or OT	
☑	Low Back	Yes / No
☐	Back Surgery	Yes / No
☐	Injection in the back	Yes / No
☐	Back Brace	Yes / No
☐	Chiropractor	Yes / No
☐	Physician	Yes / No
☐	PT or OT	Yes / No
	Other	
☐	NSAID or OTC Meds	Yes / No
☐	Prescription Meds not NSAID or Narcotic	Yes / No
☐	Prescription, Narcotic / painkillers	Yes / No
☐	Light Duty	Yes / No
☐	Aerobic Exercise	Yes / No
☐	Strength Exercise	Yes / No
☐	Stretching	Yes / No
☐	Other	Yes / No

15. Since we saw you _____ days ago, Have you:

Changed jobs / lines	Yes/No
Changed the number of hours you work	Yes / No
Started using new / different equipment	Yes / No
Changed your rotation schedule	Yes / No
Dhanged your production rate	Yes / No
Other	Yes / No

16. Does the participant complain of a "tired back" even though there is no new or recurrent Low Back Pain?

_____Yes

_____No

17. If you were absent at our last follow-up visit, what day did you return to work?

_____

Month   Day   Year

18. If you were not here the last time we collected monthly follow-up data, why were you absent?

_____ill

_____Vacation

_____Pregnancy

_____Light Duty

_____Injury

_____Surgery or medical appt.

_____Other

Monthly Follow-Up Low Back Pain Diagram #1
Typical Low Back Pain in the past month

This is to be completed by anyone indicating pain in Lumbar Immediately Paraspinal
(M), Right Lumbar **(N)** Left Lumber **(L)**, Right Gluteal **(P)**, and/or Left Gluteal **(O)**

59. **Circle** the area of the low back where you typically experienced pain **in the past month**.

60. **Mark with an "X"** on the diagram where you experienced the **WORST** pain.
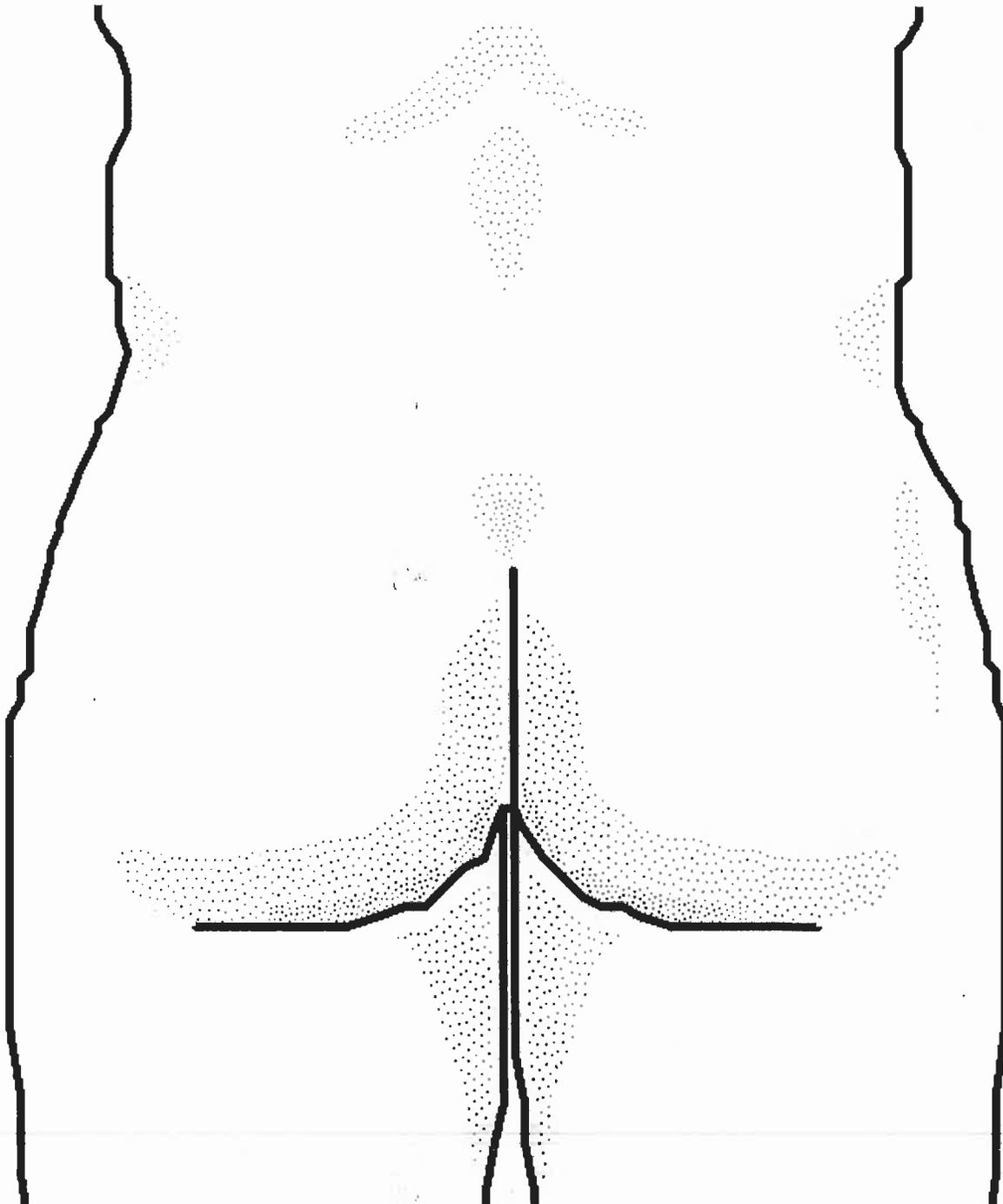
An Ergonomic-Epidemiologic Study of the Low Back: Exit Questionnaire

Directions:

Please answer each question by pointing the arrow with the mouse and clicking with you index finger to either mark "yes" or "no" or to fill in a blank. If you need help or have any questions please ask one of our research assistants. We're happy to help!

An Ergonomic-Epidemiologic Study of the Low Back:
Exit Questionnaire

1. Within the last 5 years, have you been told by a physician that you have diabetes?
   _____ Yes _____ No
   If yes:
   > When were you diagnosed with diabetes?
   > (if unsure, please enter best guess)
   >
   > _____
   > MM/DD/YYYY
   >
   > With which of the following are you treating the Diabetes?
   >
   > _____ Insulin
   > _____ Pills / Oral Agents
   > _____ Both Insulin and Pills
   > _____ Diet only (no Insulin or Pills)
   > _____ Other....

2. On average, about how many total hours of sleep do you get per night
   (don't count time you are laying awake or trying to fall asleep)?
   I average _____ total hours of sleep per night

3. What is your current weight? _____

4. Do you participate in <u>any</u> sports or physical activities on a regular basis? _____ Yes
   _____ No
   If yes:

Type of Exercise	Yes	No	Number of months per year	Average number of times per week	Average number of minutes each time
Aerobics, Jazzercise			Months	Per week	Minutes
Running, Jogging			Months	Per week	Minutes
Walking			Months	Per week	Minutes
Bicycling			Months	Per week	Minutes
Swimming			Months	Per week	Minutes
Weight Lifting			Months	Per week	Minutes
Baseball			Months	Per week	Minutes
Basketball			Months	Per week	Minutes

Football			Months	Per week	Minutes
Racquetball			Months	Per week	Minutes
Handball			Months	Per week	Minutes
Tennis			Months	Per week	Minutes
Snow Skiing or Snowboarding			Months	Per week	Minutes
Water Skiing or Wave Runner			Months	Per week	Minutes
Other (please list)			Months	Per week	Minutes
Other (please list)			Months	Per week	Minutes

Some of the following questions apply only to female participants. Please indicate your gender below.

5. Gender: _____ Male _____ Female
   If Male skip to question 6.

For women only:

a. Are you currently pregnant? _____ Yes _____ No
   If yes, when is your due date _____ / _____ / _____
                                             Month   Day   Year

b. . Have your periods <u>become irregular</u> or <u>stopped</u> or have you experienced things such as <u>hot flashes</u>?
           _____ Yes _____ No
   If yes,
           How many years have you been experiencing these things? _____ Years
           How long has it been since your last period? _____ Months _____ Years

c. Have you ever used Estrogen Replacement or Hormone Replacement Therapy (HRT)?
       _____ Yes _____ No
   If Yes,
           How many years have you used Estrogen Replacement or Hormone Replacement Therapy
           _____ Years
           Did you quit taking Estrogen Replacement or Hormone Replacement
   Therapy in the past year?
           _____ Yes _____ No

6. How often do you have family problems that irritate or bother you?

_____ Never

_____ Sometimes

_____ Often

_____ Always

7. How would you describe your general health compared to others of your own age?

_____ Much better

_____ Somewhat better

_____ The same

_____ Somewhat worse

_____ Much worse

8. How often are you physically exhausted after work?

_____ Never

_____ Sometimes

_____ Often

_____ Always

9. How often are you mentally exhausted after work?

_____ Never

_____ Sometimes

_____ Often

_____ Always

10. All in all, how satisfied are you with your job?

_____ Very satisfied

_____ Satisfied

_____ Neither satisfied nor dissatisfied

_____ Dissatisfied

_____ Very dissatisfied

11. Does your supervisor demonstrate his or her appreciation for the work that you do?

_____ Always

_____ Often

_____ Seldom

_____ Never

12. How Strongly would you recommend your job to someone else?

_____ Strongly recommend

_____ Strongly

_____ Neither recommend or discourage

_____ Discourage

_____ Strongly discourage

13. If you were looking for a new job, how likely is it that you would decide to take this job again?

____Very likely

____Likely

____Neither likely nor unlikely

____Unlikely

____Very Unlikely

14. My employer cares about my health and safety on the job.

____ Strongly agree

____ Agree

____ Neither agree nor disagree

____ Disagree

____ Strongly disagree

15. How well do you sleep at night?

____ Very well

____ Well

____ Fair

____ Poorly

____ Very poorly

16. How often during the past month have you felt nervous or anxious?

____ Never

____ Sometimes

____ Often

____ Always

For each of the following statements, please select the answer which best describes how you feel.

Modified Work APGAR

Please place a checkmark in the box corresponding with how you feel about each of the following statements.

		Almost always	Some of the time	Hardly ever
17.	I am satisfied that I can turn to a co-worker for help if something is troubling me.			
18.	I am satisfied with the way my co-worker talk things over with me and share problems with me.			
19.	I am satisfied that my co-worker accept and support my new ideas and thoughts.			
20.	I am satisfied with the way my co-worker respond to my emotions, such as anger, sorrow, or laughter.			
21.	I am satisfied with the way my co-worker and I share time together.			
22.	I enjoy the tasks involved in my job.			
23.	I am satisfied with how well I get along with my closest or immediate supervisor.			

For each of the following questions, please select the answer which best describes how you have been feeling recently.
Modified Zung Depression Index

Please indicate for each of the following questions which answer best describes how you have been feeling recently.	Rarely or none of the time (less than 1 day per week)	Some or little of the time (1-2 days per week)	A moderate amount of time (3-4 times per week)	Most of the time (5-7 days per week)
24. I feel downhearted and sad				
27. I feel that nobody cares				
28. I get tired for no reason				
29. I feel that I am useful and needed				
30. I am still able to enjoy those things I used to				
31. I eat as much as I used to				
32. I am more irritable than usual				
33. I feel hopeful about the future				

Thank you for taking the time to fill out this questionnaire.

Have a nice day!

170

APPENDIX B

Position / Worker Specific Data Form

1. Subject I.D. _____   6 Date: _____
2. Subject Name: _____   7. Time (24hr): _____
3. ☐Male ☐Female   4   Age: _____   8 Analyst #1: _____
5. Facility: _____   9 Analyst #2: _____

Position Information

10. Line / Department Title:

11. Position Title:

12. Position Description:

13. Typical Shift **Start** Time (24hr)   17 Average Work **Hours**/Week:

14. Typical Shift **End** Time (24hr):   18 Maximum Work **Hours**/Week:

15. Break-Time (Minutes/day):   Minutes   19. Average Work **Days**/Week:

16. # of **Distinct** Jobs Rotated to: 20 Maximum Work **Days**/Week:

21 Note Unusual Schedule Here:

22 Jobs Included in Position:

Job #	Line Cell Workstation	Job Title Description	PACE Self, Line Piece Rate	R/S Hour Handed	Typical Work Hrs/Day	Typical Work % of Week
1			S L P			
2			S L P			
3			S L P			
4			S L P			
5			S L P			
6			S L P			
7			S L P			
8			S L P			

Worker Information

23. Prior Work Experience: Maximum of 10 Years *OR* Maximum of 5 Jobs
(include Current Position and *significantly different* prior positions with *present* employer first)

Position	Title / Description	Years	Average Low Back Borg Rating
Current			
Prior #1			
Prior #2			
Prior #3			
Prior #4			
Prior #5			

24. Do you currently work on a second job outside of this facility? ☐Yes ☐No

25. If Yes, 2nd Job: Title/Description

26. Average Hours/Week on 2nd Job: 27. Number of Years on 2nd Job:

28. Low Back Overall (Average) Borg Rating for 2nd Job:

Worker Estimated Rating (Stress) (Low Back Only)	Worker Rating @ Beg/End (Stress) (Low Back Only)

29. Overall Worker Rating at *Beginning* of Shift (Borg CR-10)

30. Overall Worker Rating at *End* of Shift (Borg CR-10)

31. Analyst Notes (optional)

Job Summary Data Form (Form B)

1. Subject I.D. _____ 2. Job # (From "Position Data Form, Field #23"): _____
   <small>(From Position Form, Field #1)</small>

3. Facility: _____ 4. Date: _____
   <small>(MM/ DD/ YYYY)</small>

5. Data Form Inventory

Data Form 'Name'	Form 'Letter'	Not Used	# of TOTAL Pages
Job Specific Data Form	C		1
Steady State Lifting/Lowering	D		
Variable State Lifting/Lowering	E		
Pushing/Pulling	F		
Walking/Carrying/Holding	G		

6. Summary Notes/Data (include "to-do" for analysis and "issues" with data):

7. Jobs Considered Identical for Data Analysis Purposes

Name	Location	Collected?	Notes:

8. Time Adjustments for Motion Counts / Energy Expenditure

Tape Code	Video Code	Segment Length	Actual Length	Ratio

9. Motion Counts:
   <small>(use handcount)</small>

	W/ Load	W/O Load
# Trunk Flexions (>20°)		
# Trunk Rotations (>45°)		
# Lateral Bend (>10°)		
# 180° Turns		

<small>Form # LB905040004</small>

174

Job Specific Data Form (Form C)

1. Subject I.D. _____
   (From Position Form Field #)
5. Facility: _____

2. Analyst Name(s): _____
6. Time (24hr): _____
   (12:30 pm = 14:30 midnight = 00:00)

3. Observation Time (minutes): _____
7. Date: _____
   (MM/DD/YYYY)

4. Job ID (Plant Official): _____
8. Job # (From 'Position Data Form, Field #22'): _____

Job Overview

9. Specify the *Percentage of Time* Spent in EACH of the Sub-Activities Listed Below:

Manual Material Handling	Assembly (Specify Light or Heavy Assembly)	Paperwork (with or without Computer)	Fork-Truck Riding	Resting/Waiting
_____ %	_____ %	_____ %	_____ %	_____ %
☐Sitting ☐Standing	☐Sitting ☐Standing ☐Light ☐Heavy	☐Sitting ☐Standing	☐Sitting ☐Standing	☐Sitting ☐Standing

10. Specify the *Low-Back Borg CR-10 Rating* for EACH of the Sub-Activities Listed Below:

Manual Material Handling		Assembly		Paperwork (with or without Computer)		Fork-Truck Riding		Resting/Waiting	
Worker	Analyst	Worker	Analyst	Worker	Analyst	Worker	Analyst	Worker	Analyst
CR-10	CR-10	CR-10	CR-10	CR-10	CR-10	CR-10	CR-10	CR-10	CR-10

11. Specify the Single *Most Stressful Low-Back Task* and Associated Borg CR-10 Rating Below:

Task	Worker Rating	Analyst Rating
	CR-10	CR-10

12. Worker Postures (Standing + Sitting = 100%; Back Bent and Squatting are expressed as a sub percentage of standing or sitting i.e. standing = 50%. Back Bent under standing = 100%, means that 100 percent of the time spent standing is in a bent posture. NOTE: Walking is Counted as Standing)

Standing	%	Sitting	%
Back Bent >20°	Squatting	Back Bent (>20°)	
%	%		%

13. Worker Exposed to *Whole Body Vibration*:
☐Yes ☐No

14. Worker Use of *Anti-Fatigue* Mats: ☐Yes ☐No
Anti-Fatigue Mat *Usage Time*: _____ %

15. Use of "*Insoles*" in shoes: ☐Yes ☐No

16. Worker Uses *Back Belt*: ☐Yes ☐No
Back Belt *Available*: ☐Yes ☐No
Has Back Belt *Training*: ☐Yes ☐No

17. Floor: ☐Normal ☐Uneven ☐Slippery
NOTE: Floors can be Uneven & Slippery

18. Work Space (MMH): ☐Open ☐Obstructed
Type of Obstruction: _____

19. Typical Plant *Temperature*:

	January	July
	°C	°C

20. Typical Plant *Humidity*:

	January	July
	%RH	%RH

Form # LB705071004

Lifting/Lowering Steady (Form D)   Subject # _____   Job # _____

Normal Carry Height _____ n

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Object Description:_____ Object Location:_____

☐ Lift ☐ Lower	$W_{(lbs)}$	Box Width (in)	H_{OL} (in)	H_{CR} (in)	V_{o} (in)	H_{DL} (in)	H_{CR} (in)	V_{D} (in)

Date: _____   Page # ____ of ____   Form #LSLLDSD42004

176

Lifting/Lowering Variable (Form E)

Subject # _____   Job # _____

Normal Carry Height _____ in

1. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

2. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

3. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

4. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

5. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

6. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

7. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

8. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

9. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

10. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

11. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

12. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

13. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

14. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

15. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

16. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

17. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

18. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

19. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

20. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

21. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

22. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

23. | W (lbs) | Width (in) | H_c (in) | V_a (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

24. | W (lbs) | Width (in) | H_c (in) | V_c (in) | H_p (in) | V_p (in) |
|---|---|---|---|---|---|
| | | | | | |

Date: _____   Page # ____ of ____

Pushing/Pulling Notes (Form F)   Subject # _____   Job # _____

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Description _____

☐ Push ☐ Pull	Initial Force (lbs)	Sustained Force (lbs)	Hand Height (in)	Distance (ft)	Time (sec)

Date: _____   Page # _____ of _____   LEDPF0408200A

178

Walking/Carrying Notes (Form G)   Subject # _____   Job # _____

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Description _____

☐ Walk	Weight (lbs)	Distance (ft)	Time (sec)
☐ Carry			

Date: _____   Page # _____ of _____

: LIFT LOWER Biomechanical Analysis

Task # _____   : Description _____

: Object Weight: _____ lbs   : Hands: L R B

: Limb Angles:

	Left		Right	
	Horz	Vert	Horz	Vert
Upper Arm	°	°	°	°
Lower Arm	°	°	°	°
Upper Leg	°	°	°	°
Lower Leg	°	°	°	°

: Trunk Angles:

Flexion	°
Axial Rotation R L	°
Lateral Bending R L	°

NOTE: Lifting and then lowering are 2 seperate tasks (one lifting and one lowering).

: LIFT LOWER Biomechanical Analysis

Task # _____   : Description _____

: Object Weight: _____ lbs   : Hands: L R B

: Limb Angles:

	Left		Right	
	Horz	Vert	Horz	Vert
Upper Arm	°	°	°	°
Lower Arm	°	°	°	°
Upper Leg	°	°	°	°
Lower Leg	°	°	°	°

: Trunk Angles:

Flexion	°
Axial Rotation R L	°
Lateral Bending R L	°

NOTE: Lifting and then lowering are 2 seperate tasks (one lifting and one lowering).

: Task #   : Description _____

: Lift Lower

: Separate Hands Yes No   : Even Uneven Stable Unstable

: Hands Left Right Both   : Technique Stoop Semi Squat Side Share

: Object Dimensions   : Number of Lovers

: Observation Duration _____ min

: Total Magnitude _____ lbs   SCD? Yes No

V_o	°	V_{os}	°	V_{od}	°
H_o	°	H_{os}	°	H_{od}	°
L_o	°	L_{os}	°	L_{od}	°
D	°	A_o	°		

: Task #   : Description _____

: Lift Lower

: Separate Hands Yes No   : Even Uneven Stable Unstable

: Hands Left Right Both   : Technique Stoop Semi Squat Side Share

: Object Dimensions   : Number of Lovers

: Observation Duration _____ min

: Total Magnitude _____ lbs   SCD? Yes No

V_o	°	V_{os}	°	V_{od}	°
H_o	°	H_{os}	°	H_{od}	°
L_o	°	L_{os}	°	L_{od}	°
D	°	A_o	°		

PUSH/PULL Biomechanical Analysis

Task # _____

Object Weight: _____ lbs   Hands: L R B

: Limb Angles:

Upper Arm	Left Horz	Left Vert	Right Horz	Right Vert
Upper Arm	o	o	o	o
Lower Arm	o	o	o	o
Upper Leg	o	o	o	o
Lower Leg	o	o	o	o

: Trunk Angles:

Flexion	o
Axial Rotation R L	o
Lateral Bending R L	o

PUSH/PULL Biomechanical Analysis

Task # _____

Object Weight: _____ lbs   Hands: L R B

: Limb Angles:

Upper Arm	Left Horz	Left Vert	Right Horz	Right Vert
Upper Arm	o	o	o	o
Lower Arm	o	o	o	o
Upper Leg	o	o	o	o
Lower Leg	o	o	o	o

: Trunk Angles:

Flexion	o
Axial Rotation R L	o
Lateral Bending R L	o

Task # _____ : Description _____

Activity ☐ Push ☐ Pull

Type of Cart ☐ 4W Cart ☐ 2W Hand Truck ☐ Pallet Jack ☐ Box ☐ Other _____

Hands ☐ Left ☐ Right ☐ Both : Height of Hands _____

Posture ☐ Lean Forward ☐ Lean Back ☐ Lean Side ☐ Stand

Distance per Push/Pull _____ : Time per Push/Pull _____ sec

Initial Force _____ lbs : Sustained Force _____ lbs

Observation Duration _____ : Number of Push/Pulls _____

Task # _____ : Description _____

Activity ☐ Push ☐ Pull

Type of Cart ☐ 4W Cart ☐ 2W Hand Truck ☐ Pallet Jack ☐ Box ☐ Other _____

Hands ☐ Left ☐ Right ☐ Both : Height of Hands _____

Posture ☐ Lean Forward ☐ Lean Back ☐ Lean Side ☐ Stand

Distance per Push/Pull _____ : Time per Push/Pull _____ sec

Initial Force _____ lbs : Sustained Force _____ lbs

Observation Duration _____ : Number of Push/Pulls _____

Date _____ Page # ____ of ____

Walking/Carrying Tasks

Task 1

Task # _____ : Description _____

Activity ☐Walk ☐Carry : Hands ☐Left ☐Right ☐Both

Technique ☐Waist ☐Thighs ☐Side ☐Other _____

Distance per Walk/Carry _____ ft

Time per Walk/Carry _____ sec

Object ☐Box ☐Bag ☐Other _____

Object Weight _____ lbs

Observation Duration _____ min

Number of Walk/Carries _____

Task 2

Task # _____ : Description _____

Activity ☐Walk ☐Carry : Hands ☐Left ☐Right ☐Both

Technique ☐Waist ☐Thighs ☐Side ☐Other _____

Distance per Walk/Carry _____ ft

Time per Walk/Carry _____ sec

Object ☐Box ☐Bag ☐Other _____

Object Weight _____ lbs

Observation Duration _____ min

Number of Walk/Carries _____

Task 3

Task # _____ : Description _____

Activity ☐Walk ☐Carry : Hands ☐Left ☐Right ☐Both

Technique ☐Waist ☐Thighs ☐Side ☐Other _____

Distance per Walk/Carry _____ ft

Time per Walk/Carry _____ sec

Object ☐Box ☐Bag ☐Other _____

Object Weight _____ lbs

Observation Duration _____ min

Number of Walk/Carries _____

Task 4

Task # _____ : Description _____

Activity ☐Walk ☐Carry : Hands ☐Left ☐Right ☐Both

Technique ☐Waist ☐Thighs ☐Side ☐Other _____

Distance per Walk/Carry _____ ft

Time per Walk/Carry _____ sec

Object ☐Box ☐Bag ☐Other _____

Object Weight _____ lbs

Observation Duration _____ min

Number of Walk/Carries _____