# A Cross-Sectional Study of Risk Factors for Musculoskeletal Symptoms in the Workplace Using Data From the General Social Survey (GSS)

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***Objective:*** *Assessments of potential risk factors for musculoskeletal disorders (MSDs) from large, national study populations using personal interviews are critical to our understanding of exposure-response relationships. To address this need, we analyzed two outcome measures—self-reported back pain and upper extremity pain—from the quality of work life (QWL) module of the General Social Survey (GSS). We investigated several individual, psychosocial, and physical factors for their relationship to these outcome measures.* ***Methods:*** *The study population included US adults, noninstitutionalized, English-speaking, aged 18 years or older, and employed at least part time (≥20 hr/wk). Final sample size was 1484 workers.* ***Results:*** *Variables of physical exposure significantly increased the risk of both low back pain and upper extremity pain. Multiple injuries and some psychosocial factors were associated with MSDs, and there was an additive effect on risk of MSDs with exposure to both physical exposure and work stress.* ***Conclusions:*** *A relationship between physical loads and musculoskeletal disorders was indicated by the results, which will enable creating a database for tracking reports of MSDs in the US working population.* (J Occup Environ Med. *2007;49:172–184*)

The study of risk factors affecting musculoskeletal health problems in the workplace has been an important research focus area in recent years. These risk factors have been commonly grouped as individual, physical, and psychosocial or work organizational factors. Individual factors are usually treated as control variables that are accounted for in the study design or treated as statistical covariates (eg, age, gender, education, lifestyle) when their association with the health outcome measures in the study is established. Physical factors primarily refer to the physical demands of a job that can be measured quantitatively (eg, required force, task frequency, weight handled, postural demands) or qualitatively using dichotomous or multiple choice assessment instruments. Psychosocial or work organizational factors are wide ranging and include variables relevant to both the job setting (eg, job content, job control, job satisfaction, organizational climate, supervisor support, safety climate) and private life (eg, family support, social contacts, close friends). These types of factors are almost always measured qualitatively with scales and questions on surveys.

The two most studied work-related musculoskeletal disorders (MSDs) are lower back pain and upper extremity disorders. Numerous studies have examined the relationship between various potential risk factors

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The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the National Institute for Occupational Safety and Health (NIOSH).

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**DOI: 10.1097/JOM.0b013e3180322559**

and measures of back and upper extremity disorders, which include pain in the upper and lower back, hands, wrists, forearms, elbows, neck, and shoulders. Extensive review articles evaluating studies of both lower back and upper extremity disorders have been published.[1–6]

Ferguson and Marras[2] conducted a comprehensive review of the literature examining the relationship between low back disorders and potential risk factors. The authors categorized applicable studies according to five low back health outcome measures (discomfort/symptoms, injuries, incidence, lost time, and restricted time) and five risk factor categories (personal, physical, exposure, psychological, and psychosocial). Based on their review of the selected studies, they reported that a high percentage of studies found a positive association between low back disorders and a number of risk factors, including lifting, high postural demands, frequent number of lifts per day, stressful life events/stress, high mental workload, and low control over work or autonomy. The only two personal factors that showed a positive relationship to low back disorders were previous history of back pain and household income. The authors concluded that some kind of interaction or combined effect between the physical and nonphysical factors is likely, but only a few of the studies actually examined the possible role of an interaction between the different types of risk factors.[2]

Regarding work-related upper extremity musculoskeletal disorders (UEMSDs), it has been difficult to define specific outcome measures that relate to neck pain, and pain in the shoulders, forearms, wrists, and hands. To date, there is no single standardized definition for upper extremity arm pain that is useful in self-report surveys.

Studies examining the effects of individual, physical, and psychosocial factors on various outcome measures for upper extremity disorders have reported mixed results. Numerous investigators have shown a link between physical and psychosocial factors and various UEMSD outcomes.[7–12] Devereux et al,[8] reported that high perceived job stress was an intermediate factor between high exposures (eg, high exposure versus low exposure when responses were dichotomized) to both physical and psychosocial risk factors and self-reported low back, upper back, and hand/wrist complaints, but the follow-up study indicated no increased likelihood of new episodes with high perceived job stress. Results from follow-up studies indicated that high exposure to both physical and psychosocial risk factors increased the likelihood of new reports of upper extremity musculoskeletal disorders.

Two recent nationwide surveys that examined the occurrence of MSDs in Taiwan showed a high prevalence of low back and hand/wrist disorders in the working population. Guo et al[13] conducted a survey of 22,475 non-self-employed workers in Taiwan and found the prevalence of reported MSDs was between 35% and 40%, and that the "lower back and waist" were the most frequently affected body regions (18.3% of males and 19.7% of females reporting low back disorder), followed by shoulder (14.4% of males and 17.4% of females), and hand-wrist problems (10.7% of males and 10.3% of females). In the Guo et al study,[13] however, the authors indicated that their study was limited because "information on many risk factors for MSD was not collected in the survey," including psychosocial and work task loading information. In another nationwide survey conducted in Taiwan, Lee et al[14] surveyed 17,669 workers to examine the prevalence and psychosocial risk factors of upper extremity musculoskeletal pain in industries of Taiwan. After multiple logistic regression modeling adjusted for age, education, and employment duration, Lee and colleagues found that job content, physical working conditions, harmonious interpersonal relationship in the workplaces, and organizational problems were significant determinants of upper extremity disorders in manufacturing and service industries. Unfortunately, the survey did not include specific questions about physical work demands, so the researchers were unable to evaluate the relative contribution of physical and psychosocial stressors on the development of MSDs.

The purpose of the present investigation was to conduct a cross-sectional study of upper extremity and low back musculoskeletal disorders from data collected from a biannual US national survey. Two outcome measures were included in the survey: self-reported back pain, which is referred to as "back pain;" and upper extremity pain, which includes pain in the hands, wrists, arms, or shoulders and is referred to as "pain in arms." Several individual, psychosocial, and physical factors, as well as the effects of the combination of selected factors, were investigated for their relationship to these outcome measures. These individual factors and the combined effects of selected factors were chosen based on their history of relevance in prior studies.

## Materials and Methods

The data analyzed were from the General Social Survey (GSS), a biannual US national survey conducted by the National Opinion Research Center. The GSS target population was a US adult, noninstitutionalized, English-speaking population, each of who were aged 18 years or older. Full probability sampling was employed, and the survey was conducted by computer-assisted personal interviewing (CAPI). Additional details about sample selection, interviewing procedures, and data collection are provided in the Davis study.[15] The GSS has a core module that collects a variety of demographic data and social attitudes but also contains a number of specialized modules. The 2002 GSS survey contained a quality of work life (QWL) module developed by the National Institute for Occupa-

tional Safety and Health (NIOSH) with advice from a panel of experts in organizational behavior, occupational safety and health, and human resource management. The questions and response choices included in the QWL module that were considered to be pertinent to the present study of work-related low back pain and hand wrist pain are listed in Appendix A. The QWL module was administered as a part of the GSS in households across the United States during a face-to-face, 90-minute interview given only to respondents who indicated they were employed for pay in the week previous to the survey or temporarily not working because of vacation, illness, or strike. This analysis resulted in a sample of 1777 respondents who qualified and were interviewed for the QWL module. For the present analysis, the sample only included individuals who were currently employed and worked 20 hours per week or more, resulting in a final sample size of 1484 workers. Depending on the questionnaire item, the number of responses varied slightly for each question. No information about musculoskeletal health outcomes or occupations was obtained from those who did not qualify to participate in the survey (ie, those respondents who were not working at the time of the survey). Table 1 provides a breakdown of occupational categories for the respondents who qualified for the current analysis.

Two questions about the work-related MSD health outcomes (ie, self-reported back pain and upper extremity pain) and two questions about the physical exposures (ie, self-reported exposure to repeated manual material handling and exposure to repetitive or forceful hand movements or awkward posture), were included on the 2002 module. In addition, several individual, physical, and psychosocial factors that are potentially relevant to the occurrence of MSDs were also included in the 2002 module. The risk factors (ie, variables) chosen for analysis (see Appendix A) were based on reviews of previously published reports that indicated significant relationships with back pain and upper extremity pain, or those that we considered to have a significant potential for a relationship. The pertinent questions were included in the following categories: outcome measures ("back pain" and "pain in arms"); physical factors ("heavy lifting" and "hand movement"); individual factors ("age," "gender," and "hurt at work"); and psychosocial factors ("job satisfaction," "work freedom," "supervisor support," "work time," "work fast," "work hours," "must work," "safety climate," "work stress," and "work schedule"). Responses to the questionnaire items ranged from dichotomous choices of "Yes" or "No" to Likert scale items with either one to four or one to five choices. Items with continuous distributions (eg, age, work hours per week, years on current job) were recategorized for analysis purposes. After reliability analysis indicated some of the questions were essentially redundant, the responses from two questionnaire items relating to supervisor support were combined (eg, averaged) to create the data for a single variable, "supervisor support," and the four questionnaire items relating to safety climate were combined (eg, averaged) to create the data for a single variable, "safety climate" (See Appendix A).

We conducted an analysis to determine the frequency of interviewees indicating the two outcome measures ("back pain" and "pain in arms"), by eight occupational classifications. The eight occupational categories were managerial, professional, technical/sales, administrative support, service, farming/forestry/fishing, precision production/laborers, and operators. We selected these eight occupational categories to match historical NIOSH studies of occupations and are similar to the US Bureau of Labor Statistics occupational classifications. We evaluated the differences in reports of the two health outcome measures, "back pain" and "pain in arms," between the eight occupational classifications using a $\chi^2$ test. We also determined the correlation between the reports of "back pain" and "pain in arms" and the percentage of respondents reporting "Yes" to both "back pain" and "pain in arms."

**TABLE 1**
Interviewees' Reports of "Back Pain" and "Pain in Arms" by Occupational Codes

| Occupation | Frequency | % of Study Group | % Reporting "Back Pain" | % Reporting "Pain in Arms" | % Reporting Both "Back Pain" and "Pain in Arms" |
|---|---|---|---|---|---|
| Managerial | 249 | 17.11 | 26.91 | 24.60 | 14.52 |
| Professional | 259 | 17.80 | 20.46 | 22.78 | 10.04 |
| Technical/sales | 221 | 15.19 | 22.62 | 25.34 | 13.12 |
| Administrative support | 181 | 12.44 | 27.62 | 32.60 | 13.81 |
| Service | 190 | 13.06 | 34.21 | 31.58 | 21.58 |
| Farming/forestry/fishing | 23 | 1.58 | 34.78 | 21.74 | 17.39 |
| Precision production/laborers | 155 | 10.65 | 34.84 | 30.32 | 17.42 |
| Operators | 177 | 12.16 | 33.33 | 33.90 | 19.77 |
| Total | 1455 | — | 27.90 | 27.99 | 15.34 |

We calculated odds ratios to determine the significance of the risk for each factor and to evaluate risk trends. We used logistic regression analysis (SAS Version 9.1, SAS Institute, Inc., Cary, North Carolina) to calculate these statistics. Appropriate odds ratios for predicting exposure for each health outcome were also determined for each variable. We performed extensive analysis of the two factor interactions using stepwise regression analysis. We did not believe that additional combinations beyond two-factor interactions would be interpretable. In one model, all risk factors and all levels of response were used, and in another model only the interactions significantly correlated were included. None of the two-factor interactions for "back pain" was significant at the 0.05 alpha level, and only one two-factor interaction for "pain in the arms" was significant (ie, the interaction between "must work" and "work freedom").

Since the initial analyses revealed little significant interaction between the factors, we conducted a second statistical assessment using a dichotomization scheme to evaluate possible effects of combinations of selected variables. This assessment consisted of collapsing the response choices for the variables "job satisfaction," "safety climate," "work stress," "work fast," and "work time" into "Yes" and "No" categories in which responses 1 and 2 were combined as "Yes" and responses 3 and 4 were combined as "No." Note that the "Yes" category for "work time" means that workers indicated that they had enough time to get the work done, so the "No" choice would be least desirable. The choices for "work stress" were dichotomized into "Yes" and "No" by collapsing choices 1 and 2 for "Yes" and choices 3, 4, and 5 for "No" (see Appendix A for response choices for each variable). These variables were chosen for dichotomization because they were thought to be the most likely variables to impact the risk of MSDs. Odds ratios were recalculated with the dichotomized response choices for both outcome measures ("back pain" and "pain in arms") and the effects of the following combinations of factors: "heavy lifting" and "work stress"; "heavy lifting" and "work fast"; "heavy lifting" and "work time"; "hand movement" and "work stress"; "hand movement" and "work fast"; and "hand movement" and "work time."

## Results

Table 1 presents the overall frequency of interviewees indicating "back pain" and "pain in arms" by eight occupational classifications. A $\chi^2$ analysis indicated a significant difference between the different occupational classifications and the reports of "back pain" ($\chi^2 = 21.09$, df = 7.1, $P = 0.0036$). This difference was due to higher percentages of "back pain" reported for the classifications of service, farming/forest/fishing, precision production/laborers and operators, which ranged from 33% to 35%, than managerial, professional, technical/sales, and administrative support, which ranged from 20% to 28%. A similar trend was evident for the outcome measure "pain in arms" but the $\chi^2$ statistic (12.74, df = 7, $P = 0.079$) was not significant. Overall, the percentage of interviewees reporting "Yes" to the "back pain" outcome measure was 27.90%; for "pain in arms," 27.99%.

Although the percentages were similar, the correlation between the reports of "back pain" and "pain in arms," though significant, was only 0.38 ($P < 0.0001$). The percentage of respondents reporting "Yes" to both "back pain" and "pain in arms" was only 15.34%. These results are reassuring because they indicate independence between the two health outcome variables (ie, "back pain" and "pain in arms").

### Back Pain Outcome Measure

Table 2 presents the frequency responses and odds ratios (ORs) for each risk factor for "back pain." The reported values are ORs and 95% Wald confidence limits for the odds ratios. Significant values are indicated in all tables for variables in which the confidence limits of odds ratio values do not include 1.0. The results of the analysis of the variables using the dichotomization scheme and evaluation of possible effects due to combinations of factors for "back pain" are also presented in Table 2. We summarize the results of the various analyses for "back pain" below.

### Individual Factors

As can be seen in Table 2, the only individual risk factor significantly affecting reported "back pain" was "hurt at work" last year. The odds ratio for each level of response for being hurt at work 1, 2, or 3 times or greater compared with being hurt at work 0 times for "back pain" all showed significant increase in risk, with the greatest odds ratio for risk occurring for the hurt category of 3 times or greater (ie, OR = 5.510 [95% CI = 2.773–10.947]). The other individual risk factors (eg, gender, age) did not approach significance.

### Physical Factors

The two physical factors in the analysis, "heavy lifting (ie, repeated lifting, pulling, or pushing)" and "hand movements" (ie, repetitive or stressful hand movements or awkward postures), were highly significant for "back pain." The OR for "heavy lifting" and "back pain" was 2.013 (95% CI = 1.598–2.537). For "hand movement" and "back pain," the OR was 2.47 (95% CI = 1.945–3.135).

### Psychosocial Factors

As can be seen in Table 2, only two of the psychosocial factors, "work fast," and "work schedule," did not show a significant relation-

**TABLE 2**
Risk Factors for "Back Pain"

| Outcome Measure<br>Risk Factors* | Back Pain<br>Yes to Back Pain Freq (%) | Back Pain<br>OR (95% CI) |
|---|---|---|
| **Individual factors‡** | | |
| Hurt at work (How many times were you hurt at work last year?) | | Compared with 0 times |
| 0 ($n$ = 1299) | 326 (25.1) | |
| 1 ($n$ = 106) | 50 (47.2) | 2.665 (1.784–3.981)† |
| 2 ($n$ = 17) | 8 (47.1) | 2.635 (1.015–6.933)† |
| ≥3 ($n$ = 37) | 24 (64.9) | 5.510 (2.773–10.947)† |
| **Physical factors** | | |
| Heavy lifting (Does the job require repeated lifting, pulling, or pushing?) | | yes vs no |
| No ($n$ = 794) | 172 (21.7) | 2.013 (1.598–2.537)† |
| Yes ($n$ = 671) | 240 (35.8) | |
| Hand movement (Does the job require repetitive or stressful hand movements or awkward postures?) | | yes vs no |
| No ($n$ = 714) | 136 (19.0) | 2.47 (1.945–3.135)† |
| Yes ($n$ = 751) | 276 (36.6) | |
| **Psychosocial factors** | | |
| Job satisfaction (How satisfied are you with your job?) | | Compared with very satisfied |
| Very satisfied ($n$ = 721) | 161 (22.3) | |
| Somewhat satisfied ($n$ = 580) | 177 (30.5) | 1.527 (1.191–1.959)† |
| Not too satisfied ($n$ = 113) | 50 (44.3) | 2.761 (1.831–4.163)† |
| Not at all satisfied ($n$ = 48) | 23 (47.9) | 3.200 (1.769–5.788)† |
| Work freedom (Is there freedom to decide how to do your own work?) | | Compared with not at all true |
| Not at all true ($n$ = 66) | 34 (51.5) | |
| Not too true ($n$ = 118) | 31 (26.3) | 0.335 (0.178–0.632)† |
| Somewhat true ($n$ = 453) | 139 (30.7) | 0.417 (0.247–0.702)† |
| Very true ($n$ = 825) | 207 (25.1) | 0.315 (0.190–0.524)† |
| Supervisor support | | Compared with very true. |
| Very true ($n$ = 524) | 126 (24.1) | |
| Somewhat true ($n$ = 614) | 168 (27.4) | 1.190 (0.910–1.555) |
| Not too true ($n$ = 196) | 61 (63.5) | 1.427 (0.993–2.051) |
| Not at all true ($n$ = 102) | 49 (48.0) | 2.920 (1.886–4.521)† |
| Work time (Is there enough time to get the job done?) | | Compared with very true |
| Very true ($n$ = 607) | 161 (26.5) | |
| Somewhat true ($n$ = 580) | 160 (27.6) | 1.055 (0.817–1.363) |
| Not too true ($n$ = 169) | 51 (30.2) | 1.197 (0.823–1.741) |
| Not at all true ($n$ = 106) | 39 (36.8) | 1.613 (1.045–2.489)† |
| Work fast (Does the job require that I work fast?) | | Compared with strongly disagree |
| Strongly disagree ($n$ = 48) | 14 (29.2) | |
| Disagree ($n$ = 477) | 128 (26.8) | 0.891 (0.463–1.714) |
| Agree ($n$ = 619) | 160 (25.9) | 0.847 (0.443–1.618) |
| Strongly agree ($n$ = 317) | 108 (34.1) | 1.255 (0.646–2.439) |
| Work hr (What is the number of hours you worked last week?) | | Compared with ≤40 h |
| ≤40 h ($n$ = 746) | 209 (28.0) | |
| 41–50 h ($n$ = 402) | 124 (30.9) | 1.146 (0.879–1.494) |
| 51–60 h ($n$ = 188) | 35 (18.6) | 0.588 (0.394–0.877)† |
| 61–70 h ($n$ = 69) | 22 (31.9) | 1.203 (0.707–2.045) |
| >71 h ($n$ = 56) | 20 (35.7) | 1.427 (0.808–2.523) |
| Must work (Is it mandatory to work extra hours?) | | yes vs no |
| No ($n$ = 1041) | 262 (25.2) | 1.638 (1.281–2.095)† |
| Yes ($n$ = 411) | 146 (35.5) | |
| Safety climate | | Compared with strongly agree |
| Strongly agree ($n$ = 504) | 126 (25.0) | |
| Agree ($n$ = 713) | 194 (27.2) | 1.121 (0.864–1.455) |
| Disagree ($n$ = 179) | 68 (38.0) | 1.838 (1.279–2.643)† |
| Strongly disagree ($n$ = 65) | 21 (32.3) | 1.432 (0.820–2.501) |
| Work stress (How often is work stressful?) | | Compared with never |
| Never ($n$ = 88) | 20 (22.7) | |
| Hardly ever ($n$ = 255) | 51 (20.0) | 0.850 (0.473–1526) |
| Sometimes ($n$ = 622) | 151 (24.3) | 1.090 (0.641–0.854) |
| Often ($n$ = 350) | 121 (34.6) | 1.797 (1.042–3.098)† |
| Always ($n$ = 148) | 68 (46.0) | 2.890 (1.595–5.235)† |

(*Continued*)

**TABLE 2**
Continued

| Outcome Measure<br>Risk Factors* | Back Pain<br>Yes to Back Pain Freq (%) | <br>OR (95% CI) |
|---|---|---|
| Work schedule | | Compared with day shift |
| Day shift ($n$ = 1078) | 297 (27.6) | |
| Afternoon shift ($n$ = 53) | 18 (34.0) | 1.352 (0.754–2.425) |
| Night shift ($n$ = 94) | 22 (23.4) | 0.804 (0.489–1.319) |
| Split shift ($n$ = 38) | 11 (29.0) | 1.071 (0.525–2.187) |
| Irreg./on call ($n$ = 124) | 38 (30.7) | 1.162 (0.775–1.741) |
| Rotating shifts ($n$ = 73) | 23 (31.5) | 1.210 (0.725–2.018) |
| **Dichotomized variables** | | |
| Job satisfaction (Are you satisfied with your job?) | | no vs yes |
| Yes ($n$ = 1301) | 338 (26.0) | 2.364 (1.693–3.302)† |
| No ($n$ = 161) | 73 (45.3) | |
| Safety climate (Are safety conditions good at work?) | | yes vs no |
| No ($n$ = 244) | 89 (36.5) | 0.621 (0.465–0.830)† |
| Yes ($n$ = 1217) | 320 (26.3) | |
| Work stress (How often is work stressful?) | | yes vs no |
| No 3, 4, 5 ($n$ = 965) | 222 (23.0) | 2.047 (1.619–2.590)† |
| Yes 1, 2 ($n$ = 498) | 189 (38.0) | |
| Work fast (Does the job require that I work fast?) | | yes vs no |
| No ($n$ = 525) | 142 (27.1) | 1.082 (0.852–1.374) |
| Yes ($n$ = 936) | 268 (28.6) | |
| Work time (Is there enough time to get the job done?) | | yes vs no |
| No ($n$ = 275) | 90 (32.7) | 0.762 (0.574–1.011) |
| Yes ($n$ = 1187) | 321 (27.0) | |
| Risk factor combinations: | | Compared with No-No |
| Heavy lifting + work stress 3, 4, 5 | | |
| No-No ($n$ = 517) | 91 (17.6) | |
| No-Yes ($n$ = 277) | 81 (29.4) | 1.935 (1.372–2.729)† |
| Yes-No ($n$ = 448) | 131 (29.4) | 1.935 (1.427–2.623)† |
| Yes-Yes ($n$ = 221) | 108 (48.9) | 4.474 (3.161–6.334)† |
| Interaction: | | 1.195 (0.741–1.930) |
| Heavy lifting + work fast | | Compared with No-No |
| No-No ($n$ = 305) | 68 (22.3) | |
| No-Yes ($n$ = 488) | 104 (21.3) | 0.944 (0.668–1.334) |
| Yes-No ($n$ = 220) | 74 (33.6) | 1.766 (1.198–2.605)† |
| Yes-Yes ($n$ = 448) | 164 (36.6) | 2.013 (1.445–2.803)† |
| Interaction: | | 1.207 (0.743–1.959) |
| Heavy lifting + work time | | Compared with No-Yes |
| No-Yes ($n$ = 636) | 135 (21.2) | |
| No-No ($n$ = 156) | 37 (23.7) | 1.154 (0.762–1.747) |
| Yes-Yes ($n$ = 551) | 186 (33.8) | 1.891 (1.459–2.451)† |
| Yes-No ($n$ = 119) | 53 (44.5) | 2.980 (1.981–4.483)† |
| Interaction: | | 1.366 (0.766–2.434) |
| Hand movement + work stress 3, 4, 5 | | Compared with No-No |
| No-No ($n$ = 491) | 80 (16.3) | |
| No-Yes ($n$ = 223) | 56 (25.1) | 1.723 (1.171–2.534)† |
| Yes-No ($n$ = 474) | 142 (30.0) | 2.197 (1.612–2.995)† |
| Yes-Yes ($n$ = 275) | 133 (48.4) | 4.812 (3.437–6.737)† |
| Interaction: | | 1.271 (0.776–2.082) |
| Hand movement + work fast | | Compared with No-No |
| No-No ($n$ = 301) | 59 (19.6) | |
| No-Yes ($n$ = 412) | 77 (18.7) | 0.943 (0.646–1.375) |
| Yes-No ($n$ = 224) | 83 (37.0) | 2.414 (1.630–3.577)† |
| Yes-Yes ($n$ = 524) | 191 (36.5) | 2.353 (1.682–3.291)† |
| Interaction: | | 1.034 (0.629–1.670 |
| Hand movement + work time | | Compared with No-Yes |
| No-Yes ($n$ = 586) | 110 (18.8) | |
| No-No ($n$ = 126) | 26 (20.6) | 1.125 (0.697–1.816) |
| Yes-Yes ($n$ = 601) | 211 (35.1) | 2.341 (1.793–3.056)† |
| Yes-No ($n$ = 149) | 64 (43.0) | 3.258 (2.217–4.788)† |
| Interaction: | | 1.237 (0.678–2.258) |

*$n$ = number of interviewees with usable data.
†Significant values for variables in which the confidence limits of odds ratio values do not include 1.0.
‡The individual factors of age and gender were not found to be significant.

ship to "back pain" (ie, there was at least one OR value in which the 95% CI did not contain 1.0). The "work time" variable did show a significant OR for the comparison between the "not at all true" response to the "very true" response for the question about having enough time to get the work done (OR = 1.613 [95% CI = 1.045–2.489]). Similarly, the only response within the variable "supervisor support" that had a significant OR was for the response "not at all true" compared to "very true" for the two combined questions: 1) My supervisor is concerned about the welfare of those under him or her, and 2) My supervisor is helpful to me in getting the job done (OR = 2.920 [95% CI = 1.886–4.521]). Also of interest was the finding that the only significant odds ratio for any category of "work hours," was a protective effect for the 51- to 60-hour response category, compared with 40 hours or more per week (OR = 0.588 [95% CI = 0.394–0.877]).

Table 2 also displays the results from the analysis involving the dichotomization scheme and the evaluation of the possible effects of combinations of factors among the potentially significant variables for the "back pain" outcome measure. As can be seen in the table, significant OR values were found for three individual dichotomized variables, "job satisfaction" (OR 2.364 [95% CI = 1.693–3.302]), "safety climate" (OR 0.621 [95% CI = 0.465–0.830]), and "work stress" (OR 2.047 [95% CI = 1.619–2.590]), with "safety climate" showing a protective effect. The OR for the "work fast" and "work time" variables was not significant.

With respect to the analysis of the combinations of dichotomized variables seen in Table 2, several combinations of variables showed an additive effect (on a log scale), but none of the interactions between pairs of variables were statistically significant. For example, the evaluation of various combinations of "heavy lifting" and "work stress 3,4,5" revealed that the OR for "work stress" = Yes and "heavy lifting" = No was 1.935 (95% CI = 1.372–2.729). The OR for "heavy lifting" = Yes and "work stress" = No was 1.935 (95% CI = 1.427–2.623), but the OR for both "work stress" = Yes and "heavy lifting" = Yes combined was 4.474 (95% CI = 3.161–6.334). Clearly, these results show an additive relationship.

## Pain in Arms Outcome Measure

The results for the analysis of the "pain in arms" outcome measure are displayed in Table 3. A summary of the results is listed below.

## Individual Factors

For the outcome measure "pain in arms," the only significant individual risk factor was "hurt at work" last year. Odds ratios for each level of response for this variable (ie, 1, 2, or 3 or greater times hurt at work) were also significant when compared with 0 times hurt at work (see Table 3). The other individual risk factors, gender and age, did not approach significance.

## Physical Factors

The two physical exposure factors in the analysis, "heavy lifting" (ie, repeated lifting, pulling, or pushing) and "hand movement" (ie, repetitive or stressful hand movements or awkward postures), were both significant for the outcome measure of "pain in arms." The OR for the relationship between "heavy lifting" and "pain in arms" was 1.703 (95% CI = 1.354–2.141), and the OR for the relationship between "hand movement and pain in arms" was 2.421 (95% CI = 1.909–3.071).

## Psychosocial Factors

As can be seen in Table 3, all but two of the psychosocial variables included in the analysis were shown to have a significant relationship to the outcome measure "pain in arms." The findings were similar to what was found for "back pain." For the variable "job satisfaction," there was a clear increase in risk as the responses became more negative (ie, as the response went from "very satisfied" to "not at all satisfied"), with a maximum OR of 3.77 (95% CI = 2.086–6.827) for the most negative response compared to the most positive response. Similarly, there was an increase in risk as the responses for the variable "supervisor support" became more negative (ie, moved from "very true" to "not at all true" for the presence of supervisor support). As with "back pain" there appeared to be a weak protective effect for "work hours" for the response category of "51 to 60" hours per week compared to "≤40 hours" per week.

Table 3 also displays the results from the analysis involving the dichotomization scheme and the evaluation of possible effects of combinations of significant variables for the "pain in arms" outcome measure. As can be seen in the table, significant OR values were found for "job satisfaction" (OR = 2.276 [95% CI = 1.629–3.179]), "safety climate" (OR = 0.563 [95% CI = 0.422–0.750]), "work stress" (OR = 2.140 [95% CI = 1.692–2.707]), and "work time" (OR = 0.676 [95% CI = 0.511–0.893]), when examined alone. The OR for the variable "work fast" was not significant. Similar to the findings for "back pain," the OR for the variable "work time" was significant, but the effect was protective. That is, the respondents who reported having enough time to get the job done showed a lower risk of "pain in arms" then did those who reported that they did not have enough time to get the job done. The variable "safety climate" also showed a protective effect.

In terms of the combinations of dichotomized variables seen in Table 3, statistically significant increases in the risk of "pain in arms" were found for several combinations of variables. For example, for the evaluation of the combined effects of "hand

**TABLE 3**
Risk Factors for "Pain in Arms"

| Outcome Measure<br>Risk Factors* | Pain in Arms<br>Yes to Pain in Arms Freq (%) | Pain in Arms<br>OR (95% CI) |
|---|---|---|
| **Individual factors‡** | | |
| Hurt at work (How many times were you hurt at work last year?) | | Compared with 0 times |
| 0 ($n$ = 1299) | 324 (24.9) | |
| 1 ($n$ = 106) | 56 (52.8) | 3.367 (2.253–5.031)† |
| 2 ($n$ = 17) | 10 (58.8) | 4.295 (1.621–11.374)† |
| ≥3 ($n$ = 37) | 20 (54.0) | 3.537 (1.830–6.834)† |
| **Physical factors** | | |
| Heavy lifting (Does the job require repeated lifting, pulling, or pushing?) | | yes vs no |
| No ($n$ = 794) | 285 (35.9) | 1.703 (1.354–2.141)† |
| Yes ($n$ = 671) | 229 (34.1) | |
| Hand movement (Does the job require repetitive, or stressful hand movements or awkward postures?) | | yes vs no |
| No ($n$ = 714) | 138 (19.3) | 2.421 (1.909–3.071)† |
| Yes ($n$ = 751) | 276 (36.8) | |
| **Psychosocial factors** | | |
| Job Satisfaction (How satisfied are you with your job?) | | Compared with very satisfied |
| Very satisfied ($n$ = 720) | 161 (22.4) | |
| Somewhat ($n$ = 580) | 180 (31.0) | 1.562 (1.219–2.033)† |
| Not too satisfied ($n$ = 113) | 47 (41.6) | 2.473 (1.636–3.3737)† |
| Not at all satisfied ($n$ = 48) | 25 (52.0) | 3.774 (2.086–6.827)† |
| Work freedom (How much freedom do you have to decide how to do your own work?) | | Compared with not at all true |
| Not at all true ($n$ = 66) | 27 (40.9) | |
| Not too true ($n$ = 118) | 40 (33.9) | 0.741 (0.398–1.378) |
| Somewhat true ($n$ = 453) | 137 (30.2) | 0.628 (0.370–1.067) |
| Very true ($n$ = 825) | 209 (25.3) | 0.490 (0.293–0.820)† |
| Supervisor support | | Compared with very true |
| Very true ($n$ = 523) | 136 (26.0) | |
| Somewhat true ($n$ = 614) | 156 (25.4) | 0.969 (0.742–1.266) |
| Not too true ($n$ = 196) | 67 (34.2) | 1.478 (1.037–2.106)† |
| Not at all true ($n$ = 102) | 45 (44.1) | 2.247 (1.452–3.479)† |
| Work time (Is there enough time to get the job done?) | | Compared with very true |
| Very true ($n$ = 607) | 150 (24.7) | |
| Somewhat true ($n$ = 580) | 167 (28.8) | 1.232 (0.952–1.594) |
| Not too true ($n$ = 169) | 50 (29.6) | 1.280 (0.877–1.869) |
| Not at all true ($n$ = 105) | 46 (43.8) | 2.376 (1.550–3.643)† |
| Work fast (Does the job require that you work fast?) | | Compared with strongly disagree |
| Strongly disagree ($n$ = 48) | 11 (22.9) | |
| Disagree ($n$ = 477) | 127 (26.6) | 1.237 (0.613–2.498) |
| Agree ($n$ = 619) | 180 (29.1) | 1.379 (0.688–2.763) |
| Strongly agree ($n$ = 317) | 94 (29.7) | 1.418 (0.694–2.898) |
| Work hr (How many hours did you work last week?) | | Compared with ≤40 h |
| ≤40 h ($n$ = 746) | 221 (29.6) | |
| 41–50 h ($n$ = 402) | 111 (27.6) | 0.906 (0.692–1.186) |
| 51–60 h ($n$ = 188) | 37 (19.7) | 0.582 (0.393–0.862)† |
| 61–70 h ($n$ = 69) | 21 (30.4) | 1.039 (0.608–1.777) |
| >71 h ($n$ = 56) | 23 (41.1) | 1.707 (0.977–2.984) |
| Must work (Is it mandatory to work extra hours?) | | yes vs no |
| No ($n$ = 1041) | 267 (25.7) | 1.553 (1.214–1.986)† |
| Yes ($n$ = 411) | 143 (34.8) | |
| Safety climate | | Compared with strongly agree |
| Strongly agree ($n$ = 504) | 136 (27.0) | |
| Agree ($n$ = 712) | 181 (25.4) | 0.922 (0.712–1.195) |
| Disagree ($n$ = 179) | 68 (38.0) | 1.658 (1.156–2.377)† |
| Strongly disagree ($n$ = 65) | 26 (40.0) | 1.804 (1.058–3.077)† |
| Work stress (How often is work stressful?) | | Compared with never |
| Never ($n$ = 88) | 22 (25.0) | |
| Hardly ever ($n$ = 255) | 55 (21.6) | 0.825 (0.468–1.455) |
| Sometimes ($n$ = 622) | 143 (23.0) | 0.898 (0.535–1.506) |
| Often ($n$ = 350) | 125 (35.7) | 1.667 (0.981–2.831) |
| Always ($n$ = 148) | 68 (46.0) | 2.551 (1.427–4.559)† |

(*Continued*)

**TABLE 3**
Continued

| Outcome Measure Risk Factors* | Pain in Arms: Yes to Pain in Arms Freq (%) | Pain in Arms: OR (95% CI) |
|---|---|---|
| Work schedule | | Compared with day shift |
| Day shift ($n$ = 1078) | 304 (28.2) | |
| Afternoon shift ($n$ = 53) | 14 (26.4) | 0.913 (0.489–1.705) |
| Night shift ($n$ = 94) | 24 (25.5) | 0.872 (0.538–1.412) |
| Split shift ($n$ = 38) | 11 (29.0) | 1.036 (0.508–2.115) |
| Irreg./on call ($n$ = 124) | 39 (31.5) | 1.167 (0.781–1.743) |
| Rotating shifts ($n$ = 73) | 19 (26.0) | 0.895 (0.522–1.534) |
| **Dichotomized variables:** | | |
| Job Satisfaction (Are you satisfied with your job?) | | no vs yes |
| Yes ($n$ = 1300) | 341 (26.2) | 2.276 (1.629–3.179)† |
| No ($n$ = 161) | 72 (44.7) | |
| Safety climate (Are the safety conditions good at work?) | | yes vs no |
| No ($n$ = 244) | 94 (38.5) | 0.563 (0.422–0.750)† |
| Yes ($n$ = 1217) | 317 (26.0) | |
| Work stress (How often is work stressful?) | | yes vs no |
| No 3, 4, 5 ($n$ = 965) | 220 (22.8) | 2.140 (1.692–2.707)† |
| Yes 1, 2 ($n$ = 498) | 193 (38.8) | |
| Work fast (Does the job require that you work fast?) | | yes vs no |
| No ($n$ = 525) | 139 (26.5) | 1.146 (0.902–1.457) |
| Yes ($n$ = 936) | 274 (29.3) | |
| Work time (Is there enough time to get the job done?) | | yes vs no |
| No ($n$ = 275) | 96 (34.0) | 0.676 (0.511–0.893)† |
| Yes ($n$ = 1187) | 317 (26.7) | |
| Risk factor combinations: | | Compared with No-No |
| Heavy lifting + work stress 3, 4, 5 | | |
| No-No ($n$ = 517) | 94 (18.2) | |
| No-Yes ($n$ = 277) | 91 (32.0) | 2.196 (1.570–3.073)† |
| Yes-No ($n$ = 448) | 126 (28.1) | 1.757 (1.296–2.382)† |
| Yes-Yes ($n$ = 221) | 102 (46.2) | 3.848 (2.722–5.440)† |
| Interaction: | | 0.997 (0.621–1.603) |
| Heavy lifting + work fast | | Compared with No-No |
| No-No ($n$ = 305) | 64 (21.0) | |
| No-Yes ($n$ = 488) | 121 (24.8) | 1.236 (0.876–1.743) |
| Yes-No ($n$ = 220) | 75 (34.1) | 1.939 (1.310–2.870)† |
| Yes-Yes ($n$ = 448) | 153 (34.2) | 1.944 (1.387–2.276)† |
| Interaction: | | 0.811 (0.500–1.316) |
| Heavy lifting + work time | | Compared to No-Yes |
| No-Yes ($n$ = 636) | 137 (21.5) | |
| No-No ($n$ = 155) | 48 (31.0) | 1.634 (1.107–2.412)† |
| Yes-Yes ($n$ = 551) | 180 (32.7) | 1.767 (1.363–2.291)† |
| Yes-No ($n$ = 119) | 48 (40.3) | 2.462 (1.631–3.718)† |
| Interaction: | | 0.853 (0.485–1.498) |
| Hand movement + work stress 3, 4, 5 | | Compared to No-No |
| No-No ($n$ = 491) | 81 (16.5) | |
| No-Yes ($n$ = 223) | 57 (25.6) | 1.734 (1.181–2.545)† |
| Yes-No ($n$ = 474) | 139 (29.3) | 2.095 (1.537–2.856)† |
| Yes-Yes ($n$ = 275) | 136 (49.5) | 4.940 (3.532–6.911)† |
| Interaction: | | 1.36 (0.831–2.225) |
| Hand movement + work fast | | Compared to No-No |
| No-No ($n$ = 301) | 56 (18.6) | |
| No-Yes ($n$ = 412) | 82 (19.9) | 1.083 (0.742–1.580) |
| Yes-No ($n$ = 224) | 83 (37.1) | 2.565 (1.724–3.816)† |
| Yes-Yes ($n$ = 524) | 192 (36.6) | 2.520 (1.793–3.542)† |
| Interaction: | | 0.907 (0.551–1.49) |
| Hand movement + work time | | Compared to No-Yes |
| No-Yes ($n$ = 586) | 106 (18.1) | |
| No-No ($n$ = 125) | 32 (25.6) | 1.558 (0990–2.452) |
| Yes-Yes ($n$ = 601) | 211 (35.1) | 2.450 (1.872–3.206)† |
| Yes-No ($n$ = 149) | 64 (43.0) | 3.410 (2.316–5.019)† |
| Interaction: | | 0.893 (0.499–1.599) |

*$n$ = number of interviewees with usable data.
†Significant values for variables in which the confidence limits of odds ratio values do not include 1.0.
‡The individual factors of age and gender were not found to be significant.

movement" and "work stress 3, 4, 5", the OR for combination of "hand movement" = Yes and "work stress, 3, 4, 5" = No was 2.095 (95% CI = 1.537–2.856). The OR for the combinations of "hand movement" = No and "work Stress, 3, 4, 5" = Yes was 1.734 (95% CI = 1.181–2.545), whereas the OR for the combination of "hand movement" = Yes and "work stress 3, 4, 5" = Yes was 4.940 (95% CI = 3.532–6.911). These results are clearly an additive effect.

## Discussion

This study examined the effect of various individual, physical, and psychosocial/work organizational factors on self-reported low back pain and upper extremity pain using personal interviews in a sample of a national working population. Analysis of the results reveals that the only individual variable with a significant relationship to reporting back pain or upper extremity pain was whether or not the participant reported having been hurt at work more than one time in the last year. For the "back pain" outcome measure, the highest OR was found for those who reported being hurt at work three times or more in the last year (OR = 5.510 [95% CI = 2.773–10.947]). For "pain in arms," the highest OR was found for those who reported being hurt two times in the last year (OR = 4.295 [95% CI = 1.621–11.374]). Previous studies have shown that when a worker reports one injury, it is probable that multiple injuries are more likely to occur for those individuals.[16] Reports of multiple injuries were called "comorbidity" by Moore and Garg[16] who emphasized the importance of multiple measures for identifying associations between risk factors. Our findings suggest that this was not a problem in this study, since only 15.34% of respondents reported "Yes" to both "back pain" and "pain in arms." Also, back pain is a recurrent disorder, and it is likely that those who develop back pain will reinjure the back if they are not fully recovered.[2,17]

Assessment of the findings from the analysis reveals that physical factors, heavy lifting and repetitive hand movement, were significantly related to reporting both back pain and upper extremity pain. Because a significant relationship between heavy lifting and back pain has been shown often in other epidemiological studies,[3,5] it was anticipated that heavy lifting would be significantly related to self-reported back pain in this study. Overall, the percentage of interviewees reporting "Yes" to the "back pain" outcome measure was 27.90%. This is comparable to findings of Devereux et al,[8] who reported a similar 28% rate for low back complaints, even though the definition used by Devereux et al[8] (ie, low back problems occurring more than three times or lasting more than one week in the previous year) differed somewhat from the definition used in the current study. A comparison with the Devereux et al[8] study for upper extremity disorders could not be made because different outcome measures were reported.

It is not clear why jobs with exposure to repetitive or stressful hand movements or awkward hand postures would be related to an increase in risk of back pain. It is possible that jobs with repetitive hand movements or work with awkward hand postures involved light material handling that would repetitively load the back and possibly result in an increased risk of back pain. It is more likely, however, that the respondents misinterpreted the meaning of the term "awkward posture" in the question about exposure to hand activities to mean awkward back posture, rather than awkward hand postures, as was intended. This lack of clarity in the question could have resulted in a greater OR for the relationship between "hand movement" and "back pain" than might have been expected.

As reported in the results section, many of the psychosocial factors were significantly related to back pain. In a previous cross-sectional study of back pain and lifting, Waters et al[18] reported that the ORs for the relationship between job satisfaction and back pain for workers who were "not too satisfied" and "not at all satisfied" with their jobs were 4.57 (95% CI = 1.74–12.6) and 7.65 (95% CI = 1.59–45.0), respectively. Unlike the present study, however, Waters[18] reported that no other psychosocial or individual factors were shown to be significantly related to self-reported back pain. Nevertheless, other epidemiological studies have shown a significant relationship between psychosocial factors and reports of back pain.[4,8]

The relationship between work stress and back pain is especially interesting in the present study. As reported in Table 2, the ORs for the relationship between "work stress" and "back pain" for those workers who reported that their work was "often" or "always" stressful were 1.797 (95% CI = 1.042–3.098) and 2.890 (95% CI = 1.595–5.235), respectively. Although these findings are in agreement with many other studies that have shown work stress to be linked to increased risk of other health outcomes, such as cardiovascular disease, immunological problems, gastrointestinal problems, mental illness, general well-being, and musculoskeletal disorders, other studies also show no clear links of work stress to these health outcomes.[19] A major difficulty lies in the separation of work stress from personal stress. The recent report by Devereux et al,[8] where stress was treated both as an individual risk factor (beliefs about causes and alleviation of stress) and a psychosocial factor (perceived job stress) indicated that high perceived job stress was an intermediate factor for self-reported musculoskeletal complaints and that beliefs about the causes and alleviation of stress were unlikely to be involved.

There also appears to be an additive effect between exposure to phys-

ical work factors and work stress, as shown by the significant OR values for the combined effects of "heavy lifting" and "work stress," (OR = 4.474 [95% CI = 3.161–6.334]) on "back pain," and for the combined effect of "hand movement" and "work stress" (OR = 3.848 [95% CI = 2.722–5.440]) on "pain in arms." These results suggest that both factors play a role in reports of work-related MSDs, and that both factors may need to be considered for intervention to reduce incidence of MSDs in the workplace.

Also interesting is that we did not observe any significant combined effects between exposure to physical work factors ("heavy lifting" or "hand movement") and the variable "work fast" for either of the two outcome measures ("back pain" or "pain in arms"). This finding is somewhat unexpected, since task repetition has often been shown to be a significant risk factor for both back and upper extremity musculoskeletal disorders.[16,20] It is possible that respondents' perception of "work fast" differed from what experts might equate with frequency of the task or rates of repetition. That is, workers may have thought about the overall expectations of the job or how they perceive their effort, rather than how fast they actually have to work. This may result in a poor match between the physical demands of highly repetitive work and the workers' perception of "work fast." When the variable was dichotomized, it still was not significantly related to either "back pain" or "pain in arms."

The current study was limited in that the physical exposure variables for both back pain and upper extremity pain were self-reported and not quantitatively measured. Winkel and Mathisassen[21] stated that imprecise estimates of exposure may underestimate the risk due to exposure and that psychosocial factors may be overestimated, which may have occurred in this study. Another limitation is that the population of participants may have been skewed toward nonphysical work. As can be seen in Table 1, a large fraction of the workers (62.5%) who participated in the survey were employed in work that might be considered to be nonphysical (eg, managerial, professional, technical sales, and administrative support), compared with 37.5% who were employed in work that likely would be considered physically demanding. This finding suggests that the analysis may have been unbalanced regarding exposure for both the back and hands and wrists. Some sampling bias could have resulted.

Although fatigue in the respondents (eg, from answering numerous questions) is always a possibility in survey studies, this study was administered directly to the participants during a face-to-face interview. This approach lessens the likelihood that respondents would have become fatigued, bored, or misunderstood the questions.

Finally, the concern about respondents reporting multiple musculoskeletal pain outcomes may not be warranted. Although the survey population reported similar percentages of back pain (27.90%) and upper extremity pain (27.99%), overall, only 15.34% reported having both back pain and upper extremity pain. Also, those reporting both MSD outcomes were distributed as would be expected. That is, the lowest percentages of respondents reporting both health outcomes (back pain and upper extremity pain) were in the jobs with the lowest levels of physical loading (ie, managerial, professional, technical/sales, and administrative support at 14.52%, 10.04%, 13.12%, and 13.81%, respectively) compared with respondents in jobs with higher levels of physical loading (ie, service, farming/forestry/fishing, precision production/laborers, and operators at 21.58%, 17.39%, and 17.42%, respectively), where both the back and the upper extremities would be physically loaded.

## Conclusions

Based on our findings, we concluded that there was a clear relationship between physical loads and musculoskeletal disorders. Heavy lifting was associated with an increased risk of low back pain, and repetitive or forceful hand movements were associated with an increased risk of upper extremity disorders. We also concluded that there was a significant combined effect for physical factors and stress, and that the effect appeared to be additive. The OR for back pain was approximately 4.5 for those respondents who performed heavy lifting and who perceived a high level of work stress, compared with those who did not have these exposures. Similarly, the OR for upper extremity disorders was approximately 4.8 for those respondents who were involved in jobs requiring repetitive or forceful hand movements and who had a high level of work stress compared with those who did not report this exposure. Because this study is cross-sectional, it is not possible to draw conclusions about causality. However, a significant relationship among physical loading, stress, and MSDs was found in this study.

Finally, relying on a large sample from an ongoing national survey of a working population provides a database for tracking future changes in reports of MSDs. Future studies focusing on the potential effect of combined risk factors for musculoskeletal disorders, including physical, personal, psychological, and psychosocial factors, would be helpful. To improve the quality of the evaluation in future studies, it would be beneficial to actually quantify the exposures to physical risk factors, rather than rely on self-reported measures.

## References

1. Bongers PM, de Winter CR, Kompier MA, et al. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health*. 1993;19:297–312.
2. Ferguson SA, Marras WS. A literature review of low back disorder surveillance measures and risk factors. *Clin Biomech (Bristol, Avon)*. 1997;12:211–226.
3. National Institute for Occupational

Safety and Health. Musculoskeletal disorders and workplace factor: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper-extremity, and low back. DHHS (NIOSH) Publication No. 97–141. Cincinnati, Ohio: National Institute for Occupational Safety and Health; 1997.
4. Hoogendoorn WE, van Poppel MN, Bongers PM, et al. Systematic review of psychosocial factors at work and private life as risk factors for back pain. *Spine*. 2000;25:2114–2125.
5. National Research Council/Institute of Medicine. Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Washington: National Academy Press; 2001.
6. Bongers PM, Kremer AM, ter Laak J. Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist?: A review of the epidemiological literature. *Am J Ind Med*. 2002;41:315–342.
7. Nahit ES, Taylor S, Hunt IM, et al. Predicting the onset of forearm pain: a prospective study across 12 occupational groups. *Arthritis Rheum.* 2003;49:519–525.
8. Devereux J, Rydstedt L, Kelly V, et al. The role of work stress and psychological factors in the development of musculoskeletal disorders. *Health and Safety Executive Research Report 273.* Norwich: United Kingdom; 2004.
9. Fredriksson K, Alfredsson L, Thorbjörnsson CB, et al. Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period. *Am J Ind Med*. 2000;38:516–528.
10. Haufler AJ, Feuerstein M, Huang GD. Job stress, upper extremity pain and functional limitations in symptomatic computer users. *Am J Ind Med*. 2000;38:507–515.
11. Dane D, Feuerstein M, Huang GD, et al. Measurement properties of a self-report index of ergonomic exposures for use in an office work environment. *J Occup Environ Med*. 2002;44:73–81.
12. Leclerc A, Chastang JF, Niedhammer I, et al. Incidence of shoulder pain in repetitive work. *Occup Environ Med*. 2004;61:39–44.
13. Guo HR, Chang YC, Yeh WY, et al. Prevalence of musculoskeletal disorder among workers in Taiwan: a nationwide study. *J Occup Health*. 2004;46:26–36.
14. Lee HY, Yeh WY, Chen CW, et al. Prevalence and psychosocial risk factors of upper extremity musculoskeletal pain in industries of Taiwan: a nationwide study. *J Occup Health*. 2005;47:311–318.
15. Davis JA, Smith TW, Marsden PV. General Social Surveys, 1972–2002: Cumulative codebook. Chicago: National Opinion Research Center; 2002.
16. Moore JS, Garg A. Upper extremity disorders in a pork processing plant: Relationship between job risk factors and morbidity. *Am Ind Hyg Assoc J*. 1994;55:703–715.
17. Garg A, Moore JS. Epidemiology of low-back pain in industry. In: Garg A, Moore JS (eds). *Ergonomics: Low-Back Pain, Carpal Tunnel Syndrome, and Upper Extremity Disorders in the Workplace*. Occupational medicine: state of the art reviews. Vol. 7. Philadelphia: Hanley and Belfus; 1992.
18. Waters TR, Baron SL, Piacitelli LA, et al. Evaluation of the revised NIOSH lifting equation. A cross-sectional epidemiologic study. *Spine*. 1999;24:386–395.
19. ILO. Encyclopedia of Occupational Health and Safety. In: Stellman JM. (ed) Vol. II. *Part V. Psychological and Organizational Factors*. Geneva: International Labour Office; 1998.
20. Marras WS, Lavender SA, Leurgans SE, et al. The role of dynamic three-dimensional trunk motion in occupationally-related low back disorders. The effects of workplace factors, trunk position, and trunk motion characteristics on risk of injury. *Spine.* 1993;18:617–628.
21. Winkel J, Mathiassen SE. Assessment of physical work load in epidemiologic studies: concepts, issues and operational considerations. *Ergonomics.* 1994;37:979–988.

## APPENDIX A

Quality of Work Life (QWL) Questionnaire

| Outcome Measure/Variable Name | Question | Responses |
|---|---|---|
| Outcome measure | | |
| Back pain | In the past 12 mo, have you had back pain every day for a week or more? | 1. Yes. 2. No. |
| Pain in arms | In the past 12 mo, have you had pain in the hands, wrists, arms, or shoulders every day for a week or more? | 1. Yes. 2. No. |
| Individual factors | | |
| Age | Age entered at interview. | |
| Gender | Interviewer coded. | |
| Hurt at work | In the past 12 mo, how many times have you been injured on the job? | Number of times injured: ___. If "none", write 0; if "don't know", write DK; if "refused", write RF. |
| Physical factors | | |
| Heavy lifting | Does your job require you to do repeated lifting, pushing, pulling, or bending? | 1. Yes. 2. No. |
| Hand movement | Does your job regularly require you to perform repetitive or forceful hand movements or involve awkward postures? | 1. Yes. 2. No. |

(*Continued*)

**APPENDIX A**
Continued

| Outcome Measure/Variable Name | Question | Responses |
|---|---|---|
| Psychosocial factors | | |
| Job satisfaction | All in all, how satisfied would you say you are with your job? | 1. Very satisfied. 2. Somewhat satisfied. 3. Not too satisfied. 4. Not at all satisfied. |
| Work freedom | I am given a lot of freedom to decide how to do my work. | 1. Very true. 2. Somewhat true. 3. Not too true. 4. Not at all true. |
| Supervisor support (2 questions combined) | | |
| Supervisor cares | My supervisor is concerned about the welfare of those under him or her. | 1. Very true. 2. Somewhat true. 3. Not too true. 4. Not at all true. |
| Supervisor help | My supervisor is helpful to me in getting the job done. | 1. Very true. 2. Somewhat true. 3. Not too true. 4. Not at all true. |
| Work time | I have enough time to get the job done. | 1. Very true. 2. Somewhat true. 3. Not too true. 4. Not at all true. |
| Work fast | My job requires that I work very fast. | 1. Strongly agree. 2. Agree. 3. Disagree. 4. Strongly disagree. |
| Work hours | How many hr did you work last week, at all jobs? | Hours: ___. |
| Must work | When you work extra hr on your main job, is it mandatory (required by your employer)? | 1. Yes. 2. No. |
| Safety climate (4 questions combined) | | |
| Safety of workers | The safety of workers is a high priority with management where I work. | 1. Strongly agree. 2. Agree. 3. Disagree. 4. Strongly disagree. |
| Safety first | There are no significant compromises or shortcuts taken when worker safety is at stake. | 1. Strongly agree. 2. Agree. 3. Disagree. 4. Strongly disagree. |
| Safety health | The safety and health conditions where I work are good. | 1. Strongly agree. 2. Agree. 3. Disagree. 4. Strongly disagree. |
| Team safety | Where I work, employees and management work together to ensure the safest possible working conditions. | 1. Strongly agree. 2. Agree. 3. Disagree. 4. Strongly disagree. |
| Work stress | How often do you find your work stressful? | 1. Always. 2. Often. 3. Sometimes. 4. Rarely. 5. Never. |
| Work schedule | Which of the following best describes you usual work schedule? | 1. Day shift. 2. Afternoon shift. 3. Night shift. 4. Split shift. 5. Irregular shift/ on-call. 6. Rotating shifts. |