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ARTICLES

Musculoskeletal Symptoms Among Electricians

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This study ascertained the presence of musculoskeletal symptoms among electricians, in order to evaluate the prevalence of cumulative trauma disorders (CTD) in this population. We adapted the CTD surveillance questionnaire used by National Institute for Occupational Safety and Health (NIOSH) to assess the prevalence of neck, shoulder, elbow, hand/wrist, back, and knee symptoms in the year prior to the survey. Questionnaires were completed by 308 apprentices and journeymen enrolled in training classes at the local union hall. The participants were relatively young individuals, and 86% of the participants were currently working as electricians. Participants reported a high prevalence of symptoms which occurred more than three times during the past year or which lasted more than 1 week. Back symptoms and hand/wrist symptoms were experienced most frequently, by about half the population, while elbow symptoms were reported by only 15% of participants. Symptom prevalence was lower, but still notable, when defined as symptoms which had occurred at least once a month or lasted more than a week in the past year. Eighty-two percent of participants reported at least one musculoskeletal symptom using the most inclusive definition, while 57% reported two or more symptoms.

This survey highlights that: 1) low back discomfort is common in young construction workers, and resulted in medical care, missed work, or light duty for almost 35% of the participants; 2) neck discomfort is also very common and required doctor visits or work modification for almost one quarter of the participants; 3) these construction workers continued to work with symptoms that are classifiable as a CTD; and 4) history of injury is correlated with the subsequent prevalence of musculoskeletal symptoms.

Key words: cumulative trauma disorders, construction workers, occupational injuries, ergonomics

INTRODUCTION

Chronic musculoskeletal stresses resulting from strained postures or repetitive, forceful movements can cause chronic musculoskeletal conditions such as tendinitis, epicondylitis, carpal tunnel syndrome, and low back pain. These and similar conditions, known collectively as cumulative trauma disorders (CTDs), have been frequently studied among manufacturing workers [Barnhart et al., 1991; Punnett et al.,

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1991], meat processors [Armstrong et al., 1982; Kurppa et al., 1991], keyboard users [National Institute for Occupational Safety and Health (NIOSH), 1990], and workers in other industries [Hagberg and Wegman, 1987; Morgenstern et al., 1991; Silverstein et al., 1986]. A useful review of the work relatedness of upper extremity musculoskeletal disorders has recently been published [Gerr et al., 1991].

Musculoskeletal disorders from both acute and chronic stress also cause considerable disability in the construction industry, where work is strenuous and workers typically handle heavy materials and experience both static and dynamic postural stresses [Holmstrom, 1992]. For instance, Damlund et al. [1982] found that Danish construction workers who took early retirement were significantly more likely than warehouse workers to list low back pain as a reason, and also more likely to have had low back symptoms during the last year of employment. In another study (Welch and Hunting, unpublished data), 70% of sheet metal workers who received a union disability pension had a chronic musculoskeletal condition causing or contributing to their disability. An analysis of nearly 360,000 workers' compensation claims for construction injuries found that 24% of these injuries (mostly strains and sprains) were due to overexertion [Occupational Safety and Health Administration, 1992]. While many of these strains and sprains were acute in nature, undoubtedly many others were the result of chronic physical stresses. Other investigators have surveyed construction workers for symptoms of musculoskeletal pain, aching, stiffness, burning, numbness, or tingling, and have found considerable symptom prevalence [Wickstrom et al., 1978, 1983; Herberts et al., 1981; Bygghalsan Stockholm Region, 1991; Eastern Iowa Construction Alliance, 1991; Holmstrom et al., 1992a,b].

METHODS

Study Design and Participation

A study was carried out to assess the prevalence of CTD, defined symptomatically, among electricians. We adapted the CTD surveillance questionnaire used by NIOSH [1990] to determine the baseline prevalence of neck, shoulder, elbow, hand/wrist, back, and knee symptoms in the year prior to the survey. We also designed a survey to document work tasks and to assess the occurrence of CTD-related symptoms on a weekly basis for 8 weeks.

With the assistance of the International Brotherhood of Electrical Workers (IBEW) Local 26, we distributed the baseline and weekly questionnaires to apprentices and journeymen enrolled in training classes at the local union hall. The questionnaires were self-administered, although study staff were available briefly in each classroom to answer questions. Approximately 400 union members were enrolled in classes and available for participation. This paper describes data from the baseline survey for 308 IBEW members who completed a baseline questionnaire. Seventeen individuals indicated on the consent form that they did not wish to participate, an additional three members returned questionnaires missing essential data, and additional individuals declined to participate but did not indicate this on a consent form.

Assessment of Symptoms

The following question was asked for the neck, shoulders, elbow/forearm, hands/wrists, back, and knees: "In the past year, have you had pain, aching, stiffness, burning, numbness, or tingling [in the location] more than three times, or lasting more than one week?" A simple anatomic diagram of each area was provided

for reference. If symptoms were present, the individual was asked to complete additional questions on the characteristic frequency and duration of episodes; whether the symptom was present in the past 7 days; whether a sudden injury to that location had ever been sustained; whether medical care had been sought for the problem; and whether the respondent had missed work or had restricted work because of the problem.

We used three definitions to assess musculoskeletal symptomatology in the study population:

DEF1: Individuals with symptoms at a given location which occurred more than three times during the past year or which lasted more than 1 week.

DEF2: Individuals with symptoms occurring at least once per month or lasting more than 1 week during the past year, with no history of a previous traumatic injury to the site. (This is the definition used previously by NIOSH to define CTD, and is the most restrictive of the 3 definitions.)

DEF3: An alternative definition of CTD employed the frequency/duration of episode criteria used in DEF2, but did not exclude individuals with a history of acute injury to the site. (DEF3 individuals had more frequent symptoms than DEF1 individuals.)

The baseline questionnaire also collected demographic and work history information. A brief medical history section, focusing on injuries and medical conditions relevant to the outcomes under study, was also included.

RESULTS

The study participants were relatively young (median age 26 years) and had worked a median of 5 years in the electrician trade. Figure 1a and 1b show the grouped distribution of age and experience among participants; 71% were less than 30 years old and 61% had been in the trade 5 years or less. The distribution by ethnicity was 71% white, 25% black, and 4% other minority groups. Ninety-eight percent of participants were male. Although unemployment has been relatively high in the D.C. construction trades, 83% of participants had worked at least 40 weeks in the preceding year, and 86% of the participants were currently employed at the time of the baseline survey. We had specifically urged employed electricians to participate in the longitudinal study.

Participants reported a high prevalence of symptoms, using DEF1. Back symptoms (157/308 = 51%) and hand/wrist symptoms (144/308 = 47%) were experienced most frequently, while elbow symptoms were reported by only 15% (47/308) of participants. Eighty-two percent of participants (252/308) reported at least one musculoskeletal symptom, while 57% (177/308) reported two or more symptoms.

Table I and Figure 2 present data on the prevalence of symptomatic CTDs by the three definitions. The wrist/hands and back had the highest CTD prevalence by all 3 definitions. CTD prevalence according to DEF2 ranged from 39–51% of DEF1 prevalence. DEF3 prevalence varied more as a proportion of DEF1 symptoms, with DEF3 capturing 78% of all subjects with reported knee symptoms 74% of all subjects with reported back symptoms, and 58–68% of reported symptoms in other locations. The impact of including previously injured cases was seen most strongly for knee symptoms.

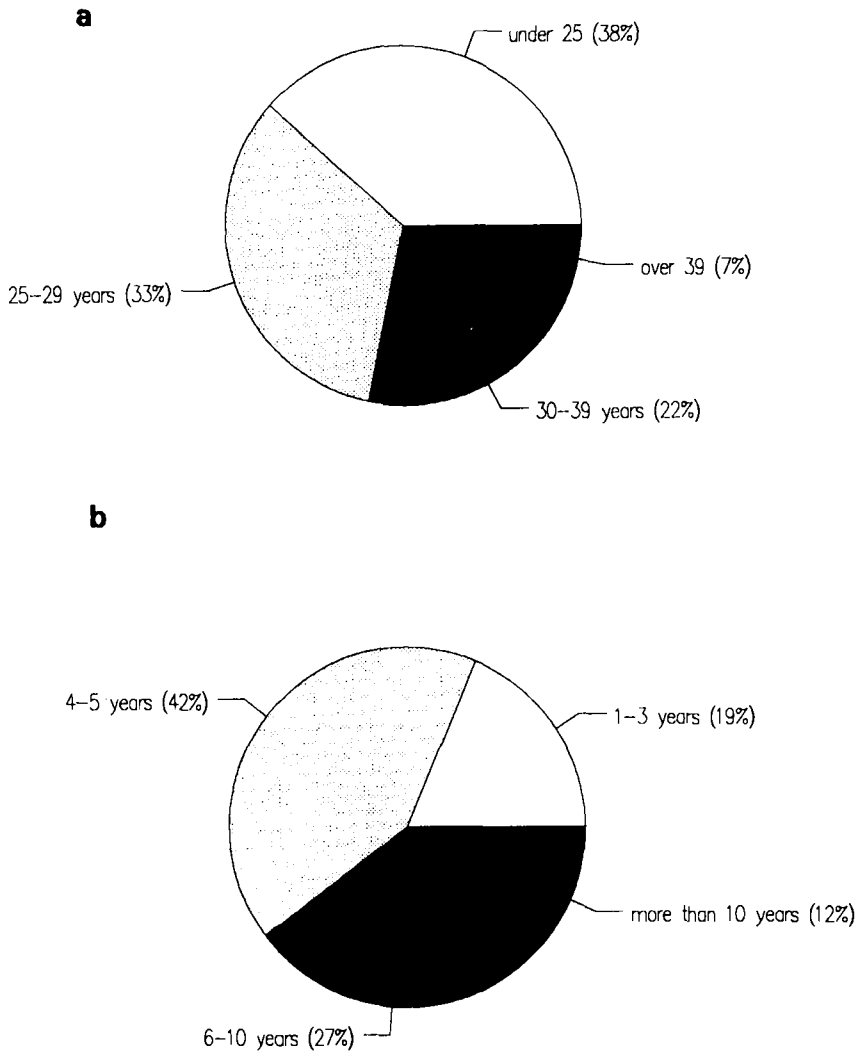

Fig. 1. **a.** Distribution of electricians by age group (N = 308). **b.** Distribution by years worked as an electrician (N = 308).

Table II describes the characteristics of individuals with symptoms by DEF1 who were not defined as CTD cases under DEF2. The shoulder was the location with the lowest proportion of symptomatic (DEF1) individuals meeting DEF2 (35/89 = 39%). Forty-two percent (42%) of symptomatic individuals were excluded because shoulder symptoms were not present at least once per month. The remaining 19% of symptomatic individuals were excluded because of a history of acute trauma to the shoulder. This contrasts with the knee, where 48% of individuals meeting DEF1 also met DEF2, with 20% excluded because of insufficient frequency of symptoms, and 30% excluded because of a history of previous knee injury.

We can look instead at all symptomatic individuals (DEF1) to evaluate the effect of excluding individuals with previous traumatic injuries. Thirty-five percent (35%)

TABLE I. Proportion of IBEW Study Population with CTD, by Various Definitions (N = 308)

	Neck		Shoulder		Forearm/ elbow		Wrist/ hands		Back		Knee	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
DEF1: symptoms occurring three times, or lasting >1 week[a]	116	(38)	89	(29)	47	(15)	144	(47)	157	(51)	103	(33)
DEF2: symptoms occurring once per month, or lasting >1 week, no traumatic injury[b]	49	(16)	35	(11)	21	(7)	73	(24)	64	(21)	49	(16)
DEF3: same as DEF2, with no injury exclusion	67	(22)	52	(17)	32	(10)	106	(34)	100	(32)	80	(26)

[a]DEF1 = a positive response to: "In the past year, have you had pain, aching, stiffness, burning, numbness, or tingling [in the given area] more than three times, or lasting more than one week?"
[b]DEF2 = symptom present at least once per month, or lasting more than 1 week, with no history of a previous traumatic injury to the site. This is the symptomatic definition of CTD used by NIOSH.

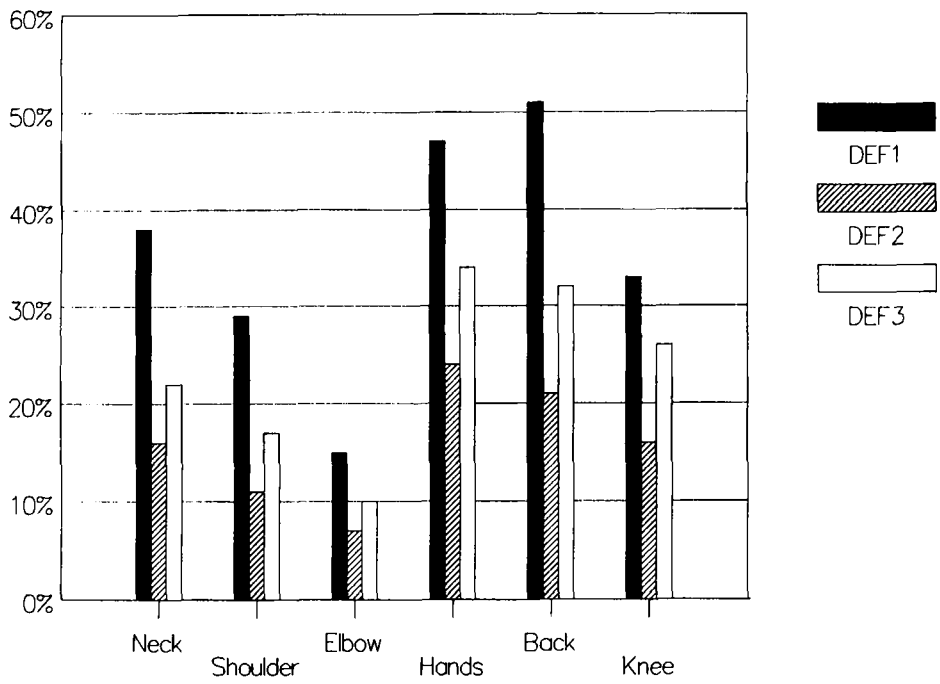

Fig. 2. Prevalence of symptoms, by various definitions (N = 308).

TABLE II. Symptomatic Individuals Included and Excluded by NIOSH Definition of CTD, and Reason for Exclusion Among IBEW Study Participants*

	Neck		Shoulder		Forearm/ elbow		Wrist/ hands		Back		Knee	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
DEF1 symptoms[a]	116	(100)	89	(100)	47	(100)	144	(100)	157	(100)	103	(100)
DEF2 symptoms[a]	49	(42)	35	(39)	21	(45)	73	(51)	64	(41)	49	(48)
Excluded by DEF2 because:												
Not present ≥ once per month or not lasting >1 week	47	(41)	37	(42)	14	(30)	33	(23)	56	(36)	21	(20)
Previous injury	18	(16)	17	(19)	9	(19)	38	(24)	35	(22)	31	(30)
Insufficient data[b]	2	(2)	0	—	3	(6)	5	(3)	2	(1)	2	(2)

*Totals may not add to 100 due to rounding.
[a]See text or Table I footnotes for definitions.
[b]Symptoms reported, but incomplete data given on frequency and duration of episode, or on previous injuries.

of participants with knee and back symptoms (DEF1) reported previous injuries, whereas lower prevalences of previous injuries were reported for neck (20%), elbow (23%), shoulder (30%), and wrist/hands (33%).

We mentioned previously that 57% of individuals reported symptoms in multiple locations. The pie charts in Figure 3 describe the number of symptoms reported per individual, according to the three definitions. Twenty-six percent (79/308) of the study population had multiple symptoms by DEF2; and 38% (118/308) had multiple locations with symptoms when DEF3 was used. We looked at the relationship between multiple symptoms and more frequent symptoms. At each location, the rate of occurrence of multiple symptoms was similar among individuals whose symptoms only met DEF1, and those whose symptoms were frequent enough to meet DEF3.

Table III presents data on DEF1 symptom prevalence by number of years working as an electrician. Since there were relatively few individuals who had worked more than 10 years, the data are spread over a relatively narrow range of experience groups. Table III shows that more experienced workers had somewhat higher symptom prevalence for every location, with Mantel-Haenszel odds ratios comparing the most experienced to the least experienced workers ranging from 1.3–2.9. Statistically significant positive trends by years worked (tested by Mantel-Haenszel chi-square) were noted for the shoulder, wrist/hands, and knees. A similar analysis (Table IV) comparing symptom prevalence (DEF1) by age group revealed only one statistically significant stratum odds ratios and no significant trends. It is important to note, however, that the range of ages was narrow and that there were very few older workers in this study.

We also compared the distribution at each symptom location of age and years worked between individuals whose symptoms met DEF3 versus individuals whose symptoms just met DEF1. Although associations were not consistent across all 6 locations, young age was associated with more frequent (DEF3) symptoms at the neck, back, and knees (p value for chi square <0.05). Inexperience was associated with more frequent back and knee symptoms (p value approximately 0.10).

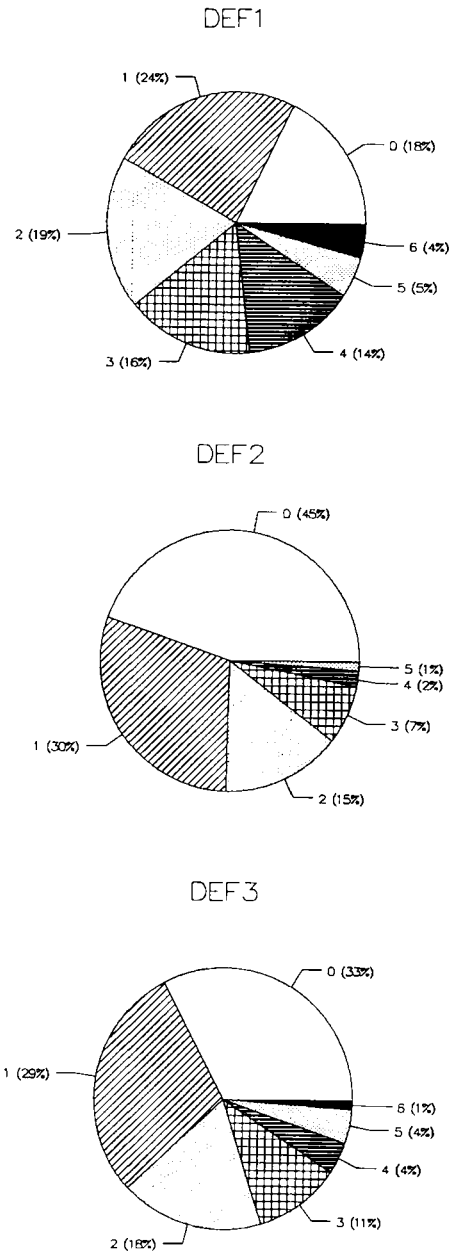

Fig. 3. Number of symptoms per individual, by various definitions (N = 308).

We also analyzed data on whether symptoms differed between those currently working as electricians and not currently working as electricians. Only 14% of the study participants were not currently working, so these analyses were based on rather small numbers. For all locations except the neck, symptom prevalence (DEF1) was higher among those electricians who were not currently working than among those who were currently working. At each location, we evaluated the relationship among

TABLE III. Proportion of Individuals With Symptoms Meeting DEF1, by Number of Years Working as an Electrician

Years worked	Number in group	Neck (% DEF1)[a]	Neck OR[b]	Shoulder (% DEF1)	Shoulder OR	Forearm/elbow (% DEF1)	Forearm/elbow OR	Wrist/hands (% DEF1)	Wrist/hands OR	Back (% DEF1)	Back OR	Knee (% DEF1)	Knee OR
1–3	57	(31.6)	1.0	(21.1)	1.0	(8.8)	1.0	(31.6)	1.0	(42.1)	1.0	(26.3)	1.0
4–5	125	(37.2)	1.3	(25.6)	1.3	(16.3)	2.0	(47.3)	1.9[c]	(47.3)	1.2	(33.3)	1.4
6–10	82	(42.7)	1.6	(37.8)	2.3[c]	(18.3)	2.3	(51.2)	2.3[c]	(62.2)	2.3[c]	(30.5)	1.2
>10	40	(37.5)	1.3	(32.5)	1.8	(15.0)	1.8	(57.5)	2.9[c]	(52.5)	1.5	(50.0)	2.8[c]
p value for trend[d]			.34		.05		.31		.01		.06		.05

[a]Proportion of individuals in each work experience group with symptoms which met DEF1. See text or Table I footnotes for definitions.
[b]Mantel-Haenszel odds ratio for each group compared to shortest work experience group.
[c]Stratum odds ratio is different from 1.0 with $p < .05$.
[d]Mantel-Haenszel chi-square test for trend.

TABLE IV. Proportion of Individuals With Symptoms Meeting DEF1, by Age Group (N = 308) in IBEW Study Participants

Age group (years)	Number in age group	Neck (% DEF1)[a]	Neck OR[b]	Shoulder (% DEF1)	Shoulder OR	Forearm/elbow (% DF1)	Forearm/elbow OR	Wrist/hands (% DEF1)	Wrist/hands OR	Back (% DEF1)	Back OR	Knee (% DEF1)	Knee OR
< 25	118	(37.3)	1.0	(21.2)	1.0	(14.4)	1.0	(46.6)	1.0	(55.9)	1.0	(39.0)	1.0
25–29	103	(40.8)	1.2	(35.9)	2.0[c]	(14.6)	1.0	(47.6)	1.0	(49.5)	0.8	(26.2)	0.6
30–39	67	(32.8)	0.8	(28.4)	1.4	(16.4)	1.2	(46.3)	1.0	(44.8)	0.6	(29.9)	0.7
≥ 40	20	(40.0)	1.1	(35.0)	1.9	(20.0)	1.5	(45.0)	0.9	(50.0)	0.8	(50.0)	1.6

[a]Proportion of individuals in each age group with symptoms which met DEF1. See text or Table I footnotes for definitions.
[b]Mantel-Haenszel odds ratio for each group compared to youngest age group.
[c]Stratum odds ratio is different from 1.0 with $p < .05$. There were no statistically significant trends by age group.

symptomatic individuals between working status and more frequent (DEF3) symptoms; no consistent associations were found. Interestingly, currently working electricians with shoulder or back symptoms had a somewhat higher proportion of more frequent (DEF3) symptoms, compared to symptomatic individuals who were not currently working.

For each symptomatic location, participants were asked when they first noticed the symptom. Symptoms first noticed longer ago did not occur more frequently (DEF3). In fact, neck symptoms noticed more recently were significantly more likely to meet DEF3, and there were similar trends (nonsignificant) for several other symptom locations.

Symptomatic participants were also asked whether specific activities made their symptoms worse, and if so, which activities. For about two thirds of the symptoms across all locations, the symptoms were exacerbated by work, and in particular by tasks such as lifting, working overhead, and working with hand tools. These data will be analyzed in detail and described at a later date, along with similar data from weekly questionnaires.

The questionnaire ascertained the symptom regarded as the "most serious or troublesome" by the worker. Back (82/308 = 27%), knee (45/308 = 15%), and hands/wrist (44/308 = 14%) were reported most often to be the most serious symptom. This question from the standard NIOSH questionnaire was not particularly effective for assessing severity of symptoms, because individuals with only one symptom would report that symptom as most serious, even if it was not very serious. Many of those symptoms reported as most serious did not meet DEF2, the definition of symptomatic CTD used by NIOSH. For instance, only 44% of subjects who said their backs or knees bothered them most met DEF2. DEF3, on the other hand, included higher proportions of symptoms which were cited as most troublesome by the worker, 68% for back and 76% for knees, indicating that previous injuries are associated with troublesome symptoms among these construction workers. Similar results were seen when this analysis was restricted to individuals with more than one symptomatic location.

One way of assessing the degree to which individuals have been affected by their musculoskeletal symptoms is to look at data on medical care and work absences. Symptomatic individuals were asked to indicate how many days in the past year they had visited a doctor/health care provider, missed work, or had light or restricted work because of their symptoms. Figure 4a shows, for each location, the number of individuals whose response was at least 1 day for any of these three questions. Back symptoms clearly stand out as having caused the most individuals (54) to seek medical care, miss work, or require light duty work, followed by neck symptoms (28 individuals). An alternate way of describing these data (Fig. 4b) is to look at the proportion of symptomatic individuals (DEF1) who sought medical care, missed work, or required light duty work. Back (34%) and neck problems (24%) affected the highest proportion of symptomatic individuals in this manner.

We also evaluated the data on medical visits, work loss, and light duty in relationship to alternate case definitions. Table V presents these results; DEF2 fails to include about two thirds of the individuals with medical visits, missed work, or light duty in the past year. DEF3, which uses the same frequency and duration criteria as DEF2 but includes cases with previous traumatic injuries, excludes only about one quarter of these affected individuals. It was notable that both DEF2 and DEF3

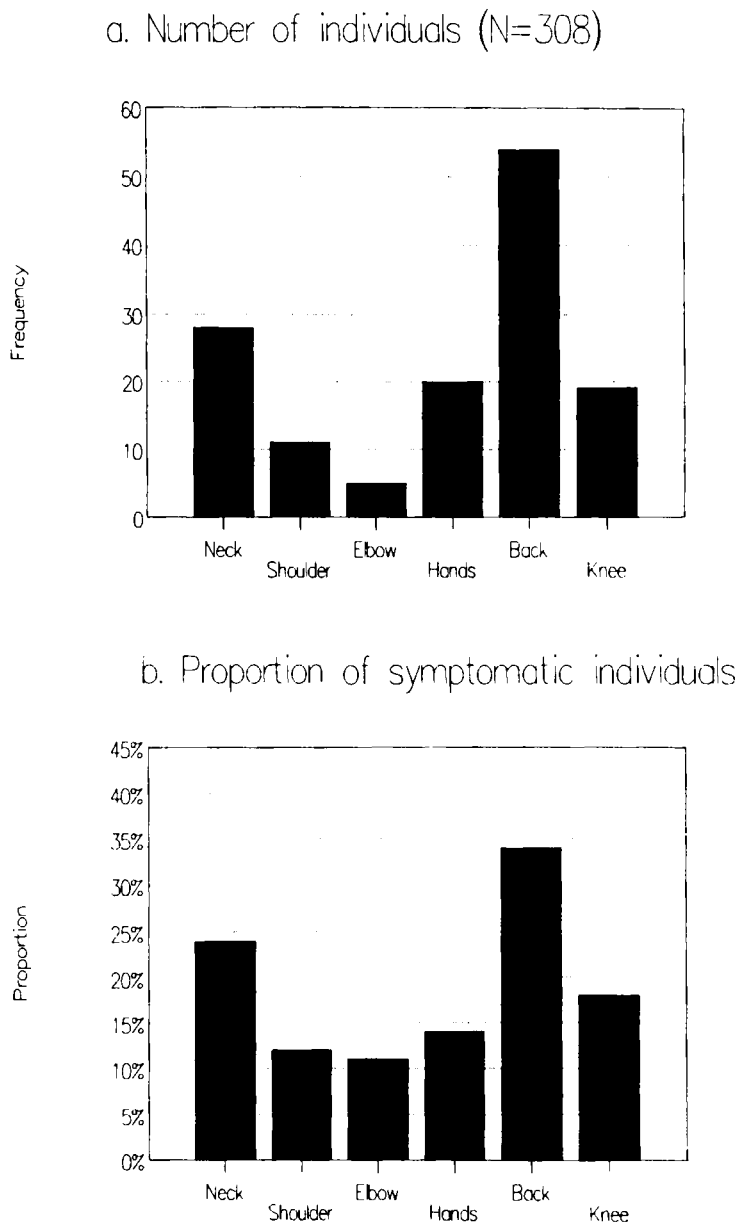

Fig. 4. Doctor visits, missed work, or light duty resulting from symptoms.

excluded individuals whose symptoms were severe enough to interfere with their work or require medical consultation. The fact that DEF2 excluded so many more cases than DEF3 highlights the importance of previous injuries as a cause for medical care, missed work, or light duty. Acute injuries are an important cause of long-term disability among construction workers, and studies of musculoskeletal disorders must assess the contribution of both acute injuries and chronic stresses.

TABLE V. Number and Proportion of IBEW Study Participants With Medical Visits, Missed Work, or Light Duty Excluded by Various Definitions of CTD (N = 308)

Individuals with medical visits, missed work, or light duty	Neck		Shoulder		Forearm/ elbow		Wrist/ hands		Back		Knee	
	28	(%)	11	(%)	5	(%)	20	(%)	55	(%)	19	(%)
Number and proportion of of affected individuals excluded by CTD definitions[a,b]												
DEF 2	18	(64)	7	(64)	3	(60)	14	(70)	36	(65)	15	(79)
DEF 3	8	(29)	3	(27)	1	(20)	2	(10)	15	(27)	4	(21)

[a]See text or Table I footnotes for definitions.
[b]DEF1 did not exclude any individuals with medical visits, lost work, or light duty.

Clearly, many individuals with recurrent musculoskeletal pain report a previous injury. We explored this further using information on previous injuries collected for the back and knees only in two different sections of the questionnaire. Comparison of the data from these two sources illustrates potential problems in interpreting data provided by participants on previous injuries. Of the 55 individuals with back symptoms who reported on the symptoms part of the questionnaire that they ever had "an accident or sudden injury to their back such as a dislocation, fracture, or muscle sprain," 17 (31%) did not report a back strain or injury or ruptured disc on the medical history portion of the questionnaire. In addition, of the 56 individuals with back symptoms who reported back strain or injury or ruptured disc on the medical history portion, 19 (34%) did not report in the symptoms part of the questionnaire that they had had a previous accident or sudden back injury. Thus, there was substantial discordance between the responses to these two questions. A similar pattern was seen for knee injuries.

Further insight into problems interpreting questionnaire data on previous injuries can be gained by looking at the temporal relationship between previous injuries and symptom onset. The medical history part of the questionnaire ascertained the year in which specific injuries or conditions were diagnosed, and the symptoms part of the questionnaire asked the year in which symptoms were first noticed by the respondent. Table VI compares these data for those subjects with back symptoms who consistently reported a previous back strain or injury on both parts of the questionnaire. Table VI shows that most individuals reported that they first noticed symptoms in the same year or after the year that they were diagnosed as having a back strain or injury. A minority of individuals, however, (11/37 = 30%) reported noticing symptoms before the year that they had a back strain or injury or ruptured disc. These are the individuals whose "previous injuries" are most likely to be related to chronic work-related stresses, for they had symptoms that predated any identified strain or injury.

DISCUSSION

This survey of electricians revealed that a large proportion of workers had experienced musculoskeletal symptoms within the past year. The symptom data were evaluated to assess the presence of CTDs in this population. Exactly how high CTD prevalence is depends on the definition used. Consequently, these data were also analyzed to explore methodologic issues in using participant-reported symptom data to define CTDs.

TABLE VI. Comparison of Diagnosis Date for Previous Back Injury or Strain or Ruptured Disc, and Date Participant First Noticed Back Symptoms, for 37 Subjects With Consistent Injury Data

Back symptoms first noticed	No.(%)[a]
Before back injury[b] was diagnosed	11 (30)
Same year back injury[b] was diagnosed	16 (43)
After back injury[b] was diagnosed	5 (14)
Missing data	5 (14)
Total	37 (100)

[a]Percentages may not sum to 100 due to rounding.
[b]Back injury means that the subject reported a diagnosis of a back strain or injury or a ruptured disc on the medical history part of the questionnaire.

Prevalence of Musculoskeletal Symptoms Among Electricians

Although each construction trade performs different tasks, it is well known that construction workers have a high frequency of musculoskeletal complaints, and that low back injury/low back pain is a leading cause of lost work time, compensation costs, and premature retirement in the construction industry. In the largest published study of symptoms, 92% of 1,773 Swedish workers from a variety of construction trades reported experiencing musculoskeletal symptoms, defined as pain, ache, or discomfort occurring sometimes, often, or very often during the past 12 months [Holmstrom et al., 1992b]. Low back symptoms were most common, experienced by 72% of those surveyed, followed by knee (52%), neck (37%), and right shoulder (37%). The prevalence of low back pain was 54% when defined to include only those whose back pain episodes lasted at least 1–7 days. In a similar survey carried out among 526 Iowa construction workers, approximately 75% of the workers had low back symptoms; the prevalences of neck, wrist, and knee symptoms were each about 40% [Eastern Iowa Construction Alliance, 1991].

A small survey [Welch et al., submitted] of musculoskeletal disorders among sheet metal workers found that 30 of the 47 participants reported symptoms in their neck, shoulder, hand, or elbow. This survey used the same symptom definitions as the electrician's study currently being described. Shoulder symptoms (DEF1—47%; DEF2—32%) and hand symptoms (DEF1—45%; DEF2—30%) were the most common complaints among the 47 workers screened. These sheet metal workers had worked an average of 33 years in the trade and one third of the participants were retired.

In our survey of 308 relatively young electricians, we found back and knee symptom prevalences (DEF1—51% and 33%) which were slightly lower than those reported from Swedish and Iowa construction workers. The 38% prevalence of neck pain (DEF1) among our electricians was very similar to these other two published findings. Surveyed electricians had less shoulder pain and about the same prevalence of hand symptoms as the older population of sheet metal workers mentioned above. Although a number of other studies have evaluated symptom prevalence, it is very difficult to compare symptom data when different questionnaires and CTD definitions are used. Also, populations differ, especially in terms of their age structures. We have presented data based on the definition of CTD used previously by NIOSH so that our results may be compared with the results of other studies using this method.

This study primarily included young workers with relatively few years in the electrician's trade. We found statistically significant increases in symptom prevalence by years worked, but not by age, over the narrow population ranges of these variables. It is interesting that the work-related risk factor, rather than the demographic risk factor, was the more sensitive predictor of symptom prevalence.

Selection biases and participation biases may have affected these results. Since this was a cross-sectional study, severely symptomatic individuals may have left the electrician's trade, which would tend to decrease observed symptom prevalence. This would explain two results suggested by our data: 1) among symptomatic individuals (neck, back, knees) who were younger and less experienced, a somewhat higher proportion of symptoms met DEF2, compared to older and more experienced individuals; and 2) that a slightly higher proportion of symptoms met DEF2 among individuals who noticed their symptoms more recently, compared to symptoms which were noticed longer ago. Another factor which may have influenced the results of this study is that only 70–80% of eligible electricians participated. If symptomatic individuals were more likely than nonsymptomatic workers to participate, this would increase the observed symptom prevalence.

The analysis of baseline data from this survey among electricians showed that: low back discomfort is common in young construction workers, and resulted in medical care, missed work, or light duty for almost 35% of the participants; hand/wrist symptoms are almost as prevalent as back disorders, although they do not result in as much medical care or work restriction; neck discomfort is also very common and required doctor visits or work modification for almost one quarter of the participants; these construction workers continued to work with symptoms that are classifiable as a CTD; and history of injury is correlated with the subsequent prevalence of musculoskeletal symptoms.

Methodologic Issues in Screening for CTDs With Symptom Data

This study assessed the presence of musculoskeletal complaints, rather than utilizing clinical examinations or electrophysiologic testing. Some studies [Holmstrom and Moritz, 1991; Katz et al., 1991] have shown that certain questionnaire symptom responses have a high predictive ability for specific clinically diagnosed conditions. Other researchers [Barnhart et al., 1991; McCormack et al., 1990; Punnett et al., 1985] have found symptoms to be more sensitive than the combination of symptoms and clinical or electrophysiologic findings, although less specific regarding the nature of the disorders. While symptom surveys alone do not lead to a specific diagnosis, they do indicate the presence of morbidity, and may be early indicators of disability.

The key question in studies such as this one is which definition is best for purposes of evaluating musculoskeletal symptomatology in a "healthy" working population. The answer to this question depends on whether the aim is to identify individuals with more severe conditions, in which case a more restrictive definition should be used, or to use symptoms as risk factors for chronic disease or as early indicators of disease, in which case a more inclusive definition should be used. A more inclusive definition would be appropriate if the aim were early detection of disease in order to prevent or minimize further injury. This definition should ideally include individuals whose symptoms are likely to progress, and exclude those whose symptoms are likely to remain mild. Little is known, however, about personal and

work-related factors which predict progression of disease, and more research is needed. In studies which seek to identify the ergonomic hazards most associated with risk of CTD, the definition of CTD is also important, because different exposure factors may be related to the risks of early symptoms and chronic symptoms.

One important issue that arises in this study is the role of acute injuries in causing musculoskeletal symptoms. This is of particular importance in construction, where it is well known that acute traumatic injuries contribute to disability and mortality. We see here that individuals who report a previous acute injury make up from 16% (for neck) to 30% (for knee) of those people whose symptoms are present more than once a month or last more than 1 week in the previous year (see Table II). In addition, those who report a prior injury are a sizeable fraction of the group who reported that they had medical visits, missed work, or were on light duty; the proportion of affected individuals who met DEF3 but not DEF2 ranged from 35% for neck to 60% for wrist/hands.

NIOSH and other researchers generally exclude symptomatic individuals with a history of traumatic injury from their definitions of CTD. Yet, musculoskeletal symptoms cannot always be clearly attributed to either an acute or a chronic stress, and often are due to a combination of the two. This leads to a problem in defining the population at risk for CTDs as well as to a problem in addressing risk reduction. Prevention programs that focus on prevention of acute injuries, such as fall protection systems, differ greatly from those that focus on prevention of chronic stresses, so the relative weight of each type of stress would be important in setting priorities for prevention. For instance, repeated heavy lifting may make the back more susceptible to an "acute" back injury. A worker may report he developed back pain after one episode of lifting a 10 pound object, an operation he has performed many times before; it is likely that repeated lifting, as well as the acute event, contributed to the injury. There may be an interaction between the sequelae of an acute injury and chronic trauma to the musculoskeletal system, such as an individual who has experienced an acute knee injury who is then more susceptible to disorders resulting from repetitive kneeling. Acute injuries, both major and minor, and chronic stresses may contribute jointly to chronic musculoskeletal symptoms. In addition, there may be an incentive for the worker to recognize a musculoskeletal complaint as beginning acutely, for the Workers' Compensation system compensates acute injuries more readily than chronic diseases. Many individuals also wish to identify acute triggering events which "explain" their injuries. Some evidence from this study suggests that: 1) subjects do not consistently report previous injuries; and 2) that reported injuries may include events resulting from both acute trauma and chronic stresses. Without more detailed information on the previous injuries themselves and on how they relate to the temporal patterns of symptoms, we cannot determine whether a condition is a CTD. Thus, a history needs to be carefully collected and subjected to the judgment of a clinician or other trained researcher. It may not be possible to collect such data using self-administered questionnaires.

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REFERENCES

Armstrong TJ, Foulke JA, Joseph BS, Goldstein SA (1982): Investigation of cumulative trauma disorders in a poultry processing plant. Am Ind Hyg Assoc J 43:103–116.

Barnhart S, Demers PA, Miller M, Longstreth WT, Rosenstock L (1991): Carpal tunnel syndrome among ski manufacturing workers. Scand J Work Environ Health 17:46–52.

Bygghalsan Stockholm Region (1991): A health and environmental survey of sheet metal workers. In Bygghalsan Bulletine 91-09-16. Sweden: Bygghalsan, pp 27–30.

Damlund M, Goth S, Hasle P, Munk K (1982): Low-back pain and early retirement among Danish semiskilled construction workers. Scand J Work Environ Health 8 (suppl 1):100–104.

Eastern Iowa Construction Alliance/The University of Iowa (1991): "Joint Project on Reduction of Work-Related Injuries and Illness Through Ergonomic Intervention, Final Report, Phase I." Iowa City, Iowa: The University of Iowa.

Gerr F, Letz R, Landrigan PJ (1991): Upper-extremity musculoskeletal disorders of occupational origin. Ann Rev Public Health 12:543–566.

Hagberg M, Wegman DH (1987): Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. Br J Ind Med 44:602–610.

Herberts P, Kadefors R, Andersson G, Petersen I (1981): Shoulder pain in industry: An epidemiological study on welders. Acta Orthop Scand 52:299–306.

Holmstrom E (1992): "Musculoskeletal Disorders in Construction Workers Related to Physical, Psychological and Individual Factors." Lund, Sweden: Lund University.

Holmstrom EB, Lindell J, Moritz U (1992a): Low back and neck/shoulder pain in construction workers; occupational workload and psychosocial risk factors. Part 2: Relationship to neck and shoulder pain. Spine 17:672–677.

Holmstrom EB, Lindell J, Moritz U (1992b): Low back and neck/shoulder pain in construction workers; occupational workload and psychosocial risk factors. Part 1: Relationship to low back pain. Spine 17:663–671.

Holmstrom EB, Moritz U (1991): Low back pain—correspondence between questionnaire, interview and clinical examination. Scand J Rehab Med 23:119–125.

Katz JN, Larson MG, Fossel AH, Liang MH (1991): Validation of a surveillance case definition of carpal tunnel syndrome. Am J Public Health 81:189–193.

Kurppa K, Viikari-Juntara E, Kuosma E, Huuskonen M, Kivi P (1991): Incidence of tenosynovitis or peritendinitis and epicondylitis in a meat-processing factory. Scand J Work Environ Health 17: 32–37.

McCormack RR, Inman RD, Wells A, Berntsen C, Imbus HR (1990): Prevalence of tendinitis and related disorders of the upper extremity in a manufacturing workforce. J Rheumatol 17:958–964.

Morgenstern H, Kelsh M, Kraus J, Margolis W (1991): A cross-sectional study of hand/wrist symptoms in female grocery checkers. Am J Ind Med 20:209–218.

National Institute for Occupational Safety and Health (NIOSH)/U.S. Department of Health and Human Services (1990): "Health Hazard Evaluation Report 89-250-2046, Newsday, Inc., Melville, New York." Cincinnati: NIOSH.

Occupational Safety and Health Administration/U.S. Department of Labor (1992): "Construction Accidents: The Workers' Compensation Data Base 1985–1988." Washington, DC: OSHA.

Punnett L, Fine LJ, Keyserling WM, Herrin GD, Chaffin DB (1991): Back disorders and nonneutral trunk postures of automobile assembly workers. Scand J Work Environ Health 17:337–346.

Punnett L, Robins JM, Wegman DH, Keyserling M (1985): Soft tissue disorders in the upper limbs of female garment workers. Scand J Work Environ Health 11:417–425.

Silverstein BA, Fine LJ, Armstrong TJ (1986): Hand wrist cumulative trauma disorders in industry. Br J Ind Med 43:779–784.

Welch LS, Hunting KL, Kellogg J (Submitted): Work-related musculoskeletal symptoms in sheet metal workers: Report of a pilot study.

Wickstrom G, Hanninen K, Lehtinen M, Riihimaki H (1978): Previous back syndromes and present back symptoms in concrete reinforcement workers. Scand J Work Environ Health 4 (suppl 1):20–28.

Wickstrom G, Hanninen K, Mattsson T, Niskanen T, Riihimaki H, Waris P, Zitting A (1983): Knee degeneration in concrete reinforcement workers. Br J Ind Med 40:216–219.