

Prevalence and Risk Factors of Tendinitis and Related Disorders of the Distal Upper Extremity Among U.S. Workers: Comparison to Carpal Tunnel Syndrome

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Background National estimates of tendinitis and related disorders of the distal upper extremity among U.S. workers have not been available with the exception of carpal tunnel syndrome.

Methods The Occupational Health Supplement Data of the 1988 National Health Interview Survey were analyzed for tendinitis and related disorders of the hand/wrist and elbow (distal upper extremity) using the Survey Data Analysis (SUDAAN) software.

Results Among the 30,074 respondents (statistically weighted population of 127 million) who had worked anytime during the previous 12 months, 0.46% (95% CI: 0.36, 0.56) reported that they experienced a “prolonged” hand discomfort which was called tendinitis, synovitis, tenosynovitis, deQuervain’s disease, epicondylitis, ganglion cyst, or trigger finger, by a medical person. This corresponds to 588,000 persons (95% CI: 457,000; 712,000) reporting one of these disorders, 28% (or 164,000) of which were thought to be work-related by the medical person. Among various risk factors examined by multiple logistic regression analysis, bending/twisting of the hands/wrists at work and female gender were significantly associated with reporting of these disorders.

Conclusions By combining these cases with the previously reported cases of work-related carpal tunnel syndrome, we estimate that there were approximately 520,000 cases of work-related musculoskeletal disorders of the distal upper extremity among US workers in 1988. *Am. J. Ind. Med.* 39:328–335, 2001. Published 2001 Wiley-Liss, Inc.[†]

KEY WORDS: tendinitis; synovitis; tenosynovitis; de Quervain’s disease; epicondylitis; ganglion cyst; trigger finger; health interview survey

INTRODUCTION

Since the early 1980s through 1994, the Bureau of Labor Statistics (BLS) reported a tenfold increase of “disorders associated with repeated trauma” or work-related musculoskeletal disorders (MSDs) in many segments of American industry. Although this increasing trend was reversed beginning in 1995 and through 1997 [Bureau of Labor Statistics, 1999] and there is hope that this downward trend may continue, the incidence rates of these disorders are still high. These disorders include conditions such as carpal tunnel syndrome (CTS), tendinitis, synovitis, tenosynovitis, and bursitis. A national prevalence estimate

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of work-related CTS based on the 1988 National Health Interview Survey, Occupational Health Supplement Data (NHIS/OHS) was previously reported [Tanaka et al., 1995, 1997]. Since CTS is not the only disorder that affects the distal upper extremity (DUE) of the working population, we looked at tendinitis and related disorders to obtain a more complete picture of MSDs in the DUE. (Although the term *tendonitis* was used in the 1988 NHIS/OHS questionnaire, we use the term *tendinitis* in this article since the latter is more commonly used.)

MATERIALS AND METHODS

The detailed features of the 1988 NHIS/OHS were reported previously [Massey et al., 1989; Park et al., 1993]. NHIS is conducted annually by the National Center for Health Statistics (NCHS) based on a multistage probability sampling of the non-institutionalized civilian population of the United States to assess health status of the nation. Each year, various supplements are added to the core health questions to examine specific topics. So far, an OHS was conducted only in 1988, which was co-sponsored by NIOSH and Bureau of Labor Statistics (BLS). Of the total 44,233 adult respondents (≥ 18 years), we focused our analysis on 30,074 persons who worked anytime during the 12 months prior to the survey (categorized as 'recent workers').

A 'recent worker' was considered a case, if within the preceding 12 months he/she had seen a medical person (medical doctor, chiropractor, physical therapist or other medical person) for "prolonged hand discomfort" (defined as pain, burning, stiffness, numbness or tingling in the hand, wrist, or fingers, which was felt for 7 or more consecutive days, or for a total of 20 days or more), and was told that the discomfort was due to one of the following conditions, "tendinitis, synovitis, tenosynovitis, de Quervain's disease, epicondylitis, ganglion cyst, or trigger finger." These diagnoses were mutually exclusive, since the respondents were allowed to report only one condition. However, no attempt was made to medically validate the diagnosis. With the exception of ganglion(ic) cyst and trigger finger, the above disorders were lumped together in the final data set and could not be separated for analysis of each disorder. De Quervain's disease is tenosynovitis of abductor pollicis longus (APL) and extensor pollicis brevis (EPB) at the radial styloid process. Although epicondylitis is a disorder at the elbow, it could not be segregated from disorders of the hand/wrist in the data set. In this paper, tendinitis, synovitis, tenosynovitis, de Quervain's disease, and epicondylitis will be referred to as 'tendinitis group'. Data for ganglion(ic) cysts and trigger fingers were analyzed separately from, or together with, the 'tendinitis group' as appropriate. When the tendinitis group, ganglion cyst, and trigger finger were combined for analysis, this assembly was identified as 'tendinitis and related disorders'.

The assessment of musculoskeletal exposure at work was done by asking two questions about the current or most recent job; "Did your job require you to bend or twist your hands or wrist many times an hour?" and "Did you work with hand-held or hand-operated vibrating tools or machinery?" However, no work site ergonomic assessment was conducted. These exposure questions were asked before, not after, the questions related to the hand discomfort.

The survey also measured the impact of these disorders on case respondent's quality of life by asking the following four questions: (1) "Was your (hand) discomfort worse when you were trying to sleep, or did it awaken you from sleep?" (Sleep disturbance); (2) "Did you miss at least a full day from work because of your hand discomfort?" (Missing work); (3) "Have you ever made a major change (not defined) in your work activities because of your hand discomfort?" (Major change in work activities); and (4) "Have you ever stopped working at a job or changed jobs because of your hand discomfort?" (Stopped working).

The NCHS data tape contained both the raw (un-weighted) counts and the weights necessary to convert the raw counts to population-based national estimates. Each respondent was given a weight to represent anywhere from 3,000 to 10,000 persons in his/her demographic category, depending on such factors as the inverse of the probability of selection and household nonresponse adjustment [Massey et al., 1989]. Thus, 30,074 respondents represented 127 million "recent workers." The population prevalence of tendinitis and related disorders was calculated with its 95% confidence intervals (95% CIs) using Survey Data Analysis (SUDAAN) software [Research Triangle Institute, 1990] using the "sampling with replacement" approximation. Multiple logistic regression analysis was conducted to examine the contributions of various dichotomized occupational risk factors (presence or absence of exposure to vibration or bending/twisting of the hand/wrist) and personal factors (gender, age, race, body mass index (BMI), smoking history, education, and family income) to the prevalence of tendinitis and related disorders of the DUE, each adjusted for the other such factors. Also, adjusted odds ratios (AORs) were calculated to estimate the strength of association of risk factors with presence of tendinitis, after adjusting for other factors in the model. These factors were included in the model because there exist certain similarities between CTS and tendinitis, and their potential effects on CTS prevalence have been reported [Tanaka et al., 1997]. All statistical testing was performed using Wald tests [Hosmer and Lemeshow, 1989] with the probability of a Type I error set at 0.05.

RESULTS

Presented in Table I are national estimates for the 12-month period prevalence of tendinitis and related disorders

TABLE I. Estimated 12 Month Period Prevalence (Percent) and Frequency (in Thousands) of 'Medically-Called' Tendinitis and Related Disorders of the Hand/Wrist and Elbow (Distal Upper Extremity) Among 127 Million 'Recent Workers' in 1988 With Proportion of Cases That Were Thought to be Work-Related

Condition ^a	Prevalence		Weighted frequency ($\times 10^3$)	Work-related ^c fraction		Estimated work-related cases		
	(%)	(95%CI) ^b		(%)	(95% CI)	Frequency ($\times 10^3$)	(95% CI)	Column percent ^d
Tendinitis group ^e	0.31	(0.23; 0.39)	394.7	37.3	(26.8; 47.7)	147.0	(91.5; 202.6)	28.2%
Ganglion cyst	0.14	(0.08; 0.20)	172.2	5.5	— ^f	9.5	— ^f	1.8%
Trigger finger	0.02	(0.00; 0.04)	20.8	— ^f	— ^f	— ^f	— ^f	— ^f
Tendinitis and related disorders	0.46	(0.36; 0.56)	587.7	27.8	(19.8; 35.9)	163.6	(106.6; 220.6)	31.4%
CTS ^g	0.53	(0.41; 0.65)	675.9	52.8	(43.2; 62.5)	357.2	(243.3; 471.1)	68.6%
TOTAL	0.99	(0.84; 1.16)	1,263.6	41.2	(34.2; 48.2)	520.8	(393.3; 648.2)	100.0%

^aThese conditions are mutually exclusive; no person reported more than one condition.

^b95% CI = 95% confidence interval.

^cPercent of cases that were thought to be work-related by the medical person.

^dPercent among conditions.

^eIncludes tendinitis, synovitis, tenosynovitis, de Quervain's disease, and epicondylitis.

^fSample size is too small to reliably estimate.

^gCarpal tunnel syndrome, presented for comparison with modifications [Tanaka et al., 1995].

of the DUE. There were approximately 395,000 estimated cases of tendinitis group (tendinitis, synovitis, tenosynovitis, de Quervain's disease, or epicondylitis), and 37% (147,000 cases) of these were thought to be work-related by a medical person. There were also 172,000 estimated cases of ganglion cyst, 6% (about 10,000 cases) of which were thought to be work-related. Since there were only 21,000 estimated cases of trigger finger (based on 4 respondents), the percentage of work-related cases could not be calculated reliably. For comparison, carpal tunnel syndrome (CTS) data are also presented from a previous report [Tanaka et al., 1995]. All of these disorders combined affected about 1% (1.26 million) of 'recent workers', and 41% (521,000) of these cases were considered work-related. As shown in the last column of Table I, approximately 69% of the work-related DUE-MSD cases were CTS and the remaining 31% of the cases were made up of tendinitis and related disorders.

Table II presents frequency (raw count) and estimated prevalence of tendinitis and related disorders among 'recent workers' by various risk factors, occupational and non-occupational. Workers whose jobs required them to bend/twist their hands/wrists or use vibrating hand tools had much higher prevalence of the disorders than those whose jobs did not. Among nonoccupational factors, females reported higher prevalence of tendinitis and related disorders than males. Race and age had smaller differences in tendinitis prevalence. Other nonoccupational factors examined (BMI, smoking history, education, and family income) showed no effects on the prevalence of tendinitis and related disorders. Analysis by age and gender as presented in Figure 1 showed that among females, the youngest age group (18 to 25 years old) had the lowest prevalence, while the rest of the age

groups had similarly elevated prevalence. Among males, in contrast, the age group of 35 to 44 years old showed the highest prevalence followed by the 25–34-year-old group, while the other age groups had similarly lower prevalence.

The results of multiple logistic regression analysis are presented in Table III. Among the variables tested, only two, repetitive bending/twisting of the hands/wrists at work and female gender, were found to be significantly associated with reporting of tendinitis and related disorders. Exposure to hand vibration was of borderline significance. None of the other variables examined, i.e., race, BMI, smoking, age, education, and family income, was significantly associated with tendinitis group disorders, whether they were analyzed as dichotomous or continuous variables. Results from a previous report on carpal tunnel syndrome [Tanaka et al., 1997] are also listed in the right column for comparison. The impact of tendinitis and related disorders on some of quality of life indicators is listed in Table IV.

DISCUSSION

Tendinitis, tenosynovitis, and de Quervain's disease, have been recognized for decades as maladies of various occupations [Smithies, 1929; Thompson et al., 1951; Lapidus and Fenton, 1952; Muckart, 1964]. This situation may be contrasted to that of CTS which received public attention more recently, probably because of its unique symptoms and dramatic increase among workers performing repetitive or forceful manual work. Although the work-relatedness of CTS and other DUE-MSDs has been questioned by some [Nathan et al., 1988; Hadler, 1991], repetitive manual work has been firmly established as a

TABLE II. Frequency and Prevalence (Percent) of 'Medically-Called' Tendinitis and Related Disorders by Various Risk Factors Among 'Recent Workers' in 1988

Risk factor	Frequency (%) ^a (unweighted)	Prevalence (95%CI) (weighted)
Bend/twist ^b		
Yes	14,616 (48.6)	0.68 (0.50; 0.86)
No	15,458 (51.4)	0.25 (0.15; 0.35)
Vibration ^c		
Yes	5,072 (16.9)	0.66 (0.39; 0.93)
No	25,002 (83.1)	0.42 (0.32; 0.52)
Gender		
Female	15,427 (51.3)	0.61 (0.45; 0.77)
Male	14,647 (48.7)	0.33 (0.23; 0.43)
Race		
White	25,262 (84.0)	0.49 (0.39; 0.59)
Non-White	4,812 (16.0)	0.32 (0.14; 0.50)
Age		
18–24	4,598 (15.3)	0.30 (0.08; 0.52)
25–34	8,997 (29.9)	0.51 (0.33; 0.69)
35–44	7,545 (25.1)	0.53 (0.35; 0.71)
45–54	4,434 (14.7)	0.50 (0.28; 0.72)
55–64	3,195 (10.6)	0.43 (0.18; 0.68)
> 65	1,305 (4.3)	0.40 (0.07; 0.73)
BMI (Body Mass Index)		
≥ 25	12,537 (41.7)	0.46 (0.32; 0.60)
< 25	17,148 (57.0)	0.47 (0.33; 0.61)
Unknown	389 (1.3)	
Smoking		
Current	9,109 (30.3)	0.53 (0.35; 0.71)
Past	6,505 (21.6)	0.47 (0.29; 0.65)
Never	14,395 (47.9)	0.41 (0.25; 0.57)
Unknown	65 (0.2)	
Education		
Up to 12 years	4,362 (14.5)	0.51 (0.29; 0.73)
12 years	11,580 (38.5)	0.52 (0.36; 0.68)
Over 12 years	14,059 (46.8)	0.40 (0.26; 0.54)
Unknown	73 (0.2)	
Income		
up to \$19,999	9,024 (30.0)	0.44 (0.28; 0.60)
\$20,000-\$39,999	10,240 (34.1)	0.50 (0.34; 0.66)
\$40,000 & up	7,470 (24.8)	0.50 (0.32; 0.68)
Unknown	3,340 (11.1)	
Total	30,074 (100.0)	0.46 (0.36; 0.56)

^aColumn percent (%).^bBending or twisting of the hands or wrist many times an hour.^cWork with hand-held or hand-operated vibrating tools or machinery.

significant etiologic factor for these disorders among working populations [Stock, 1991; Bernard, 1997; Tanaka et al., 1997]. The results in this paper offer further support for the work-relatedness of DUE-MSD.

A simplified but generally accepted scenario for the pathophysiology of work-related tendinitis is that repeated sliding of the tendons within the synovial sheath at a joint will lead to frictional tenosynovitis [Armstrong and Chaffin, 1978]. If a sufficient rest period is given to the locale at the initial onset of pain, the inflammation will subside in due time. However, if repeated exertions are continued despite pain, the inflammatory process will intensify and result in temporary incapacitation, and even progress to a chronic stage, which is characterized by reactive hypertrophy and fibrosis. If the flexor tendons are primarily involved, their inflammation within the carpal tunnel will compress the median nerve under the flexor retinaculum to cause CTS [Gelberman et al., 1981]. If the abductor pollicis longus (APL) and extensor pollicis brevis (EPB) tendons are involved, it will be identified as de Quervain's disease [Moore, 1997]. Not all tendinitides involve the carpal tunnel or the tendons of the thumb, and such nonspecific tendinitides may be clinically categorized simply as tendinitis. In this respect, it can be said that work-related CTS is a specific (involving the median nerve) and large subset of work-related tendinitis of the DUE. Compared to other reports, the share of CTS in our result appears large (69%). For example, CTS cases were about 40% in an analysis of Federal employee workers' compensation claims [Feuerstein et al., 1998]. Some of this difference may be explained by the fact that Feuerstein's data included the shoulder and neck, while ours were limited to only several disorders in the distal upper extremity. Also, a review by Hales [1994] revealed the ratio of muscle tendon disorders versus CTS ranged from 2:1 to 62:1 based on a variety of industrial surveys. Such a wide variation is probably due to the local working conditions and case definitions used by the investigators.

Whereas our analysis showed that among the defined DUE-MSD cases, only 2% were ganglion cysts and 1% were trigger fingers, others reported much higher incidence of these disorders [Gorsche et al., 1998]. We suspect that these numbers were probably diminished in our dataset, since our case definitions were restricted to "prolonged hand discomfort" and medical consultation, and the respondents were asked to name only one diagnosis, even if they had experienced more than one. Compared to CTS or tendinitis group, ganglion cysts and trigger fingers, while bothersome, would generally cause less severe symptoms and fewer days of hand discomfort, for which people may be less likely to seek medical care.

This interpretation is further underscored by the results concerning the impact of each disorder on quality of daily life. Sleep disturbance was most frequently reported among CTS cases, while it was much less frequent for tendinitis and

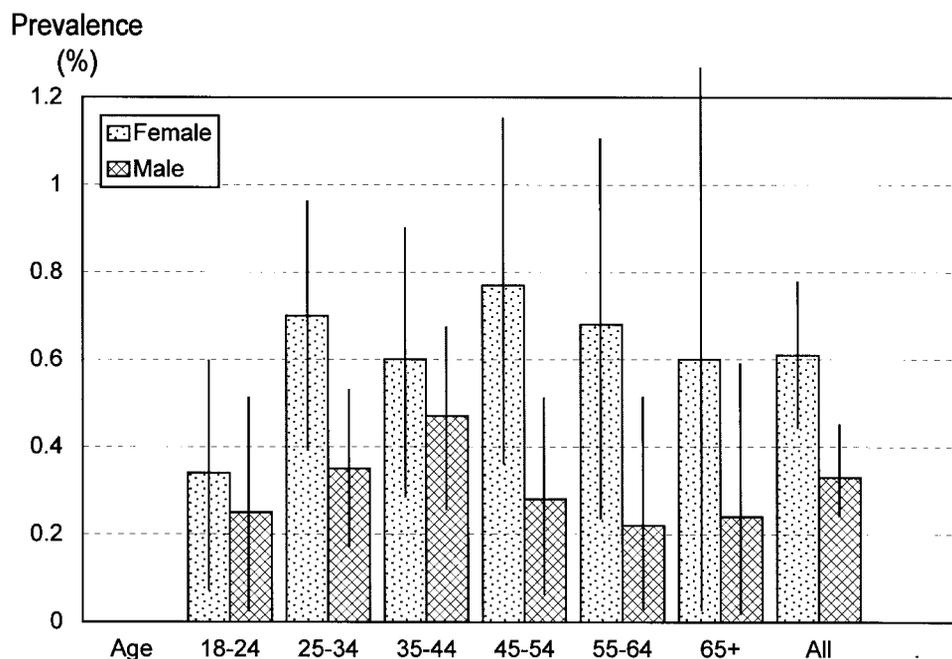


FIGURE 1. Prevalence (in percent) and 95% confidence intervals of tendinitis and related disorders of the distal upper extremity by age and gender among 127 million 'recent' U.S. workers, based on the 1988 National Health Interview Survey, Occupational Health Supplement data.

ganglion cyst groups. Nocturnal hand pain and numbness are specific symptoms of CTS (although it may also be a complaint in tendinitis). These results seem to attest to the general validity of the questionnaire response. In contrast, the percentages of cases reporting either missing work, a

major change in work activities, or stopping work or changing jobs, were not much different between the CTS and the tendinitis groups, whereas ganglion cyst cases reported lower percentages of these events, reflecting the relative severity of these conditions.

TABLE III. Adjusted Odds Ratios Based on the Multiple Logistic Regression Analysis of 'Medically-Called' Tendinitis and Related Disorders as Compared to Carpal Tunnel Syndrome Among 'Recent Workers', 1988

Variable	Adjusted odds ratio (95% CI)	
	Tendinitis and related disorders	Carpal tunnel syndrome ^a (medically-called)
Bend/twist ^b (yes vs. no)	2.56 (1.58; 4.16) ^d	5.50 (3.21; 9.42) ^d
Vibration ^c (yes vs. no)	1.54 (0.93; 2.55)	1.86 (1.23; 2.80) ^d
Race (white vs non-white)	1.47 (0.81; 2.65)	16.69 (5.22; 53.32) ^{d,e}
Gender (female vs. male)	2.51 (1.68; 3.74) ^d	2.31 (1.48; 3.60) ^d
BMI (≥ 25 vs. < 25)	1.16 (0.77; 1.76)	2.00 (1.33; 3.02) ^d
Smoking (ever vs. never)	1.15 (0.73; 1.81)	1.64 (1.03; 2.62) ^d
Age (≥ 40 vs. < 40 years)	1.12 (0.74; 1.69)	1.20 (0.81; 1.77)
Education (>12 vs. ≤ 12 Yrs)	1.03 (0.69; 1.55)	1.17 (0.77; 1.78)
Annual family income (≥ \$20,000 vs. <\$20,000)	1.23 (0.80; 1.87)	1.51 (0.95; 2.41)

^aFrom a previous report for comparison [Tanaka et al., 1997].

^bBending or twisting of the hands or wrist many times an hour.

^cWork with hand-held or hand-operated vibrating tools or machinery.

^dStatistically significantly greater than 1.

^eA very small number of non-whites reported medically-called CTS.

TABLE IV. Relative Impact of Tendinitis and Related Disorders on Some Aspects of Quality of Life Among 127 Million 'Recent Workers' in 1988

Condition ^a	Sleep disturbance	Missed work	Major change in work activities	Stopped working or changed job
Tendinitis group ^b	30.1%	22.0%	12.8%	14.1%
Ganglion cyst	10.8%	12.4%	6.6%	10.6%
Trigger finger	— ^c	— ^c	— ^c	— ^c
CTS ^d	72.8%	20.5%	17.9%	16.9%

^aThese conditions are mutually exclusive; no person reported more than one condition.

^bIncludes tendinitis, synovitis, tenosynovitis, de Quervain's disease, and epicondylitis.

^cSample size is too small to reliably estimate.

^dCarpal tunnel syndrome, presented for comparison with modifications [Tanaka et al., 1994].

Our national prevalence estimate of approximately 1% for the total DUE-MSDs is, in general, much lower than the incidence rates of MSDs reported in the literature. A major reason for this difference may be that the 1988 NHIS/OHS data are based on a national sample, while specific on-site studies are usually conducted at industries with known or suspected MSD problems, such as the textile industry [McCormack et al., 1990] or a pork processing plant [Moore and Garg, 1994]. On the other hand, our prevalence estimate is still much higher than the 1988 BLS' Annual Report for "disorders associated with repetitive trauma," even if the latter included such extraneous entities as noise-induced hearing loss and was not limited to DUE. Reasons for this difference may include differences in case definitions, reporting methods, and populations surveyed. Our data included all non-institutionalized adult civilian workers, while the BLS data excluded public employees, self-employed persons and workers on farms with fewer than 11 employees. Also, it has been known that prevalence or incidence rates based on record-based surveillance (such as OSHA-200 logs or workers' compensation record) are much lower than those obtained through data-generating surveillance (such as administration of health questionnaires) [Fine et al., 1986; Tanaka, 1996].

Also, part of the difference may be due to comparing our one-year period prevalence to BLS' incidence rates. It should be noted that only the new cases are to be included for calculation of incidence rates. This makes sense in case of infectious (e.g., tuberculosis) or chronic (e.g., diabetes) diseases. However, a worker may experience work-related CTS or tendinitis more than once during the same reporting period (usually 12 months). If the second incidence after the recovery from the first were not counted, it would result in under-reporting and might not reflect the exposure hazard truthfully. To deal with this situation, the OSHA guidelines for meatpacking plants allow for recounting of cumulative trauma disorders (CTDs) by stating, "any visit to a health care provider for similar complaints after the 30-day interval implies a reinjury or reexposure to a workplace hazard and

would represent a new case" [Duvall, 1993]. Compared to this guideline, our 12-month prevalence did not count the recurrence of the same case. Still, our annual prevalence was higher than the BLS' incidence rate for the same year.

The result of multiple logistic regression analysis for various risk factors was also informative when viewed in comparison to the result of a similar analysis for CTS. Although exposure to vibration appeared to be a risk factor when unadjusted for other factors (Table II), after the adjustment only exposure to bending/twisting of the hand/wrist and female gender were significantly associated with the prevalence of tendinitis and related disorders. This is not to say that the effects of vibration should be ignored, since it is a known risk factor for CTS. If the sample size of the tendinitis cases exposed to hand vibration had been larger, the result might have turned out to be significant. In contrast, significant risk factors for CTS included, in addition to the above two factors, exposure to hand vibration, having a higher BMI, and smoking [Tanaka et al., 1997], which were not significant for tendinitis and related disorders. The finding of these differences is consistent with our understanding that work-related CTS is a specific subset of work-related tendinitis, since CTS is due to the susceptibility of the median nerve to compression in the carpal tunnel. Nonetheless, bending/twisting of the hand/wrist had one of the strongest effects on the prevalence of both CTS and tendinitis.

Our result that females were found to show higher prevalence of tendinitis than males is consistent with other reports on the different prevalence or incidence rates of CTS by gender [Stevens et al., 1988; Tanaka et al., 1995]. The 1988 NHIS/OHS also showed that the national percentage of female workers performing work requiring bending/twisting of the hands and wrists (46.5%) was slightly lower than that of male workers (52.4%) [Tanaka et al., 1995]. When put together, these findings refute a notion that the higher incidence rate for work-related DUE-MSDs among female workers may be due to their selective placement toward repetitive manual jobs. While such employment

situations may exist in some localities, it would be difficult to ignore some basic biological differences between the two sexes as reasons for increased vulnerability among female workers. In fact, when interactions between gender and bending/twisting and between gender and vibration were added to the model, the observed effect of bending/twisting on tendinitis for females was about twice that for males (OR = 3.10 vs. OR = 1.54), although neither was significant.

Strengths and limitations of the 1988 NHIS/OHS data in regard to hand discomfort were previously discussed in detail [Tanaka et al., 1997]. Briefly, its major strength is that the data are based on a large multistage national sample of the working population with a high response rate and a minimum of selection bias. Although each diagnosis of the reported disorders was not medically validated, the responses were provided without any leading questions. While there were elements of information biases in terms of patients' recall and health care providers' observer bias, these cannot be assessed accurately. However, we believe that the questionnaire was constructed and administered in a way to minimize these biases. A detailed prevalence analysis of tendinitis and related disorders by industry or occupation was not practical with this data, because a relatively small number of responses were scattered over a wide variety of industries and occupations. BLS' Annual Survey report would be more informative in this respect.

Another limitation of this study would be that the assessment of pertinent exposure variables was incomplete in the 1988 OHS. Due to its household survey format, no work-site measurements were taken, and the exposure assessment was limited to personal recall of bending and twisting of the hands/wrists and use of vibrating hand tools. No information as to the forcefulness of hand work or pinch grip was collected. Although the two measured variables cannot be considered as surrogates for the entire range of biomechanical exposures, at least the respondents provided their best recall without incentives.

These limitations notwithstanding, overall, this analysis has achieved two major objectives of a national surveillance for work-related musculoskeletal disorders. First, it provided a national prevalence estimate of DUE-MSDs for the year 1988; and second, it provided additional evidence that repetitive manual work is a significant risk factor for DUE-MSDs among the U.S. working population.

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