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Risk Factors for Carpal Tunnel Syndrome and Median Neuropathy in a Working Population

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Abstract: Objective: To assess whether work-related physical activities are associated with CTS,
even when controlling for personal risk factors.

Methods: A cross-sectional assessment of 1108 workers from 8 employers and 3 unions completed
nerve conduction testing, physical exam, and questionnaires. CTS was
defined by median neuropathy and associated symptoms.

Results: Eighteen workers had CTS and 131 had evidence of median neuropathy. CTS was
highest among construction workers (3.0%) compared to other subjects (<1%). Logistic regression
models for median neuropathy both personal and work-related risk factors. Work-related exposures
were estimated by two methods: self-report and job-title based ratings.

Conclusions: Both work and personal factors mediated median nerve impairment. Construction
workers are at an increased risk of CTS so awareness should be raised and interventions shouldspecifically target this risk group.

INTRODUCTION

Carpal tunnel syndrome (CTS), a result of compression of the median nerve at the wrist,
is a common cause of hand discomfort and functional impairment. Using a case definition of
CTS combining symptoms and electrodiagnostic testing, prevalence estimates are between 1-5% in the general population[1, 2] and up to 10% among active workers in certain occupations.[3, 4] CTS has been identified as a leading cause of work disability with considerable associated costs. In 2005, the median number of days away from work due to CTS was 27, tied with fractures as the highest

among all major disabling workplace injuries and illnesses in the United States.[5] From 1990-1994, the cumulative worker's compensation costs for CTS claims in the state of Washington alone were about 310 million dollars.[6] Nationwide, the estimated medical costs associated with CTS exceed 2 billion dollars annually.[7]

Although CTS is more common in some occupations, the contributions of workplace physical activities and personal risk factors in its etiology are not fully understood. Among earlier studies of the work-relatedness of CTS, many had small sample sizes, used varying definitions of CTS, and did not consistently account for known personal risk factors such as increasing age, high body mass index (BMI), and comorbid diseases such as diabetes mellitus.[8, 9] Similarly, numerous recent studies characterizing the personal factors associated with CTS have not adequately measured or analyzed occupational factors.[8, 10-12] Other recent studies have shown that both personal and occupational factors are independently associated with CTS.[13-15] Evaluating the independent contributions of occupational versus non-occupational risk factors for CTS has implications for prevention, treatment, and for medical-legal issues.

The present study assessed the independent contributions of both personal and workrelated risk factors for median neuropathy and for CTS, defined as median nerve abnormality and appropriate symptoms in the same hand in a group of newly hired workers in several different industries.

METHODS

Subject Recruitment

This cross-sectional study presents baseline data from the Predictors of Carpal Tunnel Syndrome (PrediCTS) Study, an ongoing prospective study of CTS in newly hired workers.

Subjects were recruited from both high and low hand-intensive jobs within the St. Louis area between July 2004 and October 2006. Subjects were recruited from eight employers and three apprenticeship programs and included carpenters, floorlayers, sheetmetal workers, engineers, laboratory workers, computer workers, and hospital support staff. Eligibility criteria included starting a new job or having a change in job status, working a minimum of 30 hours per week, a minimum age of 18 years, and ability to speak English. Exclusion criteria were pregnancy, a prior diagnosis of CTS made by a healthcare provider, traumatic nerve injury or peripheral neuropathy, and physical conditions considered contraindications to nerve conduction testing.

Workers were recruited at the time of pre-placement, post-offer health exams, during employee orientation sessions, or at apprenticeship training programs. The Washington University School of Medicine and the University of Michigan Institutional Review Boards approved this study and all subjects provided written informed consent to participate. Subjects were compensated for participation.

Data Collection

Questionnaire

Each subject completed a self-administered questionnaire including items about neck and upper extremity symptoms, demographics, medical history, and past work history. Questions for upper extremity symptoms assessed general location, quality, severity, frequency, and duration. Subjects filled out a modified Katz hand diagram[16, 17] to depict the location of burning, pain, tingling or numbness in the hands. Demographics included age, gender, race, exercise habits, and smoking. Self-reported medical history included family history of CTS, medications, surgeries, and physician diagnosis of conditions previously described as risk factors for CTS.

Work-related physical exposures were measured in two ways. First, subjects completed a validated questionnaire[18] describing hand and arm activities in their most recent job held prior to study enrollment. These questions are listed in the appendix. Second, we assigned job-title based physical exposure ratings using the Occupational Information Network (O*NET™), a publicly available database provided by the US Department of Labor which describes the physical requirements of over 800 jobs (http://www.onetcenter.org/database.html). To assign exposure ratings for each subject, we matched the self-reported job title with the closest title in the O*NET database and used the values provided for upper extremity activities. The variables we analyzed are listed in the appendix.

Physical Examination and Nerve Conduction Studies

We performed a structured physical examination of the upper extremities that included
use of a dial caliper to measure wrist width and depth at the distal wrist crease. From these
measurements, we calculated the wrist index (the ratio of depth/width).[10, 11, 19] We measured each subject's height and weight to calculate their BMI (kg/m^2). Results of the physical exam were confidential and did not affect the worker's job placement or offer of employment.

Nerve conduction studies were performed by research assistants trained to operate an
automated nerve testing device, the NC-stat (NEUROMetrix, Inc., Waltham, MA). This
instrument has been shown to have good criterion validity when compared to traditional methods of nerve conduction testing.[20-24] We measured distal motor latencies for the median and ulnar nerve (wrist-thenar eminence and wrist-hypothenar eminence, respectively), and antidromic distal sensory latencies for the median and ulnar nerve (wrist-third finger and wrist-fifth finger, respectively) bilaterally. Summary results included amplitudes, latencies normalized to a temperature of 32ºC using correction factors provided by the manufacturer (.135 msec/degree C for median distal sensory latency), and percentile scores for the measurements, based on age and height-specific reference ranges for the general population provided by the manufacturer.

Case Definitions

We defined electrophysiological median neuropathy as a severe prolongation of median
nerve conduction time in either hand using the nerve testing device manufacturer's reference
ranges:

- Sensory median-ulnar latency difference ≥ 97.5th percentile, or
- Median distal sensory or motor latency > 99.8th percentile

Our case definition for CTS followed consensus criteria of Rempel, et al.,[25] requiring the
combination of electrophysiological abnormality of the median nerve and appropriate symptoms in the same hand. Positive symptoms were defined as a "classic" or "probable" score on a modified Katz hand diagram, which was rated by a panel of 3 experts using a consensus process. Raters of the hand diagrams were blinded to all other subject data.

Data Analysis

The software used for data analysis was SPSS version 14.0 (©SPSS Inc, Chicago, IL).

We calculated the prevalence of CTS and median neuropathy; ninety-five percent confidence intervals (CIs) were calculated using the continuity correction. Basic parametric and nonparametric statistics were used to compare potential risk factors between groups. We performed multivariate logistic regression analysis only for the median neuropathy outcome because there were too few cases of CTS to permit the analysis. The base model contained personal risk factors that were significantly associated with median neuropathy. In subsequent models, we examined the contributions of individual work-related exposure variables and combinations of these variables, controlling for the personal factors that were significant in the base model. Because of collinearity among the O*NET variables describing work-related physical activities, we performed a factor analysis using the "factor" procedure in SPSS to collapse the information into a smaller number of variables. Similar techniques have been used elsewhere to reduce the number of variables used to model biomechanical exposures.[26] We constructed additional logistic regression models using the "factors" as overall indices of physical exposure in the prior job. We used the C-statistic to assess the predictive ability of the final models. There is no universally agreed upon cut point for defining abnormal nerve conduction, therefore we performed a sensitivity analysis in which we repeated the prevalence estimates and regression models using a broader definition of median neuropathy:

- All individuals meeting the initial criteria, as well as individuals with
- Sensory median-ulnar latency difference ≥ 95^{th} percentile, or
- Median distal sensory latency > 95^{th} percentile

We also calculated linear regression models for the median nerve distal sensory latency for the left and right hands to verify that our assessment of risk factors did not depend on the form of the statistical model.

RESULTS

Study group

Among the 11 participating employers and trade unions, 2970 potentially eligible workers were invited to join the study and 1108 (37.3%) participated. Recruitment rates were 44.9% in the three construction trades apprenticeship programs, 48.3% at the hospital, and 17.8% in the other employers combined. Data analysis was restricted to the 1071 subjects with complete data sets. The analytical group consisted of 435 apprentice construction workers, 478 hospital workers, and 158 workers in computer or laboratory jobs. There was wide variability in prior jobs reported. Based on the O*NET occupation categories, there were 258 different job titles represented among the subjects included in the analysis. The demographic characteristics and medical history of the study group are shown in Table 1.

Prevalence

Of 1071 subjects, 131 (12.2%; 95% CI, 10.2%-14.2%) had electrophysiological evidence of median neuropathy. Of these subjects, 18 (1.7%; 95% CI, 0.9%-2.5%) met our case definition of CTS, which required characteristic symptoms in addition to neuropathy. Twenty-nine workers had characteristic symptoms but did not meet our criteria for electrophysiological abnormality. Prevalence rates of median neuropathy, characteristic symptoms, and CTS by new occupational group and proportion of individuals previously working in a manual trade are shown in Table 2. Newly hired construction workers had the highest prevalence of median neuropathy, characteristic symptoms, and CTS; they were also more likely to have worked in a previous manual labor job.

Analysis of Risk Factors for Carpal Tunnel Syndrome

Among the 15 variables analyzed, we found that both personal and work-related risk factors were associated with CTS. We compared the 18 subjects meeting the case definition of CTS to the 940 subjects with normal nerve conduction on all personal and work exposure variables and found that those with CTS had a higher BMI, but the difference was not statistically significant (31.0 vs. 28.1; p = 0.058). Additionally, the group with CTS had a higher median wrist index (ratio of depth/width) (0.72 vs. 0.69; p = .0006). Compared to workers with normal nerve conduction, a higher proportion of workers with CTS reported exposure to each of the eight physical exposure variables measured. This higher proportion of exposure was

statistically significant for five of the eight variables: lifting 2 or more lbs., using vibrating hand
tools, using the fingers or thumb as a pressing tool, using the fingers in a pinch grip, and forceful gripping. All other personal variables listed in Table 1 showed no statistically significant
difference between those with CTS and those with normal nerve conduction.

Analysis of Risk Factors for Symptoms of Carpal Tunnel Syndrome

To assess predictors of symptoms of CTS, we also examined differences in personal and
work exposure variables between workers with and without characteristic symptoms of CTS. We compared the 40 subjects with characteristic symptoms of CTS (Katz hand diagram of 2 or 3), regardless of nerve conduction status, to the 990 subjects without symptoms in the median nerve distribution (no symptoms or Katz hand diagram of 0, regardless of nerve conduction status). We found that those with characteristic symptoms of CTS were slightly younger (mean age 29.9 years vs. 30.8; p= 0.007). A higher proportion of workers with characteristic symptoms of CTS reported exposure to each of the eight physical exposure variables measured. This higher proportion of exposure was statistically significant for five of the eight variables: using vibrating hand tools, using a twisting motion of the forearm, using the fingers or thumb as a pressing tool, using the fingers in a pinch grip, and forceful gripping. All other personal variables listed in Table 1 showed no statistically significant difference between those with and without
characteristic symptoms of CTS.

Logistic Regression Models for Median Neuropathy

Personal Factors

All variables listed in Table 1 were included in the original model. The demographic and medical risk factors that best predicted prevalent cases of median neuropathy ($p<0.05$ for
univariates) were retained as the base model and included in all subsequent models (see Table 3).
In addition to gender, age, BMI, wrist index ≥ 0.7, and history of diabetes, history of shoulder
tendonitis was retained in the model with a significance of p = .058.

Self-Reported Work Exposures

Self-reported past work exposures were added to the base model one at a time with median neuropathy as the outcome. Table 4 shows the odds ratios for each physical exposure. As
univariates, all variables had odds ratios greater than 1 with statistically significant confidence

intervals, except using fingers/thumb as pressing tool and using fingers in pinch grip. When multiple self-reported physical exposures were added to the base model simultaneously, the best predictive model (C-statistic = 0.768) contained lifting 2 or more pounds, using vibrating hand tools and working on assembly line. This model is shown in Table 5. Because gender was unequally distributed between the current occupational categories, particularly with regard to the construction trades, we repeated this analysis with the removal of gender, and with the addition of a variable representing the occupational category for each worker's new job. The removal of gender from the model caused little change in the other risk factors for median neuropathy. As shown in Table 5, addition of current job category showed that new workers in construction and in the hospital had a higher risk of median neuropathy than those in the clerical/other group. Gender was not a significant predictor after controlling for current occupational category, but other personal and work-related risk factors were minimally changed by this addition.

Job Title Based Work Exposures

Table 6 shows the odds ratios for ascending quartiles of the job title based ratings, with the variables added one at a time for the outcome of median neuropathy. The following variables had at least one level with a statistically significant odds ratio greater than 1: static strength, dynamic strength, general physical activity, intensity level of handling objects, and time spent handling objects.

Using factor analysis, physical exposure variables from the O*NET database were collapsed into three factors. The first factor explained 56.6% of the variance with the following variables loading primarily onto it (rotated factor loading > 0.4): static, explosive, and dynamic strength, manual dexterity, general physical activity, intensity level of handling/manipulating objects with the hands, and time spent handling objects. The highest loadings (> 0.8) were among the strength variables and general physical activity, therefore this factor represented the upper extremity force requirement. The second factor explained an additional 13.1% of the variance. It represented the dexterity requirement, with the variables of manual dexterity, finger dexterity, wrist finger speed, and time spent handling objects loading primarily onto it. The third factor explained an additional 10.1% of the variance and represented the repetition requirement.

Time spent making repetitive motions and time spent handling objects were the primary variables loading onto it. The force and repetition requirements, but not the manual dexterity
requirement, were significant predictors in the regression model, which had an overall C-statistic
of 0.763 (Table 7). Removal of gender from the model strengthened the associations between
force and median neuropathy with little change in the associations with repetition. Adding
current occupational category to the model as in Table 5 reduced the strength of association with
force and repetition.

Sensitivity Analysis
Additional analyses with a more sensitive definition of nerve conduction abnormality (sensory median-ulnar latency difference ≥ 95th percentile, or median distal sensory latency >
95th percentile) found that the prevalence of median neuropathy nearly doubled (23.7%), while
the prevalence of CTS remained essentially unchanged (2.3%). Using this more sensitive outcome, the logistic regression model for personal and work-related risk factors associated with
median neuropathy showed similar results. Linear regression models of the median nerve distal
sensory latencies of the right and left hands found that gender, age, BMI, wrist index, history of
diabetes, regular physical exercise, family history of CTS, and a number of workplace physical
exposure variables were significant predictors.

DISCUSSION
We have shown that both personal and work-related risk factors are significant contributors to median neuropathy among newly hired workers. The study describes both sets of risk factors for CTS and median neuropathy in a large cohort of newly hired workers representing a wide range of prior occupational physical exposures.

Prevalence
The prevalence of CTS in this group of newly hired workers was not higher than the
prevalence in the general population[1], as would be expected in a group of healthy workers
seeking new employment. Apprentice construction workers had the highest prevalence of CTS in our study, while newly hired computer, clerical, and laboratory workers had the lowest. The

majority of the apprentice construction workers had a history of working in manual trades, supporting the hypothesis that forceful upper extremity work poses an increased risk of CTS. This finding is consistent with prior evidence indicating that occupations with high-force, high repetition physical demands have an increased risk of CTS,[3, 14] and jobs entailing typing and computer use present minimal risk.[27, 28]

The prevalence of median neuropathy in our population was similar to the prevalence found in previous studies. Prior estimates have placed the prevalence of median neuropathy between 4.7% and 18.9% in the general population and between 15% and 39% among manual laborers.[1, 4, 29-32] The majority of subjects (86.3%) classified as having abnormal median nerve conduction in our study did not have symptoms meeting our case definition of CTS. The finding that nerve conduction reference ranges based on the general population are overly sensitive when applied to a working population has been shown previously, and is not unique to our methods of nerve conduction testing. Using standard methods of nerve conduction, Bingham et al. found that 90% of a group of workers with electrophysiological median neuropathy were asymptomatic,[29] and Salerno et al. showed that reference ranges based on a population of active workers were prolonged with respect to accepted norms based on the general population. [33]

Risk Factors

The univariate analyses showed that personal factors as well as occupational factors including hand force and exposure to vibration were associated with CTS. However, the low prevalence of CTS in the study population limited the strength of the statistical inferences that could be drawn regarding risk factors. Among the personal factors that were significant in our regression models for median neuropathy were male gender and shoulder tendonitis. Prior studies have found women to be at higher risk for CTS than men, though other studies have found that women are more likely to report symptoms but are no more likely than men to have electrophysiological median neuropathy. [8 34] Because the odds ratio for male gender decreased when physical exposures were added to the model, and largely eliminated when job category was added, it is likely that the effect of male gender was predominantly due to the greater number of males in physically demanding occupations, particularly the construction trades. The risk factor of shoulder tendonitis may also be a surrogate marker for strenuous upper extremity work. Our regression models confirmed that physical exposures in the previously held job were independently associated with median neuropathy, even after controlling for a variety of personal factors. In a cross-sectional study, it is possible that subjects with symptoms may report physical exposures differently than those without symptoms. However, our study found a relationship between job physical exposures and median neuropathy whether the physical exposures were modeled using self-reported data or using the job title based ratings. This latter relationship is important to the validity of our findings since exposure estimates based on job title are not subject to reporting bias by the subjects. Additionally, since the majority of subjects with median neuropathy were asymptomatic, it is unlikely that reporting bias due to symptoms affected the logistic regression models for self-reported work activities. Among the different regression models we constructed, forceful work with the hands had the most consistent association with median neuropathy, appearing in some form in many of the models examining work-related factors. Work requirements of force, repetition, and vibration have been previously described as risk factors for CTS.[9, 13, 15]

Sensitivity Analysis

Using the less strict definition of abnormal median nerve conduction increased the prevalence of cases (23.7%) but reduced the number of significant variables in the model.

Evaluation of the continuous distal median sensory latency as a proxy for neuropathy in the right and left hands increased the number of personal variables in the model while retaining a variety of occupational physical exposures. Despite these minor changes in the logistic modeling, controlling for this new set of personal risk factors continued to show multiple self-reported physical exposures and job title based ratings as significant predictors of median neuropathy. Regardless of our modeling technique, both personal and occupational variables were associated with delayed median nerve conduction.

Limitations

A limitation of our multivariate modeling of risk factors was the use of electrophysiological median neuropathy as a surrogate for CTS. Consistent findings have shown that asymptomatic individuals with median neuropathy have a 3-4 fold increased risk of developing CTS over a period of 5-10 years.[13, 15, 34-36] Though the majority of people with asymptomatic median neuropathy will not develop symptoms,[34] this finding may represent a preclinical stage of CTS in a subset of individuals. Other studies have shown that risk factors for median neuropathy are similar to those for symptomatic CTS. Age, gender, obesity, and systemic diseases are known covariates of median nerve distal sensory and motor latencies, as well as known risk factors for CTS.[37] Occupational activities can also affect median nerve conduction. A study of 45 new employees in a pork processing plant showed that distal sensory latencies in the median nerve became significantly prolonged compared to baseline after 2 months of forceful manual work.[38]

Our study has several other limitations. The cross-sectional design permitted only a limited demonstration of a temporal relationship between outcomes and exposures that have been reported as common risk factors among workers with CTS.[39] The low prevalence of medical comorbidities such as diabetes, arthritis, and hypothyroidism in our study group limited our ability to statistically model their effects but also decreased the likelihood that the observed relationships between work-related factors, CTS and median neuropathy were confounded by these medical comorbidities.

Another limitation is that both of the methods we used to evaluate work-related physical activities could have led to exposure misclassification. We accounted only for the immediate prior job, and did not adjust for the number of years at the job nor other previous jobs. We also dichotomized physical exposures in our analysis. It is likely that these factors led to underestimation of the role of work exposures in CTS and median neuropathy. The large effect seen for current job group in Table 5 suggests that our exposure measures did not fully explain the variance due to job exposures.

CONCLUSIONS

We demonstrated that in a relatively young, healthy population of workers, work-related upper extremity physical activities are significantly associated with median neuropathy, even when controlling for known cofactors such as gender, age, BMI, wrist index, and comorbid diseases. This relationship was observed for both self-reported work exposures and for exposures derived from job titles and a standardized database of job descriptions. We also showed that physical exposures were significantly associated with CTS in our cohort. These findings indicate that reductions in workplace physical exposures may be useful for preventing CTS and median neuropathy. Workers in construction trades are at an especially increased risk of CTS, suggesting that interventions should specifically target this high-risk group. Prospective studies with more precise exposure measurements will help confirm or modify the associations found in this study.

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Table 1.

Table 1. Characteristics of the study group*

Characteristic	Analytic Sample (n = 1071)
Age, mean (SD), y	30.8 (10.3)
Body mass index, mean (SD)†	28.5 (6.6)
Wrist index, mean (SD)‡	0.70 (0.03)
Female gender	377 (35.2)
Race	
White	656 (61.3)
Other	415 (38.7)
Exercise regularly	726 (67.8)
History of cigarette smoking	509 (47.5)
History of diabetes	24 (2.2)
History of rheumatoid arthritis	12 (1.1)
History of osteoarthritis	22 (2.1)
History of thyroid disease	25 (2.3)
History of tendonitis	
Finger, hand, wrist, forearm, or elbow	42 (3.9)
Shoulder	27 (2.5)
History of fractured finger, hand, wrist, forearm, or elbow	263 (24.6)
Family history of CTS	
Yes	183 (17.1)
No	849 (79.3)
Unknown	39 (3.6)

Abbreviations: CTS, carpal tunnel syndrome.
*Data are expressed as No. (%) unless otherwise indicated.
†Calculated as weight in kilograms divided by height in meters squared.
‡Calculated as depth divided by width of wrist measured in centimeters at distal crease, average of left and right hands.

Table 2.

Table 2. Prevalence of median neuropathy, CTS symptoms and CTS case definition by current occupation and prior history of manual labor

Occupation Category of New Job†	Age	Male	Median Neuropathy*&		CTS Symptoms*		CTS Case Definition*		Prior Job Classified as Manual Labor, %‡
	Mean (SD) Range	%	No.	Prevalence, % (95% CI)	No.	Prevalence, % (95% CI)	No.	Prevalence, % (95% CI)	
Construction Workers (n = 435)	26.6 (6.6) (18-51)	99	66	15.2 (11.7-18.7)	28	3.4 (4.0-8.9)	13	3.0 (1.3-4.7)	70.6
Hospital Workers (n = 478)	33.8 (11.6) (18-67)	38	59	12.3 (9.3-15.4)	9	1.9 (0.6-3.2)	4	0.8 (0.0-1.8)	28.2
Computer / Other (n = 158)	33.2 (10.1) (20-64)	53	6	3.8 (0.5-7.1)	3	1.9 (0.0-4.3)	1	0.6 (0.0-2.2)	7.0
Total (n = 1071)	30.8 (10.3) (18-67)	100	131	12.2 (10.2-14.2)	40	3.7 (2.6-4.9)	18	1.7 (0.9-2.5)	42.3

Abbreviations: CTS, carpal tunnel syndrome; CI, confidence interval
*Median neuropathy defined as electrophysiological abnormality in either hand. CTS Symptoms defined as a rating of 'possible' or 'classic' on a Katz hand diagram (Katz 1990). CTS case definition defined as a combination of median neuropathy and classic/probable symptoms in same hand (Rempel 1998).
†Construction workers included apprentice carpenters, floor layers, and sheet metal workers. Hospital workers included primarily custodians, food service workers, medical technicians and clerical workers. Computer/other included subjects working at a desk or in a laboratory
‡Classified based on the O*NET job title code corresponding to each subject's prior job. The first 2 digits of the code, representing general families of related jobs, were used for this determination
&defined as sensory median-ulnar latency difference ≥ 97.5th percentile, or median distal sensory or motor latency > 99.8th percentile

Table 3.

Table 3. Base model for logistic regression analysis: medical and demographic factors associated with prevalent median neuropathy

Independent Variables	Odds Ratio	95% CI
Gender (male:female)	2.24	1.43-3.50
Age (per 10-year increase)	1.55	1.31-1.86
BMI (per 5-point increase) †	1.32	1.15-1.52
Wrist index ≥ 0.7 (yes:no) ‡	2.53	1.70-3.78
History of diabetes (yes:no)	2.71	1.02-7.15
History of shoulder tendonitis (yes:no)	2.55	0.97-6.73

Abbreviations: CI, confidence interval; BMI, body mass index.
N = 1071, p<.001.
†Calculated as weight in kilograms divided by height in meters squared.
‡Calculated as depth divided by width of wrist measured in centimeters at distal crease, average of left and right hands.

Table 4.

Table 4. Logistic regression analysis: odds ratios for median neuropathy for self-reported physical exposures in the prior job.

Self-reported Exposure	Odds Ratio*	95% CI	Exposed Subjects No. (%)
Lifting 2 or more lbs. (yes:no)	3.31	1.54-7.12	897 (83.8)
Using vibrating hand tools (yes:no)	1.88	1.23-2.85	410 (38.3)
Working on assembly line (yes:no)	2.86	1.64-5.01	84 (7.8)
Twisting forearm (yes:no)	1.78	1.18-2.69	564 (52.7)
Bending wrist frequently (yes:no)	1.72	1.07-2.76	773 (72.2)
Using forceful hand grip (yes:no)	1.68	1.12-2.53	539 (50.3)
Using fingers/thumb as pressing tool (yes:no)	1.19	0.80-1.76	399 (37.3)
Using fingers in pinch grip (yes:no)	1.24	0.82-1.86	321 (30.0)

Abbreviations: CI, confidence interval.
N = 1071, $p < .001$ for all models.
*Adjusted for age, gender, body mass index, wrist index, history of diabetes, and history of shoulder tend

Table 5.

Table 5. Logistic regression analysis: personal factors and self-reported physical work exposures associated with prevalent median neuropathy with occupational category excluded and included in separate models

Independent Variables	Odds Ratio*	95% CI	Odds Ratio*	95% CI
Gender (male:female)	1.68	1.03-2.74	1.13	0.64-2.02
Age (per 10-year increase)	1.58	1.32-1.89	1.79	1.48-2.37
BMI (per 5-point increase)†	1.28	1.12-1.49	1.34	1.10-1.54
Wrist index ≥ 0.7 (yes:no) ‡	2.54	1.69-3.82	2.74	1.81-4.14
History of diabetes (yes:no)	2.45	0.92-6.53	2.58	0.96-6.92
History of shoulder tendonitis (yes:no)	2.66	0.97-7.29	2.44	0.96-6.92
Lifting 2 or more lbs. (yes:no)	2.67	1.21-5.88	2.36	1.06-5.26
Using vibrating hand tools (yes:no)	1.50	0.98-2.31	---	---
Working on assembly line (yes:no)	2.57	1.46-4.54	2.71	1.52-4.82
Clerical/other±	---	---	1.0	
Hospital±	---	---	2.42	0.96-6.09
Construction±	---	---	7.01	2.65-18.54

Abbreviation: CI, confidence interval, BMI, body mass index.
N = 1071, $p<.001$, C-statistic = .768
*Adjusted for all other variables presented in the model.
†Calculated as weight in kilograms divided by height in meters squared.
‡Calculated as depth divided by width of wrist measured in centimeters at distal crease, average of left and right hands.
± Clerical/other included subjects working at a desk or in a laboratory. Hospital workers included primarily custodians, food service workers, medical technicians and clerical workers. Construction workers included apprentice carpenters, floor layers, and sheet metal workers.

Table 6

Table 6. Logistic regression analysis: odds ratios for median neuropathy for O*NET ratings of physical exposures in the prior job.

O*NET Exposure Rating	Odds Ratio*	95% CI
Static strength		
2nd quartile	2.67	1.46-4.89
3rd quartile	2.25	1.22-4.17
4th quartile	2.03	1.05-3.89
Explosive strength (yes:no)	1.27	0.84-1.92
Dynamic strength		
2nd quartile	3.21	1.75-5.92
3rd quartile	2.57	1.34-4.91
4th quartile	2.77	1.41-5.46
Manual dexterity		
2nd quartile	0.83	0.45-1.54
3rd quartile	1.43	0.84-2.44
4th quartile	1.56	0.90-2.67
Finger dexterity		
2nd quartile	0.94	0.57-1.56
3rd quartile	0.64	0.36-1.12
4th quartile	0.78	0.45-1.36
Wrist-finger speed		
2nd quartile	1.64	0.92-2.89
3rd quartile	1.55	0.89-2.72
4th quartile	1.35	0.76-2.42
General physical activity		
2nd quartile	2.55	1.38-4.69
3rd quartile	2.44	1.31-4.54
4th quartile	2.39	1.21-4.70
Handle objects		
2nd quartile	1.74	0.95-3.20
3rd quartile	2.60	1.43-4.73
4th quartile	2.19	1.18-4.08
Time handling objects		
2nd quartile	1.37	0.76-2.47
3rd quartile	1.78	1.00-3.18
4th quartile	1.97	1.11-3.52
Time repetitive motions		
2nd quartile	0.79	0.43-1.43
3rd quartile	1.17	0.70-1.94
4th quartile	1.25	0.75-2.09

Abbreviation: CI, confidence interval.

N = 1071, $p < .001$ for all models.

* Adjusted for age, gender, body mass index, wrist index, history of diabetes, and history of shoulder tendonitis. Odds ratios for each variable are in comparison to a referent group of the lowest quartile of exposure, except when otherwise noted. Quartile cutoffs are available upon request.

Table 7.

Table 7. Logistic regression analysis: personal factors and O*NET occupational ratings associated with prevalent median neuropathy.

Independent Variables	Odds Ratio*	95% CI
Gender (male:female)	1.80	1.09-2.96
Age (per 10-year increase)	1.61	1.36-1.93
BMI (per 5-point increase) †	1.32	1.14-1.52
Wrist index ≥ 0.7 (yes:no) ‡	2.60	1.73-3.90
History of diabetes (yes:no)	2.66	0.96-7.39
History of shoulder tendonitis (yes:no)	2.95	1.09-7.95
Force requirement**		
2nd quartile	2.15	1.10-4.18
3rd quartile	3.48	1.81-6.66
4th quartile	2.48	1.19-5.15
Repetition requirement**		
2nd quartile	1.48	0.80-2.74
3rd quartile	1.11	0.61-2.00
4th quartile	1.79	1.01-3.18

Abbreviation: CI, confidence interval, BMI, body mass index.
N = 1071, p<.001, C-statistic = .763
*Adjusted for all other variables presented in the model.
**Derived from factor analysis of O*NET ratings of physical exposures in prior job. Reference category for odds ratios was lowest quartile of exposure score.
†Calculated as weight in kilograms divided by height in meters squared.
‡Calculated as depth divided by width of wrist measured in centimeters at distal crease, average of left and right hands.

Appendix

Appendix Self-reported exposures and Independent ratings (O*NET database)

Self-reported Exposures* Name	Description
Lifting	On average, how long altogether each day did you lift, carry, push or pull objects weighing more than 2 pounds?
Using Vibrating Tools	On average, how long altogether each day did you work with hand-held or hand-operated vibrating tools or equipment?
Assembly Line	On average, how long altogether each day did you work on an assembly line?
Twisting Motion of Forearm	On average, how long altogether each day did you do tasks where there was twisting, rotating, or screwing motion of the forearm (using a screwdriver, ringing out a rag)?
Frequent Bending of Hand/Wrist	On average, how long altogether each day did you frequently bend or twist hands or wrists?
Forceful Grip	On average, how long altogether each day did you use your hand in a forceful grip?
Finger/Thumb as Pressing Tool	On average, how long altogether each day did you use the tip of a finger or thumb as a pressing or pushing tool?
Finger Pinch Grip	On average, how long altogether each day did you use your hand in a finger pinch grip?

Independent Ratings (O*NET database) Name	Description
Manual Dexterity†	The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.
Finger Dexterity†	The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble objects.
Wrist-finger Speed†	The ability to make fast, simple, repeated movements of the fingers, hands, and wrists.
Static Strength†	The ability to exert maximum muscle force to lift, push, pull, or carry objects.
Explosive Strength†	The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object.
Dynamic Strength†	The ability to exert muscle force repeatedly or continuously over time. This involves muscular endurance and resistance to muscle fatigue.
Performing General Physical Activities†	Performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling of materials.
Handling and Moving Objects†	Using hands and arms in handling, installing, positioning, and moving materials, and manipulating things.
Spend Time Using Your Hands to Handle, Control, or Feel Objects, Tools or Controls‡	How much does this job require using your hands to handle, control, or feel objects, tools or controls?
Spend Time Making Repetitive Motions‡	How much does this job require making repetitive motions?

*Quantified using categorical time scale, broken down into 12 categories from < 5 min. to > 8 hours.
†Quantified using weighted average of scores on a scale from 0-7, representing extent or intensity of activity defined by verbal anchors.
‡Quantified using weighted average of scores on a scale from 1-5, representing amount of time from never to continuously.