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by Silverstein B, Fan ZJ, Smith CK, Bao S, Howard N, Spielholz P, Bonauto DK, Viikari-Juntura E

Affiliation: Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries, PO Box 44330, Olympia, Washington, United States. silb235@lni.wa.gov

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Gender adjustment or stratification in discerning upper extremity musculoskeletal disorder risk?

by Barbara Silverstein, PhD,¹ Z Joyce Fan, PhD,¹ Caroline K Smith, MPH,¹ Stephen Bao, PhD,¹ Ninica Howard, MSc¹ Peregrin Spielholz, PhD,¹ David K Bonauto, MPH,¹ Eira Viikari-Juntura, PhD²

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Objectives The aim was to explore whether “adjustment” for gender masks important exposure differences between men and women in a study of rotator cuff syndrome (RCS) and carpal tunnel syndrome (CTS) and work exposures.

Methods This cross-sectional study of 733 subjects in 12 healthcare and manufacturing workplaces used detailed individual health and work exposure assessment methods. Multiple logistic regression analysis was used to compare gender stratified and adjusted models.

Results Prevalence of RCS and CTS among women was 7.1% and 11.3% respectively, and among men 7.8% and 6.4%. In adjusted (gender, age, body mass index) multivariate analyses of RCS and CTS, gender was not statistically significantly different. For RCS, upper arm flexion $\geq 45^\circ$ and forceful pinch increased the odds ratio (OR) in the gender-adjusted model (OR 2.66, 95% CI 1.26–5.59) but primarily among women in the stratified analysis (OR 6.68, 95% CI 1.81–24.66 versus OR 1.45, 95% CI 0.53–4.00). For CTS, wrist radial/ulnar deviation $\geq 4\%$ time and lifting $\geq 4.5\text{kg}$ $>3\%$ time, the adjusted OR was higher for women (OR 4.85, 95% CI 2.12–11.11) and in the gender stratified analyses, the odds were increased for both genders (female OR 5.18, 95% CI 1.70–15.81 and male OR 3.63, 95% CI 1.08–12.18).

Conclusions Gender differences in response to physical work exposures may reflect gender segregation in work and potential differences in pinch and lifting capacity. Reduction in these exposures may reduce prevalence of upper extremity disorders for all workers.

Key terms rotator cuff tendinitis; carpal tunnel syndrome; pinch; awkward posture.

Work-related musculoskeletal disorders (MSD) constitute a significant proportion of occupational morbidity, lost work days and costs. Neck, back and upper extremity work-related MSD represent 27% of all workers' compensation claims in Washington State, 36% of claims resulting in four or more lost work days and more than 43% of all costs (1).

Upper extremity MSD such as rotator cuff syndrome (RCS) and carpal tunnel syndrome (CTS) account for 10% of all workers' compensation claims. Distribution of upper extremity MSD claims differs by gender. Females account for 37% of RCS and 59% of CTS

claims (1). However, long-term earnings losses for CTS claimants, measured seven years post-filing, were much greater for male than female CTS claimants, after adjusting for age, industry and geography (2). While incidence rates for all claims were greater among men than women in West Virginia, rates for upper extremity MSD claims were greater for women (3) by industry sector. However, women claimants were more likely than men to be in low wage jobs (perhaps with higher musculoskeletal risk). For women, but not men, the impact of socioeconomic status on general health and musculoskeletal disorders is largely attenuated after adjusting for

¹ Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries, Olympia, Washington, United States.

² Musculoskeletal Centre, Finnish Institute of Occupational Health, Helsinki, Finland.

Corresponding author: Dr B Silverstein, Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries, PO Box 44330, Olympia, Washington, United States. [E-mail: silb235@lni.wa.gov]

physical demands of work (4). These administrative and survey data findings increase the need to understand the gender and job (physical and psychosocial) interactions which can impact job design and public policy.

Women and men in the same industry or occupation may have different tasks, hours worked, seniority, and interaction between equipment and tool dimensions and work activities (5). Even when doing the same task, women may exert more physical effort (greater percent maximum voluntary contraction) due to less upper body strength, different postural angles or poor tool fit (6–9). Also, women may be in jobs that have higher psychosocial job strain (high demands, low control) which may impact musculoskeletal health (10). However, existing tools for measuring such exposures differentiate poorly between physical and psychosocial demands. In one study (10) – when adjusted for age, education, job category, hours worked, and social support – symptom prevalence associated with high measured psychosocial job strain was not significantly different by gender. It may also be that women are more prone to report symptoms than men, have different healthcare seeking practices or report higher exposures (8, 11–14). However, in several multivariate analyses where individual demographic, psychosocial and physical load variables have been considered, again, gender was not a statistically significant factor (15–17). To better understand the potential differences in risk for work-related upper extremity MSD, Punnett & Berqvist (18) recommended gender-stratified rather than gender-adjusted analyses.

Few studies have examined the differences in exposure for men and women based on individual exposure and health assessments for work-related upper extremity MSD. This paper focuses on the two conditions where there are the widest gender differences in the Washington State workers' compensation data, namely RCS and CTS, the former being more frequent among men and the latter among women. The purpose of our study was to compare gender-adjusted and gender-stratified analyses of individually assessed physical and psychosocial risk factors for shoulder symptoms, clinically verified RCS, CTS symptoms and electrodiagnostically verified CTS in a fulltime working population of manufacturing and health service workers in Washington State.

If the reported female excess in upper extremity MSD is largely explained by job exposures, improving women's manual jobs should become a public health priority. We therefore undertook this study to differentiate between gender and exposure effects in jobs where exposures to risk factors are at multiple levels.

Study population and methods

Study population

We recruited candidate worksites from the manufacturing (electronics, automotive parts, windows, cabinets, and medical, and fitness equipment) and healthcare (hospitals and health research areas, excluding direct patient care) sectors in Washington State. Study ergonomists conducted an initial workplace walkthrough to roughly categorize jobs into two levels of hand force (low and high) and three levels of repetitive hand activity (low, medium, and high) using the threshold limit values for hand activity level of the American Conference of Governmental Industrial Hygienists (19). Facilities with at least three of the six potential exposure categories were eligible for inclusion as study sites. Twelve western Washington workplaces were included in the study. Of the 1136 potential eligible subjects, 795 (70%) enrolled in the study, 33 were excluded, leaving 733 in total – 383 men (52.3%) and 350 (47.7%) women. An additional 13 were excluded from the CTS analysis due to missing electrodiagnostic testing.

Those subjects eligible and willing to participate completed an informed consent form approved by the Washington State Institutional Review Board and the institutional review boards of participating health care facilities. We collected information about each participating worker's health and work using questionnaire interviews (interviewers were blinded to exposure and physical examination information), physical examination (examiners were blinded to work including job title, health history, symptoms reported to interviewers, and physical load factors of the job), and physical exposure assessment (ergonomists were blinded to health status). Health data were collected during working hours at no loss in pay. Nominal gifts were offered to participants at the end of the health assessment. Due to resource constraints, exclusion criteria included working part-time, working in a mobile job (forklift driver) or having a job with more than four tasks. Temporary workers were also excluded.

Health assessment

The health assessment included a structured questionnaire interview conducted by trained interviewers and a standardized physical examination performed by trained health team staff (physician, physical therapist, and registered nurse). The questionnaire was translated into multiple languages, with interpreters available, and included: (i) demographics: age, gender, ethnicity, education, children or adults in the home requiring care, high force or repetitive sports and hobbies, and driving time; (ii) relevant health history: diabetes,

rheumatoid or degenerative arthritis, gout, hypertension, acute traumatic injuries, smoking, medications, and treatment for MSD; (iii) work history: duration of employment with company, job, and similar work prior to current job, shift and hours, overtime and second job; and (iv) body map for recording areas of pain or discomfort in the previous year lasting more than one week or occurring more than three times in the previous year. For those meeting these criteria, more detailed information regarding duration, frequency, onset, type, and intensity of symptoms was sought.

The physical examination was conducted bilaterally on all subjects and included: (i) passive, active and resisted motions of the neck and upper extremity, (ii) maximum power and pinch grips in standardized postures, and (iii) measured height and weight to calculate body mass index (BMI) as weight in kilograms divided by height squared measured in meters (kg/m^2). Nerve conduction velocity (NCV) studies were performed on the dominant hand using standard techniques of supramaximal percutaneous nerve stimulation (20) and surface recording, using Cadwell Sierra II Wedge (Cadwell Laboratories Inc, Kennewick, WA, USA) equipment. Anatomic landmarks and standardized stimulation to recording electrode distances were used. While measuring locations for electrode placement, the wrist was held straight with the fingers extended. Skin temperature was measured using an Electromedics digital skin thermometer (Medtronic Electromedics Digital Thermometer, Parker, CO, USA). The hand was wrapped in an electric heating pad if necessary to obtain a digital temperature of greater than 32°C . Complete ulnar nerve studies were not done as part of the research protocol. A board-certified neurologist reviewed all final protocols and methods for the electrodiagnostic testing and also reviewed all wave form results. If the subject had abnormal findings on the dominant side or symptoms in the nondominant hand, the nondominant hand was also tested.

Case definitions

Current shoulder symptoms: (i) shoulder pain or burning in the last seven days and (ii) occurring more than three times or lasting more than one week in the previous 12 months and (iii) no traumatic injury onset.

Positive physical examination: (i) resisted shoulder abduction, external rotation, internal rotation (pain in respective tendon insertion area) or (ii) "painful arc" (pain in rotator cuff area with active shoulder abduction typically at $60\text{--}120^\circ$).

Positive physical exam but no current shoulder symptoms: this group of subjects was compared with those who had no shoulder symptoms or physical findings.

Rotator cuff syndrome: current symptoms and positive physical examination in the same shoulder, no history of acute trauma to the shoulder or rheumatoid arthritis.

Current carpal tunnel syndrome symptoms: (i) symptoms of burning, or pain/numbness/tingling in the planar median nerve distribution of the hand in the last seven days and (ii) lasting for more than one week, or occurred more than three times in the previous 12 months, and (iii) no acute traumatic onset.

Positive electrodiagnostic test for distal median motor or sensory nerve: positive electrodiagnostic test (NCV) which meets A and B or A and C below in table 1. Criteria were adapted from the Washington State Department of Labor and Industries Medical Treatment Guidelines (21).

Positive nerve conduction velocity but no current carpal tunnel syndrome symptoms: this group of subjects was compared with those who had no hand/wrist symptoms or abnormal NCV findings.

Carpal tunnel syndrome: current symptoms and positive electrodiagnostic test in the same hand and no history of acute trauma to the hand/wrist or rheumatoid arthritis.

Job-related psychosocial assessment

We gave the subjects a psychosocial questionnaire which included questions designed to evaluate perceived general physical and mental health, social support, job demands, and decision latitude. We used questions from the Modified Work APGAR survey (22) to assess job satisfaction in relation to social support at work. Job demands and decision latitude were evaluated using questions from the Job Content Questionnaire (23). Continuous scores of job demands and decision latitude were dichotomized at the median of the sample to create high or low demand and high or low decision latitude. These in turn were dichotomized into high job strain (high demand–low control) versus

Table 1. Positive electrodiagnostic test (nerve conduction velocity, NCV) for distal median motor or sensory nerve which meets A and B or meets A and C.

Criteria	Description
A	Median motor latency 8 cm >4.5 ms, median sensory latency D2-wrist 14 cm >3.5 ms, or mid-palmar latency 8 cm >2.2 ms
B	Ulnar sensory latency 14 cm <3.7 ms
C	Median sensory latency (14 cm) minus ulnar sensory latency >0.5 ms or mid-palmar difference >0.03 ms

all others (low demand–low control = passive job, low demand–high control = low strain, high demand–high control = active job). These instruments were also translated into multiple languages. Interpreters were available as needed.

Work organizational assessment

Organizational factors (24) were collected by ergonomist observation using supervisor input for clarification at the departmental, level unless study jobs within a department had distinctly different organizational features. Organizational assessment items included gender mix, environment (temperature, humidity, noise, housekeeping), labor content (skill level), job type, work method, posture type, social content (interaction), positioning, pacing, pacing control, rotation, work hours, and job content (structural constraints). An assessment checklist was adapted from existing instruments (17, 24, 25). During individual exposure assessments, ergonomists recorded whether jobs were single- or multiple-task jobs, where the latter could be equated with job rotation. There was 79.9% agreement on rotation between individual job assessment by ergonomists and department-level characterization “rotation”. In the departmental characterization, if there were any jobs where there was rotation, even a minority of jobs, the department was characterized as rotational. The department level characterization approach may have overestimated rotation (30.7% versus 19.3%).

Physical load assessment

In the assessment of physical load exposure, we evaluated the durations, frequencies, and intensities of postures and forces across job tasks for each individual subject. A detailed description of methods for data collection, processing and analysis is reported elsewhere (25–27). Briefly, ergonomists observed all subjects on-site and workers were videotaped using synchronized cameras positioned to film from two different angles. Filming was performed for a minimum of 15 minutes during a typical work period in order to estimate exposures to forceful exertions, awkward postures, repetitive movements and duration, and frequency of power tool use. Approximately 95% of participants were in cyclic task jobs which were filmed for 15 minutes. For cyclic jobs with between two and four tasks, subjects were filmed for ten minutes per task. For noncyclic jobs, subjects were filmed for three random five minute samples in a typical work shift.

We time-studied video data using the multimedia video task analysis (29) software to calculate frequency and duty cycle of forceful exertions in

individual workers jobs. We also conducted detailed posture analyses using a time-based posture analysis approach (25–26) with software (25) developed by SHARP. Paired analysts estimated the postures through observations of two synchronized video screens and computed the percent of time that a body part spent in each of the predefined angular sectors. All analyses were conducted at the task level. Using task distribution information (durations of tasks in a job), job level exposures were computed using the time-weighted averaging method.

During the worksite visits, we used force gauges to measure object weights and push/pull forces, and a force matching technique (27) to estimate pinch and power grip forces. Duty cycle with forceful exertions (% of time) and frequency (times/min) with forceful exertions were obtained for each of the different types of forceful exertions (lifting, pushing/pulling, power, and pinch gripping) respectively. Overall, we computed duty cycle with forceful exertions and the frequency thereof. Forceful exertions were defined as pinch grip forces ≥ 8.9 N (corresponding to 2.0 lbs or 0.9kg), and power grip forces, lifted object weights or push/pull forces ≥ 44.1 N (corresponding to 10 lbs or 4.5 kg). We estimated percent maximum voluntary contraction (% MVC) for pinch and power grips by using the maximum values obtained during the physical examination as reference. These reference values were obtained when the subject had a neutral wrist and forearm posture with the elbow flexed 90° and the forearm resting on a table. This would have underestimated the true % MVC for subjects in a non-neutral working posture. We also applied multimedia video task analysis to record the frequency and duration of handheld vibrating tool use. However, vibration level was not ascertained.

To assess the effects of physical exposures imposed on the upper extremities in work activities, we focused first on determining the optimal cut points for each of the exposure variables based on the previous, although limited, epidemiological literature (29–36), biomechanical and physiological studies (37–41), and the distributions of the data in our study population.

For the assessment of exposure-response relationships, we initially trichotomized temporal variables and dichotomized force variables. The force variables were dichotomized with pre-defined cut-off values (high and low as described above). To assess the effects of the combinations of forces and postures at the job level, we dichotomized the posture variables at the median. These combination variables were constructed using the dichotomous cut-off points for force and awkward postures. When both factors were present in the job, it was considered “high force”; the presence of one factor indicated “intermediate” while “none” meant neither factor was present. Combined variables were included

in further analyses if simultaneous exposure of the high force and awkward posture occurred more than 0.1% of the work shift. A number of trichotomous posture and force variables were constructed (eg, upper arm abduction/adduction, flexion/extension/forearm rotation, wrist flexion/extension, and ulnar/radial deviation) for power, pinch and lifting forces.

Statistical analysis

Descriptive analyses included the Student's t-test, the Wilcoxon rank sum test and the Chi-squared test. Multivariable logistic regression analyses were conducted for each group of covariates (individual characteristics, psychosocial variables, work organizational variables, and physical workload variables), stratified by gender and adjusting for age and BMI.

A final multivariable logistic model was built for each statistically significant combination variable of posture and force in univariate analysis, age, gender, BMI and the most statistically significant work organizational or psychosocial variable.

We also examined this data using a negative binomial analysis but found that there was no over-dispersion so the models did not converge. We additionally examined Poisson models for relative risk, which showed similar results, but preferred using the logistic model for cross-sectional data.

Both gender-adjusted and gender-stratified analyses are presented. All analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC, USA) statistical software.

Results

A greater proportion of women reported current shoulder symptoms but there was no significant difference in prevalence between men and women with respect to physical examination findings or clinically verified RCS. Women displayed a significantly higher prevalence of both reported CTS symptoms and electrodiagnostically verified CTS than men, but there was no significant difference between the genders in abnormal NCV findings (table 2).

Gender-stratified personal characteristics were reviewed for those with symptoms and clinical case status compared to asymptomatic subjects (table 3). A greater proportion of women with either shoulder or CTS symptoms were current smokers than asymptomatic women. Both women and men with CTS symptoms and electrodiagnostically verified CTS were significantly older than their asymptomatic counterparts, but

Table 2. Current symptoms and clinical findings related to rotator cuff syndrome (RCS) and carpal tunnel syndrome (CTS) by gender, dominant side.

	Female (N=350)		Male (N=383)		P-value ^a
	N	%	N	%	
Shoulder current symptoms	81	23.1	59	15.4	0.0078
RCS physical exams	58	16.6	65	17.0	0.88
RCS cases	25	7.1	30	7.8	0.72
CTS current symptoms	67	19.4	42	11.0	0.0016
Abnormal nerve conduction velocity test	119	34.4	127	34.0	0.90
CTS cases	39	11.3	24	6.4	0.0213

^a Chi-squared test for male-female difference.

only women had significantly greater BMI and more often relevant co-morbid conditions than their asymptomatic counterparts.

Psychosocial and work organizational factors

Psychosocial variables were available for 694 and 684 subjects in the RCS and CTS analyses respectively. Work organizational variables were available for 725 subjects in the RCS and 712 in the CTS analyses. With respect to psychosocial and work organizational factors (tables 4 and 5), there were no significant differences between those with and without CTS symptoms or clinical case status. High social support and decision latitude were protective for men in terms of shoulder symptoms and clinically verified RCS. Among women, low social support was a significant factor for those with shoulder symptoms but did not achieve statistical significance for those with RCS (table 6). Very strong structural constraints were significantly associated with shoulder symptoms and of borderline significance for RCS among women, but of borderline significance among symptomatic men. When evaluated at the departmental level, job rotation was a significant factor for RCS cases among women but not for men. However, when individual assessment was done, the association with RCS cases among women was of borderline significance.

Physical load assessment

Rotator cuff syndrome. The distribution of physical load factors for the shoulder is presented by gender and symptom or case status in table 7, and the age/BMI adjusted odds ratios (OR) are presented in table 8. Shoulder symptoms among women were associated with forceful pinching, upper arm flexion $\geq 45^\circ \geq 18\%$

Table 3. Personal characteristics of the study population, by gender and dominant side diagnosis. (BMI = body mass index, RCS = rotator cuff syndrome, CTS = carpal tunnel syndrome)

	Age		BMI		Current job (years)		Race ^a (%)	Education ^b (%)	Smoking ^c (%)	Subjects with diabetes, hypertension, thyroid disease or gout (%)	Recreation	
	Mean	SD	Mean	SD	Median	1st-3rd quartile					High hand force (%)	High repetitive force (%)
Subjects with shoulder current symptoms												
Female (N=81)	42.5	9.1	28.3	7.4	2.9	1.1–6.8	56.8	85.2	30.9 ^d	27.2	34.6	32.1
Male (N=59)	39.2	12.9	27.4	5.9	3.3	0.9–7.6	55.9	81.4	42.4	11.9	32.2	33.9
RCS cases												
Female (N=25)	42.3	9.1	28.0	6.9	2.6	1.2–6.6	52.0	76.0	20.0	24.0	32.0	20.0
Male (N=30)	41.3 ^e	11.6	28.9	6.5	2.4	1.0–8.0	56.7	80.0	36.7	13.3	26.7 ^e	30.0
Subjects with CTS current symptoms												
Female (N=67)	42.3 ^d	9.1	28.0 ^d	6.9	2.5	0.9–6.6	64.2	83.6	26.9 ^e	37.31 ^d	38.8	34.3
Male (N=42)	41.3 ^d	11.6	28.9	6.5	2.4	1.0–8.0	57.1	88.1	45.2	9.5	38.1 ^e	33.3
CTS cases												
Female (N=39)	47.1 ^d	9.2	29.8 ^d	6.2	3.6	1.0–6.6	59.0	76.9	20.5	41.0 ^e	41.0	38.5
Male (N=24)	45.1 ^d	11.2	28.9 ^e	6.3	1.4	0.4–5.4	41.7 ^e	87.5	41.7	12.5	37.5	20.8 ^d
All subjects												
Female (N=350)	41.7	10	27.4	6.4	2.5	0.9–5.3	59.7	84.9	22.0	26.6	36.9	32.6
Male (N=383)	37.4	11.4	27.2	5.2	2.1	0.5–5.4	59.3	82.2	36.8	13.1	43.6	36.8

^a Percentage white.^b Percentage with at least high school education.^c Current smokers.^d P<0.05 (student's t-test, Wilcoxon rank sum test, or Chi-squared test, stratified by gender); subjects with symptoms or clinically verified disease compared with asymptomatic subjects.^e P<0.10 (student's t-test, Wilcoxon rank sum test, or Chi-squared test, stratified by gender).**Table 4.** Psychosocial and work organizational factors, by gender and dominant-side diagnosis. (RCS = rotator cuff syndrome, CTS = carpal tunnel syndrome)

	Shoulder current symptoms compared to non-symptoms (% symptoms)		RCS cases compared to non-cases (% cases)		CTS current symptoms compared to non-symptoms (% symptoms)		CTS cases compared to non-cases (% cases)		All subjects (%)		
	Female (N=80)	Male (N=58)	Female (N=25)	Male (N=30)	Female (N=60)	Male (N=40)	Female (N=37)	Male (N=23)	Female (N=345)	Male (N=380)	
Psychosocial											
High decision latitude	46.1	28.3 ^a	45.8	27.6 ^a	43.3	37.5	54.1	39.1	48.6	46.8	
High social support	40.8 ^a	26.4 ^a	62.5	27.6 ^b	50.0	45.0	48.6	56.5	56.8	42.4	
Work organizational											
Very strong structural constraints	62.5 ^a	69.0	68.0 ^b	70.0	48.4	61.9	51.4	66.7	50.1	57.9	
Yes rotation	41.3	27.6	56.0 ^a	23.3	37.5	28.6	40.5	29.2	36.8	25.0	
Task based job rotation ^c											
Yes rotation	32.1 ^b	18.6	40.0 ^b	13.3	24.6	19.5	30.8	25.0	24.6	15.1	

^a P<0.05 for subjects with symptoms or clinically verified disease compared with asymptomatic subjects.^b Chi-squared test, P<0.10.^c Ergonomist-evaluated job rotation at the individual level, multiple task jobs = yes rotation.

Table 5. Associations of psychosocial and work organizational factors with shoulder current symptoms and clinically defined rotator cuff syndrome, adjusted for age and body mass index. (RCS=rotator cuff syndrome, OR = odds ratio, 95% CI = 95% confidence interval)

	Shoulder current symptoms				RCS cases			
	Women		Men		Women		Men	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Psychosocial factor								
High decision latitude	0.84	0.50–1.41	0.36	0.19–0.69	0.88	0.38–2.03	0.33	0.14–0.79
High social support	0.41	0.24–0.70	0.43	0.22–0.82	0.75	0.32–1.77	0.51	0.24–1.11
Work organizational factor								
Very strong structural constraints	1.99	1.18–3.36	1.71	0.94–3.12	2.27	0.95–5.46	1.68	0.74–3.82
Rotation (yes versus no)	1.29	0.77–2.18	1.15	0.61–2.17	2.40	1.05–5.51	0.91	0.37–2.23
Task based job rotation ^a								
Rotation (yes versus no)	1.60	0.91–2.80	1.32	0.64–2.74	2.22	0.95–5.22	0.84	0.28–2.52

^a Ergonomist-evaluated job rotation at the individual level, multiple task jobs = yes rotation, single task (cyclic or noncyclic) job = no rotation.

Table 6. Associations of psychosocial and work organizational factors with current symptoms of carpal tunnel syndrome (CTS) and electrodiagnostically verified CTS, adjusted for age and body mass index. (OR = odds ratio, 95% CI = 95% confidence interval)

	CTS current symptoms				CTS cases			
	Women		Men		Women		Men	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Psychosocial factor								
High decision latitude	0.76	0.43–1.35	0.56	0.28–1.12	1.24	0.61–2.51	0.56	0.23–1.37
High social support	0.70	0.40–1.25	1.12	0.57–2.19	0.66	0.32–1.34	1.81	0.75–4.34
Work organizational factor								
Very strong structural constraints	0.87	0.50–1.53	1.12	0.57–2.20	1.04	0.51–2.12	1.28	0.52–3.16
Rotation (yes versus no)	1.00	0.56–1.79	1.21	0.58–2.51	1.24	0.60–2.55	1.18	0.46–3.03
Task based job rotation ^a								
Rotation (yes versus no)	0.85	0.44–1.63	1.39	0.60–3.21	1.30	0.61–2.77	1.96	0.72–5.33

^a Ergonomist-evaluated job rotation at the individual level, multiple task jobs = yes rotation, single task (cyclic or noncyclic) job = no rotation.

time, and upper arm elevation $\geq 45^\circ$ combined with percent time (% time) using a forceful pinch grip, and vibration combined with % time using a forceful pinch grip. In general, higher OR were observed for RCS than for symptoms alone among women. In the age- and BMI-adjusted models, statistically significant factors for RCS among women were frequency of forceful exertions ≥ 5 /minute, duty cycle (mid-level category), forceful pinching, lifting ≥ 4.5 kg, and % time with upper arm flexion $\geq 45^\circ$. Of combined exposures, the highest OR was seen for upper arm flexion and forceful pinch among women. Among men, the only statistically significant finding was the association between RCS and the middle category of duty cycle (% time)

of forceful exertions. This was, therefore, the only significant association that was similar for men and women. For men, while in general the OR increased for the combination of upper arm flexion or elevation and either pinch or vibration, these were not statistically significant. The OR for women increased somewhat for the highest category when we used an estimated $\geq 50\%$ MVC pinch (OR 4.42, 95% CI 1.68–11.52), rather than >8.9 N pinch as the cut-off point. The change in the cut-off value did not change the results among men.

We also examined exposure differences between those with positive physical examination but no reported symptoms and those with no shoulder symptoms or physical findings (the population total for this

Table 7. Distribution of physical load factors for the dominant shoulder by diagnosis and gender. (RCS = rotator cuff syndrome)

Variable	All subjects (%)		Shoulder current symptoms compared to non-symptoms (% symptoms)		RCS cases compared to non-cases (% cases)	
	Female (N=350)	Male (N=383)	Female (N=81)	Male (N=59)	Female (N=25)	Male (N=30)
Frequency of forceful exertions (times/minute)						
<1 cut point	45.7	31.6	38.3	32.2	28.0	30.0
1 ≤ x < 5 cut point	34.9	36.0	38.3	33.9	36.0	33.3
≥5 cut point	19.4	32.4	23.5	33.9	36.0 ^a	36.7
Duty cycle of forceful exertions (% time)						
<3 cut point	40.9	24.5	35.8	16.9	20.0	16.7
3 ≤ x < 15 cut point	31.7	27.9	39.5	37.3	44.0	50.0
≥15 cut point	27.4	47.5	24.7	45.8	36.0 ^a	33.3 ^b
Pinch grip force, time-weighted average (% time)						
0 cut point	65.1	62.4	50.6	57.6	40.0	63.3
>0 cut point	34.9	37.6	49.4 ^b	42.4	60.0 ^b	36.7
Lifting force, time-weighted average (% time)						
0 cut point	52.0	25.8	48.1	25.4	24.0	30.0
>0 cut point	48.0	74.2	51.9	74.6	76.0 ^b	70.0
Upper arm flexion ≥45° (% time)						
<18 cut point	52.9	54.3	48.1	54.2	28.0	43.3
≥18 cut point	47.1	45.7	51.9 ^b	45.8	72.0 ^b	56.7
Upper arm extension ≥5° or flexion ≥45° (% time)						
<20 cut point	38.0	29.0	32.1	35.6	12.0	33.3
20 ≤ x < 35 cut point	39.4	40.5	51.9	35.6	68.0	36.7
≥35 cut point	22.6	30.5	16.0	28.8	20.0 ^b	30.0
Upper arm flexion ≥45° and pinch grip force (% time)						
Low-low cut point	33.7	28.2	23.5	27.1	12.0	33.3
Intermediate cut point	42.6	54.3	42.0	52.5	36.0	40.0
High-high cut point	23.7	17.5	34.6 ^b	20.3	52.0 ^b	26.7
Upper arm flexion or abduction ≥45° and pinch grip force (% time)						
Low-low cut point	36.6	31.1	28.4	33.9	24.0	40.0
Intermediate cut point	44.9	52.0	45.7	45.8	36.0	36.7
High-high cut point	18.6	16.4	25.9 ^a	20.3	40.0 ^b	23.3
Vibration and pinch grip force (% time)						
Low-low cut point	56.9	54.3	42.0	49.2	32.0	50.0
Intermediate cut point	39.7	43.9	53.1	45.8	60.0	46.7
High-high cut point	3.4	1.8	4.9 ^b	5.1	8.0 ^b	3.3

^a Chi-squared test, P<0.10.^b P<0.05 for subjects with symptoms or clinically verified disease compared with asymptomatic subjects.

analysis was 525). In women, the OR for upper arm flexion ≥45° was still elevated for the positive physical examination–no symptoms category (OR 2.38, 95% CI 1.00–5.66). It was higher in this category than for those with symptoms alone but lower than for those with both positive symptoms and physical findings (data not shown). There were no significant associations for men with positive physical findings but no symptoms.

Carpal tunnel syndrome. Adjusting for age and BMI, there were 720 subjects available for the analysis of associations between physical load factors and CTS among women and men. Use of forceful pinch and power grip as well as frequency of forceful exertions were associated with CTS symptoms among women (tables 9 and 10). Combinations of non-neutral wrist postures and power or pinch grip, or lifting showed in general higher OR than the respective exposures alone. OR were mostly higher for clinical cases than for those with symptoms alone. Among men, increased duty cycle of forceful exertions, % time in power grip and % time lifting >4.5 kg were associated with CTS cases, whereas pinch was not a significant factor. Additionally, while OR for men tended to be lower than for women, they were largely in the same direction but not statistically significant. The combination of wrist radial/ulnar deviation and lifting ≥4.5 kg was significant for both women and men.

The prevalence of those with abnormal NCV was not different between men (34.0%) and women (34.4%) (table 2). We restricted the age- and BMI-adjusted analyses to those with abnormal NCV *but* no symptoms compared to those with normal NCV *and* no symptoms (N=432, data not shown). For women with abnormal NCV, there was an elevated OR for: (i) frequency of forceful exertions (highest category OR 2.13, 95% CI 1.01 and middle category OR 2.86, 95% CI 1.52–5.41), (ii) increased duty cycle (≥15% OR 2.65, 95% CI 1.34–5.26, and 3–15% OR 2.12, 95% CI 1.08–4.17), (iii) percent time lifting more than 4.5 kg (>10% OR 2.49, 95% CI 1.19–5.10 and >0.1–9% OR 1.76, 95% CI 0.94–3.31), (iv) lifting frequency (>5.0/minute OR 2.99, 95% CI 1.14–7.82 and 0.1–5.0/minute OR 1.83, 95% CI 1.02–3.38), and (v) ulnar/radial deviation combined with % time lifting (OR 3.31, 95% CI 1.49–7.49). In general, these OR were higher than for those with symptoms alone but lower than for clinical cases (table 10). For men with abnormal NCV *but* no reported symptoms, significantly elevated OR were identified for (i) increased duty cycle (>15% OR 2.00, 95% CI 1.07–3.77), (ii) % time lifting more than 4.5 kg (>10% OR 2.17, 95% CI 1.13–4.17), (iii) lifting frequency (>5.0/minute OR 2.20, 95% CI 1.04–4.68), and (iv) pinch (>50% MVC OR 2.08, 95% CI 1.04–4.18). In general, men and women showed roughly similar OR for these exposures.

Gender adjustment or stratification

For the RCS analysis, adjustment for gender appears to mask an elevated OR for age among men and greatly underestimates (more than twofold) the OR for upper arm flexion combined with pinch among women (table 11). By the same token, the adjusted analysis showed a significantly reduced OR for RCS with high

Table 8. Associations of physical load factors with current shoulder symptoms and clinically defined rotator cuff syndrome, adjusted for age and body mass index (dominant side). (RCS = rotator cuff syndrome, OR = odds ratio, 95% CI = 95% confidence interval)

	Shoulder symptoms				RCS cases			
	Women		Men		Women		Men	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Frequency of forceful exertions								
≥1–<5 versus <1 times/minute	1.50	0.84–2.65	0.93	0.47–1.84	1.75	0.63–4.84	1.05	0.41–2.71
≥5 versus <1 times/minute	1.56	0.80–3.07	1.09	0.54–2.17	3.35	1.19–9.42	1.38	0.54–3.52
Duty cycle of forceful exertions								
≥3–14 versus <3% time	1.67	0.92–3.02	2.22	0.99–4.98	3.16	1.06–9.44	3.16	1.09–9.17
≥15 versus <3% time	1.10	0.58–2.10	1.58	0.72–3.45	2.91	0.94–9.01	1.25	0.41–3.82
Pinch grip force, time-weighted average								
>0 versus 0% time	2.36	1.41–3.95	1.33	0.75–2.34	3.04	1.32–7.01	1.09	0.49–2.39
Lifting force, time-weighted average								
>0 versus 0% time	1.23	0.75–2.04	1.04	0.55–1.97	3.76	1.46–9.68	0.85	0.37–1.93
Upper arm flexion ≥45°								
≥18 versus <18% time	1.28	0.77–2.12	0.98	0.56–1.72	3.12	1.27–7.68	1.63	0.76–3.51
Upper arm extension ≥5° or flexion ≥45°								
20–34 versus <20% time	1.86	1.05–3.28	0.64	0.33–1.26	6.16	1.76–21.57	0.77	0.31–1.92
≥35 versus <20% time	0.87	0.41–1.82	0.72	0.35–1.46	2.97	0.69–12.82	0.89	0.34–2.32
Upper arm flexion ≥45° and pinch grip force								
Flexion ≥15% or pinch grip versus flexion <15% and no pinch grip % time	1.62	0.85–3.06	1.05	0.54–2.06	2.48	0.66–9.41	0.71	0.29–1.75
Flexion ≥15% and pinch grip versus flexion <15% and no pinch grip % time	2.80	1.42–5.52	1.26	0.55–2.89	7.06	1.94–25.66	1.44	0.53–3.94
Upper arm flexion or abduction ≥45° and pinch grip force								
Flexion or abduction ≥20% or pinch grip versus flexion or abduction <20% and no pinch grip % time	1.47	0.81–2.66	0.82	0.43–1.56	1.25	0.43–3.63	0.62	0.26–1.48
Flexion or abduction ≥20% and pinch grip versus flexion or abduction <20% and no pinch grip % time	2.33	1.16–4.68	1.19	0.54–2.64	3.72	1.28–10.81	1.22	0.45–3.31
Vibration and pinch grip force								
Vibration or pinch grip >0% versus no vibration and no pinch grip % time	2.27	1.35–3.84	1.23	0.69–2.18	2.83	1.16–6.88	1.33	0.61–2.90
Vibration and pinch grip >0% versus no vibration and no pinch grip % time	2.67	0.75–9.47	4.35	0.92–20.66	4.80	0.90–25.77	1.98	0.22–18.13

job security. While the job security OR were basically the same in the stratified analyses, they did not achieve statistical significance. For CTS (table 12), adjusting for gender appears to mask the somewhat more elevated OR among women for wrist radial/ulnar deviation with lifting and somewhat overestimates the OR for men when compared to the stratified analysis.

Discussion

The major findings of this study include the following: (i) prevalence of symptoms reporting is higher in women than men, but there is little difference between males and females in the prevalence of positive clinical tests; (ii) a greater proportion of CTS symptoms and cases among women had greater age and co-mor-

bid conditions, and an elevated BMI than non-cases whereas age was the only significant personal factor for men; (iii) high decision latitude and high social support were associated with non-symptoms and non-RCS status among men but not among women; (iv) women had significantly increased odds of RCS with increasing forceful exertions, particularly high pinch force, and when combined with upper arm flexion in the same job whereas no such association was identified among men; and (v) among both women and men, there was a significant association between CTS and the combination of ulnar/radial deviation and lifting in the same job.

In a review of occupational “accident” reports where men and women had different injury rates, interviews about job content revealed that, although job titles might be the same, job content was different. Consequently, this implies different exposures for men and women (42). These authors urge caution

Table 9. Distribution of physical load factors for the dominant side hand/wrist by diagnosis and gender. (CTS = carpal tunnel syndrome)

Variable	All subjects (%)		CTS current symptoms compared to non-CTS symptoms (% symptoms)		CTS cases compared to non-cases (% cases)	
	Female (N=346)	Male (N=374)	Female (N=67)	Male (N=41)	Female (N=39)	Male (N=24)
Frequency of forceful exertions (times/minute)						
<1 cut point	45.1	31.6	26.9	26.8	28.2	20.8
1 ≤x <5 cut point	35.3	36.4	47.8	34.1	48.7	33.3
≥5 cut point	19.7	32.1	25.4 ^a	39.0	23.1 ^b	45.8
Duty cycle of forceful exertions (% time)						
<3 cut point	40.5	24.3	26.9	17.1	28.2	8.3
3 ≤x <15 cut point	31.8	28.1	37.3	29.3	35.9	33.3
≥15 cut point	27.7	47.6	35.8 ^a	53.7	35.9	58.3
Power grip force, time-weighted average (% time)						
0 cut point	72.8	71.7	59.7	68.3	51.3	54.2
>0 cut point	27.2	28.3	40.3 ^a	31.7	48.7 ^a	45.8 ^a
Pinch grip force, time-weighted average (% time)						
0 cut point	65.0	62.6	52.2	63.4	51.3	66.7
>0 cut point	35.0	37.4	47.8 ^a	36.6	48.7 ^b	33.3
Lifting force, time-weighted average (% time)						
0 cut point	51.7	25.4	44.8	19.5	38.5	8.3
0 <x <10 cut point	30.3	35.3	38.8	39.0	46.2	37.5
≥10 cut point	17.9	39.3	16.4	41.5	15.4 ^b	54.2
Wrist flexion or extension ≥15° and power grip force						
Low-low cut point	33.5	34.0	25.4	29.3	23.1	25.0
Intermediate cut point	52.0	48.1	47.8	51.2	41.0	41.7
High-high cut point	14.5	17.9	26.9 ^a	19.5	35.9 ^a	33.3
Wrist flexion or extension ≥15° and pinch grip force						
Low-low cut point	29.8	24.6	16.4	26.8	12.8	20.8
Intermediate cut point	51.7	57.8	58.2	51.2	61.5	62.5
High-high cut point	18.5	17.6	25.4 ^a	22.0	25.6 ^a	16.7
Wrist radial deviation <-5°/ulnar >20° dev and power grip force						
Low-low cut point	41.9	41.4	28.4	34.1	15.4	20.8
Intermediate cut point	46.2	45.7	49.3	51.2	59.0	58.3
High-high cut point	11.8	12.8	22.4 ^a	14.6	25.6 ^a	20.8 ^b
Wrist radial deviation <-5°/ulnar >20° dev and pinch grip force						
Low-low cut point	40.5	37.4	26.9	39.0	15.4	37.5
Intermediate cut point	41.3	44.7	44.8	36.6	59.0	37.5
High-high cut point	18.2	17.9	28.4 ^a	24.4	25.6 ^a	25.0
Wrist radial deviation <-5°/ulnar >20° dev and lifting force						
Low-low cut point	34.7	24.6	25.4	26.8	15.4	16.7
Intermediate cut point	48.0	48.4	49.3	29.3	59.0	33.3
High-high cut point	17.3	27.0	25.4 ^b	43.9 ^a	25.6 ^a	50.0 ^a

^a Chi-squared test, P<0.05.^b Chi-squared test, P<0.10.

in adjusting for gender as a confounder in studies when it may be a proxy for specific exposures (43). The importance of gender stratification as one step in understanding the data was borne out in our study for both the shoulder and the hand/wrist. In particular, had we not stratified, we might have missed the increased importance of a pinch grip for females compared to males (9). At the same time, when we further analyzed the gender-stratified data by physical exam findings alone, the OR between men and women especially for abnormal NCV were very similar. Significant results also appeared for men when we used more than 50% MVC as the cut-off value for pinch grip force. Thus, if men and women are using the same proportion of their pinch strength rather than an absolute value, there is little difference in findings. By relying on symptoms reporting alone we may have missed important effects for men. Differential reporting of symptoms may explain some of the differences we found between men and women in the analysis of clinical case status which required both reporting of symptoms and abnormal NCV. The clinical significance of abnormal NCV in the absence of symptoms is not known. It may be that in general women tend to be more aware of symptoms than men or more willing to report them, resulting in an artificially lower OR for men than women.

There were no exposures studied where women had a higher percentage of exposure at the highest level than men, irrespective of symptoms or clinical findings. Forceful pinch appeared to play a more important role for women than men with respect to RCS, and to a lesser extent with CTS. In a previous study of pinch and grip strength (27), we found that on average men had 1.4 times the pinch grip and 1.6 times the power grip strength of women. Force in the current study was based on force-matching techniques and then whether >0.9kg (8.9 N) pinch force and >4.5kg (44.1 N) power or lifting force was used. Maximum power grip and pinch grip strength data were collected during the physical examination in standard postures but were not initially used with the exposure assessment to estimate % MVC because muscle strength is related to many factors (eg, hand/wrist postures, individual motivation) and a normalized force estimate of task performance may not represent the true muscle capacity used by the individual worker at that particular hand/wrist posture during work. Nonetheless, we used this rough estimate to assess whether women were using a greater % MVC than men. Although the highest levels of combined shoulder exposure variables were somewhat more prevalent for women than men and might explain some of the observed increased odds for RCS, this was not the case for CTS.

Another possible explanatory hypothesis for the gender differences is based on our study design. If men

Table 10. Associations of physical load factors with current symptoms of carpal tunnel syndrome (CTS) and electrodiagnostically verified CTS, adjusted for age and body mass index. (OR=odds ratio, 95% CI= 95% confidence interval)

	CTS symptoms				CTS cases			
	Women		Men		Women		Men	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Frequency of forceful exertions								
≥1–<5 versus <1 times/minute	2.93	1.53–5.63	1.21	0.52–2.82	2.84	1.25–6.47	1.68	0.52–5.44
≥5 versus <1 times/minute	2.42	1.13–5.17	1.71	0.75–3.93	2.16	0.83–5.67	2.99	0.97–9.23
Duty cycle of forceful exertions								
≥3–14 versus <3% time	2.09	1.05–4.17	1.67	0.62–4.50	2.01	0.84–4.81	4.25	0.86–20.99
≥15 versus <3% time	2.40	1.20–4.81	2.07	0.83–5.15	2.22	0.93–5.32	5.37	1.16–24.86
Power grip force, time-weighted average								
>0 versus 0% time	2.14	1.21–3.79	1.22	0.60–2.49	2.90	1.44–5.87	2.43	1.02–5.80
Pinch grip force, time-weighted average								
>0 versus 0% time	2.06	1.18–3.58	1.06	0.54–2.11	2.03	1.01–4.08	1.00	0.40–2.45
Lifting force, time-weighted average								
0.1–9.9 versus 0% time	1.53	0.83–2.80	1.44	0.58–3.57	2.29	1.07–4.88	3.07	0.63–14.90
≥10 versus 0% time	1.17	0.54–2.54	1.63	0.66–4.01	1.42	0.51–3.97	6.00	1.28–28.03
Wrist flexion or extension ≥15° and power grip force								
Flexion or extension ≥40% or power grip >0% versus flexion or extension <40% and no power grip % time	1.39	0.72–2.69	1.24	0.58–2.63	1.26	0.53–3.03	1.17	0.41–3.37
Flexion or extension ≥40% and power grip >0% versus flexion or extension <40% and no power grip % time	3.37	1.52–7.48	1.29	0.50–3.38	4.68	1.80–12.21	2.90	0.92–9.09
Wrist flex/ext ≥15° and pinch grip force								
Flexion or extension ≥40% or pinch grip >0% versus flexion or extension <40% and no pinch grip % time	2.45	1.16–5.20	0.84	0.38–1.84	2.85	1.03–7.87	1.51	0.52–4.40
Flexion or extension ≥40% and pinch grip >0% versus flexion or extension <40% and no pinch grip % time	3.48	1.46–8.31	1.26	0.48–3.27	4.14	1.30–13.14	1.36	0.34–5.42
Wrist radial deviation <–5°/ulnar >20° deviation and power grip force								
Radial deviation or ulnar deviation ≥4% or power grip >0% versus radial deviation or ulnar deviation <4% and no power grip % time	1.76	0.93–3.32	1.60	0.77–3.33	4.43	1.69–11.62	3.55	1.20–10.50
Radial deviation or ulnar deviation ≥4% and power grip >0% versus radial deviation or ulnar deviation <4% and no power grip % time	4.26	1.88–9.68	1.40	0.50–3.95	9.68	3.10–30.23	3.43	0.91–12.98
Wrist radial deviation <–5°/ulnar >20° deviation and pinch grip force								
Radial deviation or ulnar deviation ≥4% or pinch grip >0% versus radial deviation or ulnar deviation <4% and no pinch grip % time	1.95	1.01–3.77	0.84	0.40–1.78	5.88	2.18–15.88	0.95	0.36–2.52
Radial deviation or ulnar deviation ≥4% and pinch grip >0% versus radial deviation or ulnar deviation <4% and no pinch grip % time	3.32	1.56–7.08	1.51	0.64–3.60	5.67	1.83–17.56	1.78	0.59–5.40
Wrist radial deviation <–5°/ulnar deviation >20° and lifting force								
Radial or ulnar deviation ≥4% or lifting ≥3% versus radial or ulnar deviation <4% and lifting <3% time	1.58	0.82–3.04	0.54	0.22–1.28	3.48	1.31–9.22	1.05	0.30–3.66
Radial or ulnar deviation ≥4% and lifting ≥3% versus radial or ulnar deviation <4% and lifting <3% time	2.57	1.16–5.67	1.78	0.77–4.08	5.18	1.70–15.81	3.63	1.08–12.18

are less likely to report symptoms than women, they could not have become a clinical case in our study even if they had abnormal physical findings. Additionally, it is notable that more than 50% MVC pinch among men with abnormal NCV *but* not reporting symptoms was associated with an increased OR for forceful pinching. This potential for under-reporting among men is an area for further study.

Additionally, there was some indication of gender segregation with respect to work organizational factors where more men were in jobs with high structural constraints and more women were rotating (table 4).

However these factors were not significant in the final models. Women reported shoulder symptoms more frequently than men but RCS was as common in men as women. A higher proportion of women reported high social support and decision latitude than men, perhaps increasing the likelihood of women to report symptoms. In the final adjusted model for RCS, social support was protective and, although it had the same OR in the gender-stratified analysis, it did not achieve statistical significance.

Our results on RCS are in agreement with those obtained in a representative Finnish population

Table 11. Final logistic regression model for dominant-side rotator cuff syndrome. (BMI = body mass index, OR=odds ratio, 95% CI = 95% confidence interval)

	Unadjusted ^a		Adjusting for age, gender and BMI in unstratified sample		Adjusting for age and BMI, stratified by gender ^a			
	OR	95% CI	OR	95% CI	Female		Male	
					OR	95% CI	OR	95% CI
Age	.	..	1.02	0.99–1.05	1	0.96–1.04	1.03	1.00–1.07
Gender								
Male	.	..	1	..	–	..	–	..
Female			0.79	0.44–1.43	–	..	–	..
BMI (kg/m ²)	.	..	1.04	0.99–1.09	1.02	0.95–1.09	1.06	0.99–1.13
Job security								
Low	.	..	1	..	1
High	.	..	0.53	0.30–0.95	0.55	0.23–1.31	0.54	0.25–1.18
Upper arm flexion ≥45° and forceful pinch (% time)								
Flexion <15% and no pinch	1	..	1	..	1	..	1	..
Flexion ≥15% or forceful pinch >0	1.02	0.50–2.09	1.01	0.49–2.11	2.41	0.63–9.17	0.65	0.26–1.63
Flexion ≥15% and forceful pinch >0	2.67	1.29–5.51	2.66	1.26–5.59	6.68	1.81–24.66	1.45	0.53–4.00

Table 12. Final logistic regression model for dominant-side carpal tunnel syndrome. (BMI = body mass index, OR = odds ratio, 95% CI = 95% confidence interval)

	Unadjusted ^a		Adjusting for age, gender and BMI in unstratified sample		Adjusting for age and BMI, stratified by gender			
	OR	95% CI	OR	95% CI	Female		Male	
					OR	95% CI	OR	95% CI
Age	.	..	1.07	1.04–1.10	1.07	1.03–1.11	1.07	1.03–1.11
Gender								
Male	.	..	1	..	–	..	–	..
Female	.	..	1.74	0.99–3.05	–	..	–	..
BMI (kg/m ²)	.	..	1.07	1.03–1.11	1.06	1.01–1.12	1.09	1.01–1.17
Wrist radial deviation <–5°/ulnar dev >20° and lifting force (% time)								
Radial or ulnar deviation <4% and lifting <3%	1	..	1	..	1	..	1	..
Radial or ulnar deviation ≥4% or lifting ≥3%	1.98	0.95–4.13	2.35	1.09–5.04	3.48	3.31–9.22	1.05	0.30–3.66
Radial or ulnar deviation ≥4% and lifting ≥3%	3.20	1.47–6.96	4.85	2.12–11.11	5.18	1.70–15.81	3.63	1.08–12.18

sample (43). For CTS, both symptoms and electrophysiologically verified disease were almost twice as common in women as in men in our study. A similar gender difference has been observed in a Swedish population sample (44). However, in our study, in the adjusted analysis, female gender was not significantly associated with CTS. In the stratified analysis, both women and men had significantly higher OR for CTS with the combination of lifting >4.5 kg and ulnar/radial deviation (table 12) with women having a somewhat higher OR than men.

Reporting increased risk for non-modifiable factors such as gender has little apparent public health value. Rather than doing this, by stratifying results on gender we can see differential risks that may exist for males and females on important modifiable workplace exposures. In the case of CTS in the adjusted model, it appears that exposure to awkward wrist posture or lifting more than doubles the odds of developing CTS in this working population. When stratified by gender, the analysis showed the increase largely affecting women. However, the combination of both radial/ulnar deviation

and lifting more than quadrupled the risk in the adjusted model, with a somewhat higher OR for women than men in the stratified analysis. On the other hand, men with an abnormal NCV had a higher OR associated with $\geq 50\%$ MVC pinch. These results suggest that high pinch forces and awkward wrist postures combined with lifting should be reduced for everyone. In the adjusted model for RCS, the inclusion of awkward arm flexion and forceful pinch appeared to more than double the risk of developing RCS in this population. When stratified by gender, the risk was increased six-fold for female workers with both awkward arm flexion and forceful pinch on their jobs, while the risk was not observed in men. A somewhat higher proportion of women were exposed to this combined risk factor than men (table 7).

Two notes of caution should be mentioned for the results found in this study. The first is that our study was cross-sectional. An argument could be made for a healthy worker effect in the highest exposure categories, particularly for men. For most exposures, there was a much larger proportion of workers in the middle categories than in the highest exposure category. Our results need to be tested in prospective studies. Second, while these results can further pinpoint where workplace modifications should occur, they should not lead to job segregation or the exclusion of one gender in some jobs. The equal prevalence of abnormal NCV suggests that both genders are at risk and earlier reporting by men should be encouraged.

In their review (45, p.582), Kennedy & Koehoorn reported a "qualified yes" to the question of whether gender matters in exposure assessment for epidemiologic studies, "but that the direction of potential bias cannot be predicted a priori". Our study supports this qualified recommendation to explore gender differences and similarities in exposures and outcomes but to look deeper into understanding what may underlie those observed differences. This is consistent with the recommendation by McDiarmid et al (46) that the focus on gender attributes alone fails all workers because preventive interventions in the workplace are deterred and it fails women disproportionately because they are often over-represented in jobs at high risk of CTS and, from our study, more willing to report symptoms.

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