

Risk factors for visiting a medical department because of upper-extremity musculoskeletal disorders

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Objectives This study followed 279 auto assembly workers over 1 year to identify which factors influenced whether a worker would visit the plant medical department because of an upper-extremity musculoskeletal problem.

Methods Incident cases were defined as involving workers who had not gone to the plant medical department in the preceding 6 months and then subsequently visited the medical department with a work-related musculoskeletal disorder that was potentially due to repetitive work activity (acute fractures or lacerations were excluded).

Results There were 45 cases identified during the study period. Based on Cox regression analysis, significant predictors for visiting a medical department included exceeding the threshold limit value for hand activity and peak force, a history of diabetes, a current diagnosis of carpal tunnel syndrome, elbow tendonitis, and age under 40 years.

Conclusions The results of this study are consistent with those of other prospective studies that showed that both ergonomic and past medical history are risk factors for an upper-extremity musculoskeletal disorder and suggests that there is a healthy worker or survivor effect among older workers.

Key terms Cox regression; cumulative trauma disorder; occupational medicine; repetitive strain injury.

Upper-extremity musculoskeletal disorders continue to account for most reported occupational disorders (1–3). These disorders include carpal tunnel syndrome, hand, wrist, elbow and shoulder tendonitis, muscular fatigue, other nerve entrapments, such as ulnar neuropathy and radiculopathy, as well as nonspecific muscle and joint pain. Prior cross-sectional studies have shown that 40–70% of active workers have repeated episodes of symptoms associated with upper-extremity musculoskeletal disorders, but most of these workers do not seek medical attention (4, 5). Many workers have upper-extremity symptoms, and many even have signs of an upper-extremity musculoskeletal disorder, but the impetus to seek medical attention varies. Some studies suggest that

women are more likely to seek medical care for work-related repetitive strain disorders (6). Other factors, such as job satisfaction, job security, education level and supervisory support, have been suggested to influence the decision to seek medical attention (7). The workers' compensation environment, within the state and the company, has also been suggested as an important factor. Although there are known risk factors for the development of upper-extremity musculoskeletal disorders that include ergonomic stressors (8), median mononeuropathy (9), body mass index (BMI) (10), gender (11), diabetes (12, 13), and rheumatoid arthritis (14, 15), it is less clear why an individual worker seeks medical care. The intensity of the discomfort or the potential for

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permanent harm would seem to be a likely influence on the decision-making process, but there is less literature in this area specific to work-related injuries and few prospective studies.

The purpose of this study was to prospectively examine a cohort of workers with a moderately high-risk occupation, automobile assembly workers, over 1 year to identify what factors influenced the workers' decisions to report to medical professionals for the evaluation and treatment of their upper-extremity musculoskeletal problem. For this study, we prospectively followed a cohort of active workers with no history of reporting to the plant medical department during the 6 months preceding their recruitment into the study.

We hypothesized that new medical visits would more likely be related to the worker being female, work on jobs with higher ergonomic stressors (hand activity level, peak force), a higher prevalence of diabetes, the worker being older, and the worker having a higher BMI.

Study population and methods

This was a longitudinal study of workers from an auto assembly plant in the southern part of the United States. Of the 1200 assembly plant workers, 454 agreed to participate in the study, but only 279 participants completed the initial detailed symptom questionnaire and sensory-nerve conduction studies. No participants were lost to follow-up since we had access to the plant's medical records. The Institutional Review Board at the University of Michigan approved the project, and all the participants completed a signed consent form to participate and allow access to the plant's medical records. Any person who had visited the medical department in the 6 months prior to entering the study was excluded from the cohort. The participants signed a release of information to allow the study team to review the company medical records. A worker did not have to be free of any symptoms; those with symptoms or a history of an upper-extremity musculoskeletal disorder were included in the cohort as long as they did not seek any medical attention at the plant medical department within the 6 months prior to entering the study.

The case definition for a "new medical visit" included any visit to the plant medical department for a work-related musculoskeletal problem of the upper extremities during the study. Visits for traumatic injuries, contusions, burns, and fractures were not designated as a new visit. The workers' medical records were reviewed by a physiotherapist, and uncertain cases were reviewed by a physiatrist to determine if the medical visit was a work-related musculoskeletal problem of the upper extremity. The date of the medical visit was recorded, and

the number of days from the time of entrance into the study and the medical visit was the primary outcome measure used in the analysis. If a worker had multiple visits to the plant medical department, the time to the first visit was the defining time interval used.

All the participants underwent electrodiagnostic testing and a directed physical examination of the upper extremities and completed a symptom questionnaire, including a hand diagram (16), when they entered the study. Recruitment took place on a rolling basis over the 12 months that coincided with a plant-wide symptom survey. All the participants were weighed, and height was measured; these data were used to calculate the BMI (kg/m^2). All the jobs were assessed and rated for ergonomic exposures at baseline.

The workers also completed a psychosocial questionnaire evaluating job security and satisfaction, supervisor and co-worker support, job creativity, decision authority, and skill discretion, as defined by Karasek et al (7).

Nerve conduction studies of the median and ulnar sensory nerves were carried out as described by Kimura (17). The studies were performed using antidromic supramaximal stimulation, a distance of 14 cm, and ring recording electrodes placed around digits 2 and 5. A standard interelectrode distance of 3 cm was used. Hand temperature was recorded, and the hand was warmed if the midpalmar temperature was below 32°C. All the studies were performed onsite by a certified electrodiagnostic technician on a Synergy EMG machine (TECA Inc/Oxford Instruments, Pleasantville, NY, USA). The difference in peak sensory latencies was used as the primary electrodiagnostic outcome measure.

The methods used to assess the jobs have been described previously by Latko et al (18). Each job in the plant was videotaped and rated for the degree of repetition, average and peak hand contact stress, average and peak force, average and peak posture of the shoulder, elbow, forearm, and wrist-hand. The ratings were performed using a 0–10 visual analogue scale for each stressor with verbal anchors on the 10-cm scale. A rating of 0 corresponded to no stress (or neutral posture), and a 10 corresponded to the greatest possible stress (or deviation from neutral). The formal ratings were conducted by a team comprised of university faculty and research staff specializing in ergonomic analysis. The job was rated, but the rating was not necessarily done on the person who was entered in the study. If the worker changed jobs during the study period, a time-weighted average was calculated to estimate the ergonomic exposure of each worker for hand repetition, contact forces, and wrist, elbow and shoulder postures. If the worker visited the medical unit prior to the job change, the ergonomic assessment of the first job was used in the analysis and not the time-weighted average. Each job was rated according to the American Conference of

Governmental Industrial Hygienists' (ACGIH) threshold limit values (TLV) for hand-activity level based upon the hand repetition level and the normalized peak force (1 = acceptable, 2 = borderline, 3 = unacceptable) (19). The TLV for hand activity is based on the interaction of the level of hand repetition, which is rated on a scale of 1–10 (1 = hands resting all the time, 10 = hands moving rapidly without any rest time) on the x-axis and peak force, which is also rated on a 1–10 scale (1 = low force, 10 = maximal exertion) on the y-axis. The graph is divided into the following three zones: acceptable work exposure, borderline exposure, and unacceptable exposure.

Statistical analysis

A stepwise Cox regression analysis was performed using time to medical visit as the dependent variable. Variables were included in the initial regression analysis if the univariate analysis had a P-value of <0.2 , and they were maintained in the model if the P-value remained <0.1 in the multivariate model. Demographic, medical-history, ergonomic, and psychosocial variables were included in the analysis. The demographic risk-factor analysis included age, gender, education, and race. Age was used as a continuous or dichotomous variable with 40 years as the cutoff for higher risk for upper-extremity tendonitis. The medical risk factors included a history of carpal tunnel syndrome, tendonitis, diabetes, rheumatoid arthritis, and thyroid dysfunction. The ergonomic variables included hand repetition, local contact forces, and postures. The psychosocial variables were comprised of the workers' self-perception of job security and satisfaction, supervisor and co-worker support, job creativity, decision authority, and skill discretion, as defined by Karasek et al (7). A Kaplan-Meier survival analysis was used to graphically represent which workers did not seek help in a medical visit for a musculoskeletal problem (survivors).

Results

Of the 279 workers, 43 were excluded because of a medical visit in the prior 6 months. The mean age of the remaining 236 workers was 48.6 (SD 7.9) years, and 32% were female. Fifty-nine percent of the workers reported recurrent neck or shoulder discomfort, while 70% reported hand and wrist discomfort. The mean BMI of the cohort was 28.3 (SD 4.5) kg/m². A total of 45 persons sought medical care for a new upper-extremity problem during the course of the study. Of the 45 visits, 25 (56%)

were classified as for sprain or strain, 2 were for carpal tunnel syndrome, 1 involved cervical pain, 8 (18%) concerned joint pain, and 7 (16%) were for nonspecific disorders. Altogether 6 of the 45 visits (13%) were deemed "recordable" according to standards of the Occupational Safety and Health Administration (OSHA).

The largest fraction of visits (47%) was for wrist-hand-finger symptoms. Altogether 38% was for neck-shoulder pain, and 13% was for elbow-forearm symptoms. A total of 6 of the 45 (13%) visits were subsequent to starting on a new job in the plant, and 12 of 45 (27%) were attributed to a change in the participant's regular job.

Altogether 26 participants (58%) were treated by an occupational health nurse in the plant medical department, 16 (36%) were seen by the plant physician, and 3 were seen originally by an outside physician.

Eight (18%) generated a referral to the ergonomic team for an evaluation of the job. Nine (20%) eventually required a referral for testing or treatment outside of the plant medical department. Three were eventually considered for workers' compensation.

The Kaplan-Meier analysis of each individual risk factor in the model (not controlling for any other factor) are presented in figures 1–5. Each graph represents the entire cohort being present at the time the participants were recruited into the study. Recruitment was done throughout the year so that time 0 represented the time of recruitment into the study and not the calendar year. The fraction of the cohort who remained healthy [ie, had no medical visits (for each particular exposure)] is depicted over time. Figure 1 demonstrates that workers with a TLV rating of borderline (2) and unacceptable (3) had a higher risk of visiting the medical department. This was a trend and did not reach statistical significance ($P=0.18$). Workers with a diagnosis of carpal tunnel syndrome (figure 2) or elbow tendonitis (figure 3) were more likely to visit a medical department, and both of these disorders reached statistical significance in the univariate model as well ($P=0.004$ and $P=0.05$, respectively). Figure 4 demonstrates that workers <40 years of age were more likely to visit the medical department ($P<0.001$), and figure 5 shows that diabetic workers were at higher risk of visiting a medical department ($P=0.02$). The only other variable that showed a trend in the univariate analysis was job satisfaction.

The Cox regression model that predicted which independent variable would predict that a worker would seek medical care included a borderline or high TLV for hand activity, a diagnosis of active carpal tunnel syndrome at the time of entrance into the study (based on their hand diagram and nerve conduction studies at baseline), a diagnosis of elbow tendonitis (based upon their symptom questionnaire and physical examination findings at baseline), a history of diabetes, and age <40 years. The hazard ratio for each risk factor is presented

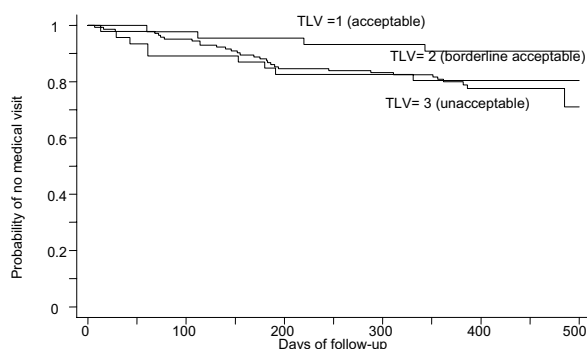


Figure 1. Kaplan-Meier survival estimates for the threshold limit value (TLV) for hand activity. There were 50 workers in category 1, 72 in category 2, and 114 in category 3. (1 = acceptable workload, 2 = borderline workload, 3 = unacceptable workload)

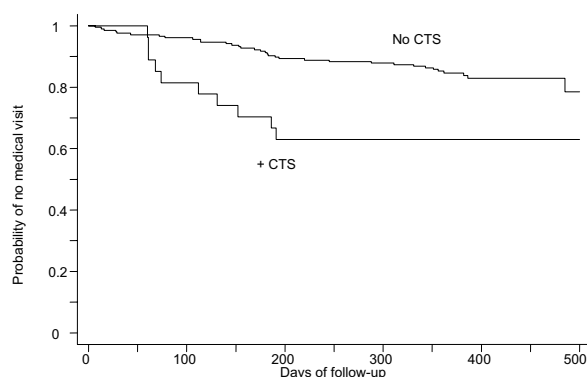


Figure 2. Kaplan-Meier survival estimates using presence or absence of diagnosis of active carpal tunnel syndrome at the time of entrance into the study. Thirty workers had a diagnosis of carpal tunnel syndrome, while 206 did not.

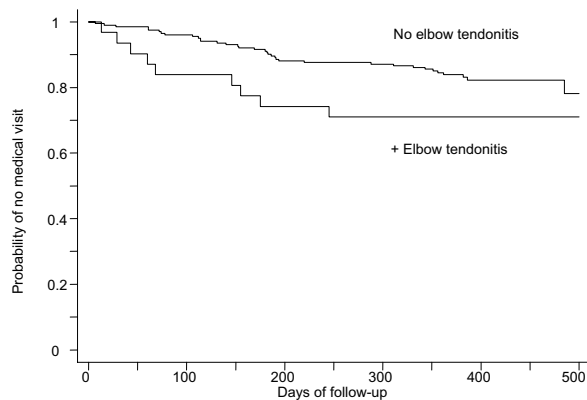


Figure 3. Kaplan-Meier survival estimates using presence or absence of diagnosis of active elbow tendonitis at the time of entrance into the study. Thirty-five workers had an active diagnosis of elbow tendonitis, while 201 did not.

in table 1. A TLV rating of borderline or unacceptable hand activity increased the risk of visiting a medical department approximately threefold when compared with jobs with an acceptable rating ($P=0.06$). A diagnosis of carpal tunnel syndrome or elbow tendonitis at the time of entrance into the study increased the risk of

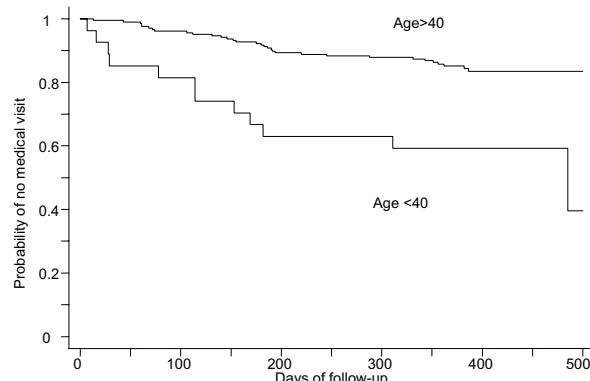


Figure 4. Kaplan-Meier survival estimates using an age of ≥ 40 years at the time of entrance into the study. Thirty-four workers were under the age of 40 years, while 202 were older.

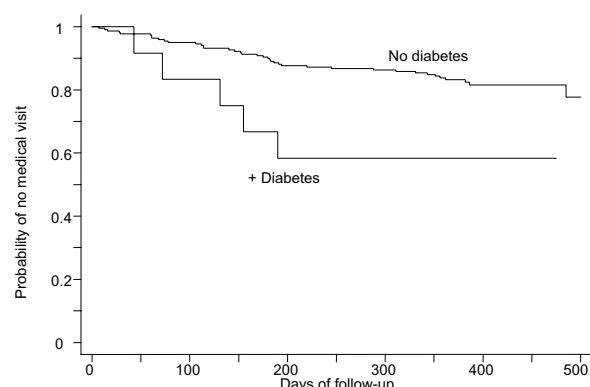


Figure 5. Kaplan-Meier survival estimates using presence or absence of a diagnosis of diabetes at the time of entrance into the study. Twelve workers had a history of diabetes, while 224 did not.

Table 1. Cox Regression analysis demonstrating predictors of who would report to the medical department for the evaluation of a work-related upper-extremity musculoskeletal disorder. The threshold limit value (TLV) for exposure to hand activity levels is rated on a scale of 1–3. (TLV 1 = acceptable exposure, TLV 2 = borderline, TLV 3 = unacceptable workload, SE = standard error, 95% CI = 95% confidence interval, CTS = carpal tunnel syndrome)

	Hazard ratio	SE	z	$P> z $	95% CI
TLV 2 versus TLV 1	3.1	1.9	1.84	0.066	0.93–10.3
TLV 3 versus TLV 1	2.7	1.5	1.86	0.063	0.95–7.9
Diagnosis of CTS	3.8	1.5	3.45	0.001	1.8–8.1
Diagnosis of elbow tendonitis	2.8	1.1	2.61	0.009	1.3–6.0
Diabetes	3.2	1.6	2.36	0.018	1.2–8.3
Age >40 years	0.96	0.02	-2.49	0.013	0.92–0.99

Log likelihood = -218.25217; prob $>\chi^2 = 0.0002$.

visiting a medical department almost four- and three-fold, respectively. A worker with diabetes was three times more likely to visit the medical department with a work-related upper-extremity musculoskeletal disorder than nondiabetics were. Younger workers (<40 years of age) were also more likely to report to the medical

department. The presented hazard ratios represent the risk for each factor when the other factors were controlled in the model. The model is significant at the $P=0.0002$. Gender was not a significant factor in this analysis.

Discussion

The study shows that predicting whether a worker will seek medical care for an upper-extremity disorder is multifactorial and suggests that both ergonomic factors and medical history are important. This study confirms the suspicion that workers in jobs with higher hand repetition and peak forces are more likely to develop a musculoskeletal disorder of the upper extremity that is significant enough for them to seek medical attention. It is clear from prior studies that symptoms are more prevalent among workers with high-repetition jobs (4), but this difference takes the findings one step further and defines a high TVL for hand activity as a risk factor for seeking medical care. Neither hand repetition nor peak hand force was significant as an isolated risk factor in the Cox regression analysis. This finding lends further support to the concept of a combined "hand activity rating" as a valuable risk assessment.

It is not surprising that workers with an active musculoskeletal problem at the start of the study, such as carpal tunnel syndrome or elbow tendonitis, would be more likely to seek medical care. What is surprising is that they had not sought medical care in the preceding 6 months. All workers received a letter from the study coordinator approximately 2 months after entrance into the study and were informed of the results of their nerve conduction tests and physical examination. If they met the criteria for carpal tunnel syndrome or upper-extremity tendonitis, they were informed of this finding. We expected that this letter would have influenced the worker's decision to seek medical care but were surprised to find that less than 7% of the workers who reported to the medical department, and for whom we had diagnosed carpal tunnel syndrome or tendonitis, visited the medical department within 3 months of receiving the medical summary letter in the mail. We did not see a 2-month peak that would be associated with the timing of the letter. Regardless of the impact of our medical summary, these workers had active medical problems, and it would be expected that they would seek medical attention for these problems.

The risks for carpal tunnel syndrome in association with diabetes are well documented (12, 13), but diabetes is not known to increase the risk for other upper-extremity musculoskeletal disorders. The study suggests that diabetes is an independent risk factor associated

with higher rates of medical visits. Even when age, history of carpal tunnel syndrome or tendonitis and ergonomic risk factors were controlled, diabetes increased the risk of seeking medical attention for an upper-extremity musculoskeletal disorder by a factor of 3.

We had hypothesized that older workers and women would report to medical care more frequently than younger workers and men in general. Gender was not a significant factor in either the univariate or Cox regression modeling, however. Age was a significant factor, but not in the direction we hypothesized. This study demonstrates that it is the younger worker who is more likely to seek medical care with an upper-extremity musculoskeletal disorder. This finding probably represents a healthy worker or survivor effect (20). The older, established worker has survived the rigors of the job. The workers who have had problems have left the job, and only the successful workers are left in the cohort. Alternately, a younger worker may not be as well conditioned to the job demands as is an older worker. While there is a seniority system at this particular automobile assembly plant and the older workers may have had the easier jobs, the Cox regression modeling controlled for the person's job characteristics, and yet age of <40 years was still a significant factor.

One of the major limitations of this study was the poor participation rate (23%) at the plant. Recruitment was done on a rolling basis as the plant carried out a mandatory symptoms questionnaire survey. Unfortunately, we missed the first 3 months of this biennial cycle, but, if included, the first 3 months would only have increased our effective participation rate to 35%, and, therefore, selection bias was a possible confounder. The cohort we studied was similar in age to the rest of the plant and similar in terms of their regional symptoms (compared with the 32% who completed the biennial symptom survey), but we do not have any other data on the remainder of the workers in the plant. Another limitation is the failure to identify any psychosocial factors that helped predict a worker visiting the plant medical department. Why a worker seeks attention for a musculoskeletal complaint is not well understood. Most of these workers had recurrent upper-extremity discomfort at the time of entrance into the study, but only 45 workers visited the medical department for evaluation. There are many cultural and financial incentives for workers to continue working despite having pain. None of the psychosocial variables we included were predictive in our study. There are studies that attempt to analyze the motivation to see a physician, but none have been done in the occupational setting. Future studies need to attempt to replicate these findings in a study population with a greater percentage of worker participation and find better psychosocial variables to define a worker's motivation to seek medical attention.

In conclusion, significant predictors for visiting a medical department included the TLV for hand activity and peak force, as well as a history of diabetes, a current diagnosis of carpal tunnel syndrome or elbow tendonitis, and age under 40 years. This result corresponds with the findings of other prospective studies that showed that both ergonomic factors and past medical history were risk factors for an upper-extremity musculoskeletal disorder, and it suggests a healthy worker or survivor effect among older workers.

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