

## Predictors of Persistent Elbow Tendonitis Among Auto Assembly Workers

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**Introduction:** Lateral and medial epicondylitis associated with work activity is a common upper extremity musculoskeletal disorder with a prevalence of 4–30% depending upon the work setting and diagnostic criteria. The influence of treatment, ergonomic factors, medical history, psychosocial variables, and aging on the improvement of symptoms has not been well defined. **Methods:** This was a prospective cohort study of a cohort of 45 workers with active elbow tendonitis for an average of 13 months. Complete resolution of symptoms was the defined outcome measure. **Results:** The predictive factors for persistent elbow tendonitis included older age (OR = 1.1, 95% CI: 0.99, 1.33), higher hand repetition level for their job(s) (OR = 2.5, 95% CI: 1.00, 6.25), more deviation from a neutral wrist position during the work activity (OR = 2.0, 95% CI: 0.80, 5.56), and lower perceived decision authority on the job (OR = 0.9, 95% CI: 0.79, 0.98). Other ergonomic, psychosocial, and electrophysiologic measures were not predictive. The models had relatively high sensitivity and specificity. Treatment effects could not be evaluated due to incomplete data available. **Conclusions:** Older workers with jobs requiring more repetition and awkward wrist postures, and less decision authority were less likely to have resolution of their elbow tendonitis. **Implications:** Workers at highest risk for persistent elbow tendonitis should be placed at jobs with lower repetition levels and that use more neutral wrist postures. Effective interventions must address both the ergonomic and psychosocial risk factors in a multifaceted approach to this problem.

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**KEY WORDS:** tendonitis; cumulative trauma disorders; occupational diseases; natural history.

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## INTRODUCTION

Lateral and medial epicondylitis are the common sites of work-related tendonitis and several epidemiologic studies have demonstrated that ergonomic factors play a significant role in their development (1–7). Elbow tendonitis is one of the more common examples of repetitive strain disorders. The associated costs are estimated at over \$22 billion per year in the United States (medical and lost work time) (8).

Although the prevalence of elbow tendonitis is 1–3% in the general population (9,10), the rate among industrial workers ranges from 4 to 30% depending on the type of job and diagnostic criteria (1). The natural history of workers with elbow tendonitis is not well established but the typical duration of symptoms is 6 months to 2 years (11,12). The risk factors for elbow tendonitis include ergonomic factors such as forceful work, high rates of elbow flexion and extension, awkward postures, and exposure to vibration. The highest incidence rates are found in occupations that are manually intensive and require high work demands such as mechanics, butchers, meat processing plants, construction workers, and boilermakers (1,7). Work factors have also been demonstrated to influence the response to conservative treatment; manual workers were more likely to have higher pain scores after conservative treatment (at 4 weeks and 6 months) compared to white collar workers with elbow tendonitis (13). Both ergonomic and psychosocial factors have been demonstrated to influence work-related upper extremity disorders (14–16). Workers who have prolonged pain associated with their tendonitis may feel less control and produce feelings of helplessness which may impact their function as well as response to treatment (16).

The purpose of this study was to prospectively examine a cohort of workers within a moderately high-risk occupation, automobile assembly, over 1 year to identify factors which influence the persistence of active elbow tendonitis. For this study we examined active workers with an active diagnosis of medial or lateral epicondylitis at baseline, who subsequently had resolution of their symptoms and compared them to a group of workers with elbow tendonitis who had persistent symptoms. The auto assembly worker is an excellent model for evaluating the roles of ergonomic and psychosocial variables that may influence the persistence of elbow tendonitis.

We hypothesized that workers with persistent elbow tendonitis would be older, work at jobs with higher ergonomic stressors (hand activity level, peak force), and have significant psychosocial risk factors.

## METHODS

This was a longitudinal study of workers from an auto assembly plant in the southern United States. Of the 1,700 assembly plant workers, 475 agreed to participate in the study but only 279 subjects completed the initial detailed symptom questionnaire and sensory nerve conduction studies. The Institutional Review Board at the University of Michigan approved the project and all subjects completed a signed consent form.

All subjects underwent a directed physical examination of the upper extremities at baseline, and completed a symptom questionnaire, at both baseline and follow-up. All subjects were weighed and height was also recorded and used to determine the body mass index (BMI, kg/m<sup>2</sup>). All workers had evaluation of the median and ulnar sensory nerves at the wrist using the techniques described by Kimura (antidromic, 14 cm) (17). All jobs were assessed and rated for ergonomic exposures at baseline and whenever a job change took

place. The methods used to assess the jobs were described previously by Latko *et al.* (18) Jobs were videotaped and rated for the degree of repetition, average and peak hand contact stress, average and peak hand force, average and peak posture of the shoulder, elbow, forearm, and wrist/hand. The ratings were performed using a 0–10 visual analog scale for each stressor with verbal anchors on the 10 cm scale. A rating of zero 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. Each team member rated the jobs independently and then final ratings for the jobs were achieved through consensus. If a worker changed jobs within the plant during the study, a time-weighted average was calculated to estimate the ergonomic exposure for hand repetition, contact forces, wrist, elbow, and shoulder postures. 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 workers also completed a psychosocial questionnaire evaluating job security and satisfaction, supervisor and coworker support, job creativity, decision authority, and skill discretion as defined by Karasek (20).

Subjects were defined to have epicondylitis if they had symptoms of pain, aching, stiffness, or burning at the elbow and had physical examination findings that reproduced their symptoms with loading of the muscles that attach to the medial or lateral epicondyle or tenderness to palpation at the medial or lateral epicondyle. There were 45 subjects for the original sample of 279 workers who met these criteria for active elbow tendonitis. All cases were informed of these findings and advised to seek appropriate care. Cases were considered "resolved" if there was complete resolution of their symptoms at 6 or 12 months after entrance into the study. Follow-up was performed by a self-administered questionnaire. Subjects were asked if they had elbow or forearm discomfort that occurred three or more times or lasted for over a week in the preceding 6 months.

We only had access to plant medical records. Workers often seek medical care, even for work-related disorders, from outside providers. Hence the plant records are incomplete, and so we were not able to include medical treatments and interventions in analyses.

## STATISTICAL ANALYSIS

Univariate analyses using *t*-tests or chi square analysis were performed on the two groups ("Persistent Elbow Tendonitis Cases" vs. "Resolved Cases") comparing them for baseline demographics, medical history, ergonomic stresses, psychosocial factors, and discomfort ratings. Multivariate logistical regression was performed using resolution of elbow tendonitis as the dependent variable to create a predictive model based on the data from the initial screening. All demographic, ergonomic, and medical history variables were initially included in the stepwise logistic regression analysis; variables that had a *p* value greater than .2 in the univariate analysis were excluded in the model and those that maintained a *p* < .15 in the regression model remained. All analyses were performed with Stata 5.0 (College Station, TX).

## RESULTS

The prevalence rate for elbow tendonitis was 16% at the study site. Of the 45 subjects with elbow tendonitis, 26 (58%) reported resolution of their elbow symptoms at the 6

or 12-month follow-up. The average age was 48 years, the average BMI was 29.2, 40% were female, and the mean duration of follow-up was 13 months. The workers in the original cohort of 279 subjects were similar in age ( $48.6 \pm 7.9$ ), gender (32% female), BMI ( $28.3 \pm 4.5$ ), and duration of follow-up (12.6 months).

The demographic profile of each elbow tendonitis group is presented in Table I(A). Women were more likely to have persistent symptoms. There was no difference between the two groups in terms of hand dominance and rheumatoid arthritis. Persistent cases tended to have a higher prevalence of diabetes and a higher BMI. Both groups had similar symptoms in other regions of the upper extremity as well as a similar prevalence of carpal tunnel syndrome.

The psychosocial variable developed by Karasek (20) were similar in each group except for perceived coworker support and decision authority which were lower in the subjects with persistent symptoms. Both groups had similar levels of visits to the plant medical department and similar numbers of workers' compensation cases. The ergonomic variables were similar except for a higher hand repetition rate among the workers who had persistent symptoms; these workers also tended to have higher deviation of the wrist from a neutral posture (See Table I(B)).

The logistic regression modeling (Table II), which controls for confounding variables, demonstrated that older subjects, higher hand repetition level for their job(s), more deviation from a neutral wrist position during the work activity, and lower perceived decision authority on the job were predictive of persistent symptoms. The model had relatively high sensitivity (80%) and specificity (78%) and the area under the receiver operator curve was 0.86.

## DISCUSSION

The study cohort had a prevalence rate of 16% which is comparable to studies among other industrial workers and high compared to the general population (1,9,10). Fifty-eight percent of study subjects had resolution of their symptoms within the year and this compares to an expected rate of improvement of 70–90% in the general population (21). A lower improvement rate might not be unexpected, given that all subjects in this study were actively employed in automobile assembly operations, jobs that are associated with greater than average rates of upper extremity MSDs.

The study demonstrated that older age, higher hand repetition level for their job(s), more deviation from a neutral wrist position during the work activity, and lower perceived decision authority on the job were predictive factors for persistent elbow tendonitis. Although repetition, posture, and force have been associated with the development of elbow tendonitis, this is the first report of ergonomic factors influencing the recovery of elbow tendonitis.

We were not able to accurately document the treatment interventions for these workers but all of the workers had excellent health insurance as well as access to in-plant medical care. The assumption is that they all had opportunity for adequate medical care. Both groups used the plant medical department at the same rate (approximately 50% visited the medical department during the study). Several studies have demonstrated that the type of intervention (steroid injections, NSAIDs, physical therapy, or a wait and see policy) does not influence the outcome at 12 months (21). Randomized controlled trials have demonstrated short-term benefits for steroid injections but at 12 months all treatments (or lack of treatment) lead to

**Table I.** Comparison of Subjects with “active” Elbow Tendonitis at Baseline Whose Symptoms Resolved Versus Those with Persistent Symptoms

	Persistent tendonitis <i>n</i> = 19	Resolved cases <i>n</i> = 26	<i>P</i>
(A) Demographic, psychosocial and electrodiagnostic factors			
Age	49.0	47.7	0.45
BMI	30.9	28.3	0.07
Gender (% female)	52.6%	23.1%	0.04
% Right hand dominant	100%	96.2%	1
Diabetes	10.5%	0%	0.17
Rheumatoid arthritis	15.8%	7.7%	0.64
Current neck/shoulder symptoms	89.5%	73.1%	0.26
Current elbow/forearm symptoms	100%	92.3%	0.5
Current wrist/hand/finger symptoms	84.2%	84.6%	1
Smoke now	42.1%	36%	0.7
Regular exercise	68.75%	57.1%	0.47
CTS at baseline	5.3%	7.7%	1
Active shoulder tendonitis	21.0%	7.7%	0.37
Active wrist/hand tendonitis	52.6%	38.5%	0.35
Neck/shoulder discomfort rating (1–10) in last 30 days	6.7	5.4	0.19
Elbow/forearm discomfort rating (1–10) in last 30 days	7.2	6.2	0.25
Wrist/hand discomfort rating (1–10) in last 30 days	6.4	5.9	0.61
Education (school)	3.8	3.4	0.24
Skill discretion	23.6	26.3	0.34
Decision authority	20	26.7	0.004
Supervisor support	10.06	10.96	0.45
Job dissatisfaction	0.52	0.48	0.59
Coworker support	10.2	11.7	0.02
Job insecurity	5.47	5.4	0.94
% of Workers who changed jobs during study	31.6%	46.2%	0.32
Worker compensation claims	11%	8%	.76
Plant medical visits for upper extremity symptoms	47%	50%	.92
Plant medical visits for elbow/forearm symptoms	21%	15%	.68
Median sensory peak latency (ms)	3.86	3.73	0.51
Ulnar sensory peak latency (ms)	3.42	3.58	0.65
Median–Ulnar sensory peak difference (ms)	0.42	0.46	0.88
(B) Time-weighted-average ergonomic exposure ratings:			
Ergonomic/treatment factors			
TLV*	2.4	2.2	0.5
Hand Repetition level	4.4	3.7	0.02
Peak force	4.6	4.5	0.84
Average force	1.01	0.96	0.45
Peak contact stress (fingers)	4.0	4.0	0.98
Average contact stress (fingers)	1.4	1.4	0.77
Peak contact stress (palm)	3.7	3.9	0.29
Average contact stress (palm)	1.2	1.3	0.28
Peak contact stress (forearm)	1.9	1.6	0.46
Average contact stress (forearm)	0.49	0.31	0.17
Peak contact stress (elbow)	0.06	0.29	0.14
Average contact stress (elbow)	0.001	0.09	0.19
Peak wrist flexion/extension	5.4	4.9	0.12
Average wrist flexion/extension	1.9	1.7	0.07
Peak wrist radial/ulnar deviation	5.0	4.8	0.47
Average wrist radial/ulnar deviation	1.5	1.5	0.91
Peak elbow posture	6.3	6.5	0.42
Average elbow posture	2.8	3.0	0.18
Peak shoulder posture	7.6	7.2	0.3
Average shoulder posture	2.8	2.6	0.29

Note. *N* = 45, 26 improved.

\*1 = Acceptable, 2 = Borderline, 3 = Unacceptable.

**Table II.** Logistic Regression Modeling Resolution of Elbow Tendonitis Symptoms

	Odds Ratio	Std. Err.	z	p >  z	[95% Conf. Interval]
Repetition	2.5	.19	-1.96	0.050	1.00, 6.25
Decision authority	0.9	.06	2.29	0.022	-0.79, 0.98
Peak wrist flex/ext	2.0	.23	-1.52	0.130	0.80, 5.56
Age	1.1	.07	-1.81	0.071	0.99, 1.33

Note. Area under the Receiver Operator Curve = 0.86, Sensitivity = 80%, Specificity = 78%, Positive Predictive Value = 83%, Negative Predictive Value = 74%, Logit estimates Number of obs = 43, LR  $\chi^2(4) = 16.80$ , Prob >  $\chi^2 = 0.0021$ , Pseudo  $R^2 = 0.2873$ , Log likelihood = -20.833804.

improvement in approximately 80% of subjects (21). It is therefore reasonable to assume that the predictors of symptom resolution are not tied to, or only weakly associated with, the treatment that study subjects received.

If work activity can cause tendonitis, it is reasonable to assume it can influence recovery and this study supports that assertion. It has been demonstrated that manual workers with elbow tendonitis are less likely to have as much improvement in symptoms when compared to office workers with elbow tendonitis (11). In our study, workers who had higher hand repetition levels and nonneutral wrist postures were less likely to have resolution of their elbow symptoms. Although force was measured, this was not a significant factor in the analysis. A change in job was not a predictor of resolution of symptoms in this cohort.

Age has been known to influence recovery from injury so it is plausible that older workers would be less likely to have resolution of their symptoms. In the study work environment, there is a seniority system that allows workers with more seniority to request jobs that they perceive as easier or more desirable.

Psychosocial factors have been known to be predictive of low back pain and to a lesser extent upper extremity musculoskeletal disorders. Karasek *et al.* (20) developed the job content questionnaire to determine the psychosocial aspect of the job that might influence health outcomes. Job insecurity, decreased locus of control, less decision discretion, lower job satisfaction, and less supervisor/coworker support are supposed to be predictive of higher rates of repetitive strain disorders. Huang *et al.* (15) demonstrated that both biomechanical and work organizational factors, particularly time pressure, impacted work-related musculoskeletal disorders. In this study, lower perceived decision authority, which is similar to time pressure, was predictive of persistent elbow tendonitis; however, the other psychosocial variables were not significant in the model. If workers can pace their activities, theoretically, they could avoid activities that aggravate their symptoms and thereby allow for healing to occur.

The findings in this study complement those of Huang *et al.* (15) and Shaw *et al.* (16) in demonstrating that the combination of ergonomic and psychosocial factors influence the persistence of upper extremity work-related musculoskeletal disorders. In order to facilitate improvement in these workers, we must address both aspects of the job in order to resolve their disorder. Addressing only one aspect of the problem is unlikely to be successful.

The study has several limitations that influence its generalizability. It has a small sample size and this may have affected the statistical power to demonstrate other predictive factors. The lack of data on treatment is also a concern but there are randomized controlled studies in the literature that have demonstrated that the treatment (or lack of treatment) does not influence the outcome at 12 months (21).

The study strengths include the prospective cohort design, standardized diagnostic criteria, individualized ergonomic evaluation, standardized psychosocial evaluation and its focus on a single diagnostic entity as opposed to grouping all upper extremity musculoskeletal disorders into one group. The prospective design allows us to confirm the findings of cross-sectional studies such as Huang *et al.* (15) which found an association between persistent symptoms and both ergonomic and psychosocial factors. The standardized diagnostic criteria allows for comparison to other studies while the use of both self-reported symptoms and physical examination strengthens the validity of the study. The detailed evaluation of the ergonomic characteristics of each job, based on standardized, validated criteria (18) is a unique strength of this study. Self-reported measures of ergonomic risk factors are a poor substitute for these objective measures. The standardized psychosocial assessment based upon Karasek's model of job content (20) has been used extensively and has proven reliability and validity. Finally, this study is focused on a specific diagnostic category while most of the current literature has evaluated risk factors for all upper extremity musculoskeletal disorders as a whole. It is clear that carpal tunnel syndrome has different risk factors when compared to a rotator cuff injury so when they are aggregated into one group of disorders, some risk factors could be missed because of confounding. The more specific the diagnostic entity, the more likely we are to define the true risk factors. The tradeoff of focusing on a single diagnostic category is a smaller sample size and less statistical power. We chose to focus on the clarity of a single diagnostic group over the option of grouping multiple diagnostic groups that would allow a larger sample size.

In conclusion, we have demonstrated that older workers, with more repetition and awkward wrist postures associated with their jobs, and less decision authority were less likely to have resolution of their elbow tendonitis. The study highlights the importance of recognizing that both ergonomic and psychosocial factors influence the outcome of work-related elbow tendonitis. Additional studies are necessary to evaluate how effective a multifaceted approach to this problem could be.

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