The Impact of Workplace Screening on the Occurrence of Cumulative Trauma Disorders and Workers' Compensation Claims

J. Mark Melhorn, MD

Work-related musculoskeletal pain, commonly referred to more specifically as musculoskeletal disorders or cumulative trauma disorders, has continued to occur despite efforts by employers, employees, health care providers, and the government to eradicate it. The National Institute for Occupational Safety and Health has encouraged employers to establish ergonomic prevention programs; however, many employers are concerned that screening, education, and focused attention on workplace pain will cause an increase in the number of OSHA 200 events and the incidence of workers' compensation claims. This prospective cohort study demonstrated that there was no increase in the number of OSHA 200 events and no increase in the incidence of workers' compensation claims after completion of an individual risk screening program that included education and employee awareness about work-related musculoskeletal pain. Incidence of cumulative trauma disorders has been most effectively reduced by use of individual risk-screening programs. Therefore, employers should be encouraged to develop and implement prevention programs that include individual risk screening.

The recognition and control of occupational injuries involving musculoskeletal pain has become a major concern of employees, employers, health care providers, and the federal government. In 1997, the cost of workplace health and safety was estimated at over $418 billion in direct costs, and (using the lower range of estimates) indirect costs were $837 billion.[1] Reducing this total cost of over $1.256 trillion would have a major impact on corporate productivity, as well as improve the quality of life for the individual employee. In 1990, the National Institute for Occupational Safety and Health (NIOSH) estimated that 15% to 20% of Americans are at risk for developing cumulative trauma disorders (CTDs).[2]

In 1998, the Bureau of Labor and Statistics (BLS)[3,4] released its most current data for 1996 in its annual survey of lost-worktime injuries and illnesses. Data reported for 1996 showed that a total of nearly 1.9 million injuries and illnesses in private-industry workplaces required recuperation away from work beyond the day of the incident. The 1996 figure of 1,880,500 cases is a decline from the 2,040,929 cases reported in 1995. In fact, the number of injuries and illnesses resulting in time away from work has declined since 1992 (there were 2,236,600 cases reported in 1994; 2,252,600 in 1993; and 2,331,100 cases in 1992). While this reduction in incidence is important, the estimated costs for 1996 are higher than those for 1995.

From the Section of Orthopaedics, Department of Surgery, University of Kansas School of Medicine-Wichita, Wichita, Kans.

Address correspondence to: J. Mark Melhorn, MD, The Hand Center, P.A., 625 N Carriage Parkway, Ste 125, Wichita, KS 67208-4510.

1076-2752/99/4102-0084$3.00/0

Additionally, ten occupations accounted for nearly one third the number of injuries and illnesses requiring recuperation away from work for 1992 through 1996.[4] Also, despite the decreased overall incidence rate, the number of lost workdays is increasing per incidence, and CTD cases are disproportionately higher (median number of lost workdays for all cases in 1996 is 5 days, whereas that for carpal tunnel syndrome (CTS) is 25 days).[4]

Although a reduction in incidence is important, it is but one part of the maze. Webster and Snook[5] found that the mean cost per case of upper extremity CTD was $8070, compared with a median cost of $824 for all other cases. Medical costs represented 32.9% of the total costs; indemnity costs were 65.1%. The goal of intervention programs should include a reduction in incidence rate, lost workdays incidence rate, lost time case incident rate, lost time day severity rates, and costs.

Feuerstein et al[6] reported 185,927 claims in the federal workforce from October 1, 1993, to September 30, 1994. Upper extremity CTD represented 8,147 (4.4%) of all claims. The mean number of lost workdays was 84 for CTS, at a direct medical cost of $4,941. They concluded that upper extremity CTD had significantly higher direct and indirect medical costs, because of the longer duration of treatment and greater work disability. The authors also suggested that there is a need for risk-factor identification to be used to decrease disability severity and shorten recovery time.

Unfortunately, many myths about work-related injuries have developed because of the difficulty of integrating individual risk factors with risk factors in the workplace.[7] Recent studies tend to demonstrate that occupational diseases involve multiple factors in the etiology and that a specific job may not be the primary cause for occurrence.[8–19] In reviewing this literature, many questions are raised regarding etiology and job relationship. Sufficient epidemiological evidence is present to demonstrate an association between the individual's risk and activities (workplace and nonwork environment).[20,21] Therefore, prevention is the best approach to the reduction of CTDs, and prevention is best accomplished by individual screening and surveillance in the workplace.[21–27]

In 1986, NIOSH proposed a national strategy for the prevention of work-related diseases and injuries.[27a,27b] The BLS 1992 figure of 281,800 was more than double the comparable count reported 4 years earlier; the Occupational Safety and Health Administration's Office of Ergonomic Support stated that 33% to 40% of people receiving workers' compensation have musculoskeletal workplace injuries.[2,28,29]

The effectiveness of workplace screening programs for the reduction of musculoskeletal disorders (MSDs) is supported by the current reduction in the BLS incidence rate.[3,4] Screening contributes to prevention of work-related disease when individual and group test results are routinely scrutinized for indications of adverse health effects and appropriate actions are taken in response to such findings.[22] Golaszewski et al[30] demonstrated that for every dollar spent on health prevention, 3.40 dollars are saved (benefit-to-cost ratio). Employers have been reluctant to undertake workplace screening because of a concern that the process of screening and the associated education would cause an increase in the number of reportable OSHA 200 events, requests for medical care, and workers' compensation claims, thereby resulting in increased workers' compensation costs.

The outcome measure for this prospective study on MSDs and CTDs, using an individual risk assessment instrument, was the number of reportable OSHA 200 events and the incidence of workers' compensation claim filings.

TABLE 1
Number of Employees, by Year

Year	Average	Turnover	New Hires
1998	94	7	19
1997	82	26	26
1996	82	29	35
1995	76	22	29
1994	69	20	21
1993	68	19	20

Methods

In 1997, a financial institution with 82 employees assigned to six branch offices agreed to participate in this research project. Records were available from 1993 to 1997 for total employees, new hires, and employees lost from employment for each year (Table 1).

The individual screening program, education materials, and data collection were completed using OSHA's[31] prevention program guides that follow. Data was collected for age, gender, job, branch local, and study group (control or screened). The control group was made up of individual employees who received no information regarding the study or CTDs in the workplace. The study (screened) group was introduced to CTDs in the workplace by an office memorandum, employee management meetings, educational materials, and a question-and-answer session over a 4-week period. Examples of the educational materials are included in Appendix A.

At the end of the 4-week CTDs introduction and education program, 40 of the employees were screened using an individual CTD MSD risk-assessment instrument (screened group).[32] The CTD MSD risk-assessment instrument includes 139 questions and 56 physical examination data points. Examples of the questions are included in Table 2. This instrument was developed using psychometric principles.[33–36] Questions regarding age, gender, inherited genetic characteristics, workplace, nonwork environment, and psychosocial issues were collected.[37,38] The

TABLE 2
Examples of Questions and Physical Measures

1. Present Job or New Job: Please select the number above that best describes your present job.
6. Hobby or Leisure Activity: Please select the number from the list above for your favorite leisure activities or hobbies.
9. I have trouble turning a key to open a door — No Yes
10. I have trouble pouring milk — No Yes
11. I have trouble holding utensils like knives and forks — No Yes
12. I have trouble cutting my meat at meals — No Yes
13. I have trouble with zippers, buttons, or hooks — No Yes
14. I have trouble opening doors — No Yes
37. No-Yes Thyroid disease (hormone imbalance)
38. No-Yes Rheumatoid arthritis (disease of the joints with swelling and drifting)
57. Average hours worked per day for all jobs. If not working use 8.
<6 8 10 12 14>
70. Do your hands feel cold? No Left Right Both
71. Do your hands swell? No Left Right Both
135. Your overall impression or feelings about the screening? good fair poor
1. Percussion median
3. Phalen's
15. Finkelstein's
21. Lateral epicondylitis pain
29. Shoulder impingement pain
33. Wrist depth and width
35. Circumference, forearm
37. Grip strength
41. Two point sensory

instrument combines the questionnaire with the physical measures. Relative risk levels are obtained by statistical analysis using a range of 1 to 7, with 1 as lowest risk. The instrument has previously been studied for reproducibility (test-retest reliability using Spearman's correlation demonstrated substantial agreement at 0.89), internal consistency (Cronbach's alpha of .76), validity (evidence of construct validity by correlation between physician examination and risk level), and sensitivity to clinical changes (decreased combined risk level by exercise intervention group while control group was unchanged, confirming responsiveness).[32,39,40]

The screened group was further divided into a group of 20 individuals who were informed of their risk-assessment score and 20 who were not informed. Random assignment to the informed versus the not-informed groups was established by use of the three bank branches involved in the screening by flipping a coin for one branch to be informed, one branch not to be informed, and one branch to be a blend based on last digit of Social Security Number, with the odd number not informed. Individuals were notified or informed of their individual risk level by letter and a follow-up interview. Education was provided to the informed group, but no specific health interventions, workplace modifications, or ergonomic programs were provided (see Appendix B).

Retrospective data was collected for the 5 years before the start of this study. During the retrospective and prospective study period, no ergonomic programs or workplace changes were made. During the retrospective period, two branches were located to new facilities but no specific ergonomic construction designs were used during the building process. No change in facilities occurred during the prospective period. The work areas, jobs tasks, and performance expectations were the same for all branches. The general job of financial services remained similar during the study period.

Occupational injuries were defined as injuries that resulted from a work-related event or from a single instantaneous exposure in the work environment and that resulted in lost worktime or required medical treatment (other than first aid), or as cases in which the worker experienced loss of consciousness, restriction of work activities or motion, or was transferred to another job.[41] Occupational illnesses were defined as any abnormal condition or disorder (other than one resulting from an occupational injury) caused by exposure to a factor(s) associated with employment, including acute or chronic illnesses or disease caused by inhalation, absorption, ingestion, or direct contact.[41] Disorders commonly called CTDs (for example, CTS) would be included in the illnesses definition.

The employer studied has encouraged early reporting of workplace injuries and illnesses. During the study period, the employer experienced the usual first aid and workplace injuries. Although the employer is a financial institution and therefore exempt from filing OSHA 200 logs, the employer has maintained these records, along with the state-required workers' compensation records. The employer's commercial insurance underwriter has not observed any change in the frequency of visits or claims filed for non–work-related musculoskeletal pain during the study.

Confounding is always possible. In a study of this type, there are many factors that can not be controlled. Examples would include the following: corporate culture regarding reporting of CTDs, employee turnover, lay-media education regarding CTDs, employee satisfaction with the workplace, community employment opportunities, general economic conditions, and the effect of being included in a research study.

Results

In 1997, 82 employees were available for this prospective study, with an average age of 32.6 years and a

age range of 19 to 77 years. There were 13 (16%) males and 69 (84%) females. After a 4-week CTD introduction and education program, 40 (49%) of the employees were screened using an individual CTD MSD risk assessment instrument (screened group). The average age for the screened group was 31 years, compared with the total group average age of 32 years, with a age range of 19 to 68 years compared with 19 to 77 years, respectively. Six (16%) of the 40 subjects in the screened group were male, compared with 13 (16%) of the 82 subjects in the total group, and 34 (84%) of the 40 subjects in the screened group were female, compared with 69 (84%) of the 82 subjects in the total group. The individual risk scores in the screened group ranged from 1 to 7, with an average risk level of 4.1. In addition to the individual upper extremity risk score, 12 of 40 (30%) in the screened group were at increased risk for musculoskeletal pain located in the back or lower extremities.

The screened group was further divided by random assignment into a group of 20 individuals who were informed of their risk assessment score and 20 who were not informed.

The individual risk scores ranged from 1 to 7, with the average for the screened group[40] at 4.10 left and 4.15 right (average company risk level, 4.125). The informed (informed or told of individual risk level) group risk was left 4.1 and 3.9 right (average, 4.0), compared with the not-informed (not told) group of left 4.1 and right 4.4 (average, 4.25). Individual risk scores and their groups are listed in Table 3.

The CTD MSD risk assessment instrument also provides information for the back (thoracic and lumbar spine) and the lower extremity. Table 3 demonstrated that 8 of 20 (40%) in the screened and informed group were more likely to have musculoskeletal pain complaints for the back and lower extremity, compared with 4 of 20 (20%) in the screened and not-informed group, with a company average of 12 of 40 (30%).

The combined individual risk score distribution for the left and right upper extremity for the screened group is listed in Table 4. For 1998, the employer has experienced increasing growth. The number of employees has increased and the turnover has decreased. Two members of the screened group and five members of the nonscreened group have left employment. The two members of the screened group were interviewed by phone and reported that they had left work for family reasons. Four of the five nonscreened group members were interviewed by phone and reported that they had left work for family reasons. No forwarding information is available so that the fifth individual can be located.

The employer has continued to maintain OSHA 200 logs and state workers' compensation claims records. During the 11 months after the screening, education, and focused attention on workplace pain began, no OSHA 200 events or workers' compensation claims for occupational illnesses in the category of cumulative trauma, repeated trauma, or repetitive strain injury have occurred.

Discussion

With the cost of workplace health and safety (both direct and indirect costs) for 1997 estimated at over $1.256 trillion,[1] reduction of CTD MSD remains a priority for employees, employers, business, and health care services. In 1986, NIOSH developed a national strategy for prevention of work-related diseases and injuries.[42,43] Although the BLS[41] had been collecting and annually reporting data since 1970 on workplace injuries, more information was required so that effective prevention programs could be designed. In 1990, NIOSH estimated that 15% to 20% of Americans are at risk for developing CTDs.[2] In 1994, the addition of demographic and case characteristics were included in the annual BLS report "Occupational Injuries and Illnesses: Counts, Rates, and Characteristics." When this information was combined with studies by the Centers for Disease Control[44] and NIOSH,[27a,27b] guidelines and suggestions for prevention and reduction were provided for employers by NIOSH.

These earlier efforts appear to be having some effect, as a 1996 BLS report demonstrated a drop in the numbers of "disorders associated with repeated trauma" from a high in 1994 of 4.9% to 4.5% in 1996. Unfortunately, although the incidence rate may be stable or decreasing, the costs associated with this type of occupational injury are increasing disproportionately.

Further efforts in the form of prevention and guides for the employer have included the American College of Occupational and Environment Medicine's[47] "1997 Labor Day Checklist: Ergonomic Tips to Prevent Cumulative Trauma" and NIOSH's 1997 publication no. 97–117, "Elements of Ergonomics Programs." NIOSH recommends that an ergonomic prevention program contain seven steps: (1) looking for signs of work-related musculoskeletal problems, (2) setting the stage for action, (3) training to build in-house expertise, (4) gathering and examining evidence of work-related MSDs, (5) developing controls, (6) health care management, and (7) proactive ergonomics (screening for individual and group risk of work-related MSDs).[31]

For proactive ergonomics to be effective, a screening program should include a written plan for data collection, analysis, and response to abnormal findings. Screening programs can include questionnaire-based measures only; questionnaires and physical measures (clinical examination); or questionnaires, physical measurements, and physical testing (nerve conduction studies or electromyographic studies). Recent studies have suggested that for

TABLE 3
Individual Data

Patient No.	Sex	Age	Upper Extremity Risk Level		Back/Lower Extremity Pain	%
			Left	Right		
Told						
27	F	35	1	1	Y	
28	F	27	2	1	Y	
29	F	26	7	7	Y	
30	F	45	4	5		
31	F	20	3	4	Y	
32	F	46	6	6	Y	
33	F	34	5	4	Y	
34	F	28	4	4	Y	
35	F	29	4	5		
36	F	39	3	3		
37	F	30	6	7		
38	F	22	4	3		
39	M	51	5	3	Y	
40	F	40	2	4		
1	M	29	2	2		
2	M	34	7	4		
3	M	36	4	4		
4	F	39	5	3		
5	F	19	4	4		
6	F	33	4	4		
Upper extremity average risk levels for 20 told*			4.1	3.9		
Total with back/lower extremity pain					8/20	40.0
No. male	4				4/20	20.0
No. female	16				16/20	40.0
Not told						
7	M	29	4	4		
8	M	30	5	5		
9	M	51	3	3	Y	
10	F	68	4	3	Y	
11	F	28	4	4		
12	F	26	1	3		
13	F	24	4	5		
14	F	25	5	4		
15	F	31	5	4		
16	F	36	4	5	Y	
17	F	20	4	5		
18	F	19	5	4		
19	F	21	4	5		
20	F	25	4	5		
21	F	25	3	3		
22	F	31	4	3	Y	
23	F	30	5	5		
24	F	26	5	7		
25	F	22	4	4		
26	F	29	5	7		
Upper extremity average risk levels for 20 not told*			4.1	4.4		
Total with back/lower extremity pain					4/20	20.0
No. male	3				3/20	15.0
No. female	17				17/20	85.0
Upper extremity average risk levels for all 40 patients*			4.1	4.15		
Total with back/lower extremity pain					12/40	30.0
No. male	7				7/40	17.5
No. female	33				33/40	82.5

* Average of left and right upper extremity risk scores were as follows: for 20 patients told, 4.00; for 20 patients not told, 4.25; for all 40 patients, 4.125.

TABLE 4
Combined Risk Levels

Risk Level	1	2	3	4	5	6	7
Left	2	3	4	17	10	2	2
Right	2	1	9	14	9	1	4
Total	4	4	13	31	19	3	6
% of total	5.00	5.00	16.25	38.75	23.75	3.75	7.50
		Groups 1, 2, 3		Group 4		Groups 5, 6, 7	
Total by group		21		31		28	
Standard distribution		26		28		26	

screening purposes, the questionnaire only or the questionnaire and physical measures are the most sensitive and best predictors.[48–64]

Unfortunately, many employers have not initiated individual screening programs because of the belief that if the individual employee is evaluated, educated, or informed about CTD MSD related to the workplace, the employer's reported rate of occurrence will increase and their workers' compensation costs will therefore increase. A review of the published literature does not reveal any studies to confirm or refute this employer concern. Also, employers are concerned about how to integrate individual risk screenings with OSHA's requirement for a safe workplace and Americans with Disabilities Act (ADA) requirements regarding employment discrimination. Although a complete review is not possible, the general concepts are that the employer is required to provide a safe workplace as instructed by the General Duty Clauses section 5 A 1 of the Federal Registry outlining requirements for OSHA.[65] An individual screening program can be a beneficial part of those requirements. The employer would also be in compliance with the ADA if the employer used the individual screening information to help match individuals to essential functions of jobs and if the work guides are applied fairly and equally to all employees.[66–69] The ADA permits an employer to require that an individual not pose a direct threat to the health and safety of himself (herself) or others in the workplace. A direct threat means a significant risk of substantial harm. The determination that an individual poses a direct threat must be based on objective, factual evidence regarding the individual's present ability to perform essential job functions.[66,70,71]

This prospective cohort study demonstrated that when the employer implemented an individual risk screening program, education, and employee awareness, there was no increase in the incidence of work-related musculoskeletal pain, as measured by OSHA 200 events, workers' compensation claims, workers' compensation costs, or commercial insurance visits. Since individual risk screening can be in compliance with both OSHA and the ADA guides, employers should be encouraged to develop, implement, and use individual screening programs because they provide the best opportunity for prevention of CTDs and do not increase the incidence rate or costs of CTD MSD in the workplace.

Appendix A

Cumulative Trauma Disorders—Just the Facts

Occupational diseases affect 15% to 20% of all Americans. CTDs account for 56% of all occupational injuries. The government predicts that by the year 2000, 50% of the American workforce will have occupational injuries annually. The recognition and control of occupational injuries has become a major concern of employees, employers, health care providers, and the government. Many myths about work-related injuries have developed because of the difficulty of integrating individual risk factors with risk factors in the workplace. Recent studies tend to demonstrate that occupational diseases are multifactorial in etiology and that a specific job may not be the primary cause for occurrence. Reduction of the individual risk factors provides the best opportunity for reaching the preferred treatment, which is prevention.

Although discussions of diseases of human soft tissue date back to the Greeks, the documented history of CTDs is vague. Today we have a better understanding of the workplace and of the limits of the human body, but the dose relationships or tolerance thresholds for an individual remain questionable. Evaluating the dose relationships or tolerance levels is difficult because each individual brings a different set of risk factors to the workplace. Although the workplace may appear—through ergonomic assessments of the environment or demographic studies of the people—to be the same, the workplace is uniquely experienced by each individual.

CTD is not a medical diagnosis but a label for pain perception. The US government has defined the term CTD as describing any musculoskeletal pain that an individual believes is associated with activities performed at work. Musculoskeletal pain is defined as any pain that may involve the muscles, nerves, tendons, ligaments, bones, or joints. For the

pain to be considered work-related, state governments have legislated a variety of work-contribution requirements. The workers' compensation system was created to provide benefits for work related pain that meets the state specific legislative requirements.

Because CTD is a term and not a medical diagnosis, current research will be unable to establish a pathoanatomical diagnosis for every individual who experiences pain associated with the workplace. CTD causation is multifactorial. Work activities may contribute to, but are not the sole cause for, CTD development and exacerbation. Individual, social, and cultural factors play similarly important roles in their development and whether affected individuals, their employers, and society recognizes or accepts the medical disorder. The individual human risk factors are age, gender, genetic make-up, work activities, non-work activities, and linked elements. Health-belief models may contribute to when, where, and how these disorders materialize. Different countries have different health care systems and avenues for recognizing these disorders, making international comparisons difficult. Repetitive activities from nonoccupational pursuits such as tennis, racquetball, or basketball (to name a few) may also contribute to or exasperate these conditions. There has been considerable controversy recently in the scientific literature and in society at large about the relative importance of repetitive motion and other occupational factors in the etiology of CTDs.

In 1986, NIOSH proposed a national strategy for the prevention of work-related diseases and injuries. NIOSH, without any specific guidelines or methods for testing, stated "When job demands. . . repeatedly exceed the biomechanical capacity of the worker, the activities become trauma-inducing. Hence, traumatogens are workplace sources of biomechanical strain that contribute to the onset of injuries affecting the musculoskeletal system." OSHA has been unable to provide specific corrective direction because medical and epidemiology studies on CTS were demonstrating inconsistencies with the original hypothesis that CTS was due to the workplace. This lack of direction left every company, small or large, on its own to develop a system to comply with the new rules. For industry to make changes, it will require tools for evaluating the individual's response to the workplace. State and federal organizations have focused on how to cut costs; industry has focused on established health programs; medicine has focused on education and health guides; and OSHA has focused on mandatory reporting in the workplace. Prevention has been discussed, but awareness of the multiple human factors only complicates the effort to establish guides for the dose relationship or tolerance level for each individual.

Although the need for further research is clear, there are associations between different work activities and upper-limb musculoskeletal pain. Studies of benefit-to-cost analysis for prevention programs demonstrate significant savings for the employer. From a public health perspective of prevention, there is enough information to allow these risk factors to begin to decrease with engineering and administrative controls, while the research continues.

Appendix B

Letter of Risk Level

Thank you for completing the CTD MSD risk assessment. A statistical analysis has been completed using the information that you have provided. As a screening instrument, the statistical analysis does not make a medical diagnosis. Since such analysis is limited in nature, the instrument can not identify all possible or potential health risks to individuals. This analysis is designed to provide you insight into your risk for the development of a Cumulative Trauma Disorder.

"CTD" is a term that has been used by the government to describe any musculoskeletal pain that an individual feels is associated with activities he or she performs at work. Musculoskeletal pain may involve the muscles, nerves, tendons, ligaments, bones or joints that make up the body. The term "CTD" is not a medical diagnosis, and our knowledge about CTD is developing through research. All individuals are at risk for CTD. There are many myths about CTD. Your individual risk level for the development of CTD on the left is "L" and on the right is "R". Your risk for the lower extremity and back was determined as "B". Many individuals can benefit from a better understanding of CTD.

Research studies have been difficult to complete because of the combination of high costs, long periods of time, large number of people, and multiple linked factors. Several studies have suggested that prevention is the best approach. Prevention is possible with early identification and early intervention, much like high blood pressure, heart disease, or diabetes. Intervention can include education, modification of activities, and medical treatment.

Why individuals develop CTD symptoms is related to their unique human risk factors that include: age, gender, genetics (inherited physical characteristics, although no gene studies are done), workplace, non-work environment and other factors.

Acknowledgments

The author thanks Peggy Gardner, PhD, Executive Director, Via Christi Health System, for her review of the article. Funding for the study was provided by The Hand Center, P.A., Wichita, KS. Reference support was provided by The Via Christi Medical Libraries. Statistical analyses were performed by James Riggs, MS.

References

1. Brady W, Bass J, Royce M, Anstadt G, Loeppke R, Leopold R. Defining total corporate health and safety costs: signif-

icance and impact. *J Occup Environ Med.* 1997;39:224–231.
2. US Bureau of Labor Statistics. Repetitive tasks loosen some workers' grip on safety and health. *Issues.* 1994;94–9:1–4.
3. Bureau of. Labor Statistics. *Survey of Occupational Injuries and Illnesses, 1996.* Washington, DC: US Government Printing Office; 1998:1–56.
4. Bureau of. Labor Statistics. BLS issues 1996 lost-worktime injuries and illnesses survey. *ACOEM Rep.* 1998;98–5;6–7.
5. Webster BS, Snook SH. The cost of compensable upper extremity cumulative trauma disorders. *J Occup Med.* 1994;7: 713–718.
6. Feuerstein M, Miller VL, Burrell LM, Berger R. Occupational upper extremity disorders in the federal workforce. *J Occup Environ Med.* 1998;40:546–555.
7. Melhorn JM. CTD: carpal tunnel syndrome, the facts and myths. *Kans Med.* 1994;95:189–192.
8. Silverstein BA, Fine LJ, Stetson DS. Hand-wrist disorders among investment casting plant workers. *J Hand Surg [Am].* 1987;12:838–844.
9. Nathan PA, Keniston RC, Myers LD. Longitudinal study of median nerve sensory conduction in industry: relationship to age, gender, hand dominance, occupational hand use, and clinical diagnosis. *J Hand Surg [Am].* 1992;17:850–851.
10. Eversmann WW Jr. Reduction of cumulative trauma disorders by a comprehensive ergonomic program in a major commercial bakery. *ASSH News.* 1990;9:1–8.
11. Tanaka S, Seligman PJ, Halperin W. Use of worker's compensation claims data for surveillance of cumulative trauma disorders. *J Occup Med.* 1988;30:488–492.
12. Armstrong TJ, Chaffin DB. Carpal tunnel syndrome and selected personal attributes. *J Occup Med.* 1979;21:481–486.
13. Louis DS. A historical perspective of workers and the work place. In: Millender LH, Louis DS, Simmons BP, eds. *Occupational Disorders of the Upper Extremity.* New York: Churchill Livingstone; 1992:15–18.
14. Ireland DCR. Psychological and physical aspects of occupational arm. *J Hand Surg [Br].* 1988;13:5–10.
15. Hadler NM. Illness in the work place: the challenge of musculoskeletal symptoms. *J Hand Surg [Am].* 1985;10:451–456.
16. Hadler NM. Arm pain in the workplace: a small area analysis. *J Occup Med.* 1992; 34:113–119.
17. Silverstein BA. Cumulative trauma disorders of the upper extremity: a preventive strategy is needed. *J Occup Med.* 1991;33:642–644.
18. Kasdan ML. *Occupational Diseases.* Philadelphia: WB Saunders; 1993.
19. Melhorn JM. CTD injuries: an outcome study for work survivability. *J Workers Compensation.* 1996;5:18–30.
20. US Department of Health and Human Services. *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back.* Cincinnati, OH: National Institute for Occupational Safety and Health; 1997.
21. Gordon SL, Blair SJ, Fine LJ, eds, and the American Academy of Orthopaedic Surgeons. *Repetitive Motion Disorders of the Upper Extremity.* Rosemont, IL: American Academy of Orthopaedic Surgeons; 1995.
22. Matte TD, Fine LJ, Meinhardt TJ, Baker EL. Guidelines for medical screening in the workplace. *Occup Med.* 1990;5:439–456.
23. van Damme KV, Casteleyn L, Heseltine E, et al. Individual susceptibility and prevention of occupational diseases: scientific and ethical issues. *J Occup Environ Med.* 1995;37:91–99.
24. Katz JN, Larson MG, Fossel AH. A self-administrated hand symptom diagram for the diagnosis and epidemiologic study of carpal tunnel syndrome. *J Rheumatol.* 1990;17:1495–1498.
25. Katims JJ, Patil AS, Rendell M, et al. Current perception threshold screening for carpal tunnel syndrome. *Arch Environ Health.* 1991;46:207–212.
26. Franzblau A, Werner RA, Johnston EC, Torrey S. Evaluation of current perception threshold testing as a screening procedure for carpal tunnel syndrome among industrial workers. *J Occup Med.* 1994; 36:1015–1021.
27. Silverstein BA, Stetson DS, Keyserling WM, Fine LJ. Work-related musculoskeletal disorders: comparison of data sources for surveillance. *Am J Ind Med.* 1997;31:600–608.
27a. National Institute for Occupational Safety and Health. *NIOSH Criteria for a Recommended Standard: Occupational Exposure to Hand-Arm Vibration.* Cincinnati, OH: US Department of Health and Human Services; 1989.
27b. Centers for Disease Control. *Cumulative Trauma Disorders in the Workplace. Bibliography.* Cincinnati, OH: US Department of Health and Human Services; 1995.
28. American College of Occupational and Environment Medicine. Bureau of Labor Statistics for 1991. *ACOEM Conference.* 1992;92–11:1–9.
29. US Bureau of Labor Statistics. *Work Injuries and Illnesses by Selected Characteristics, 1992.* Washington, DC: US Department of Labor, US Government Printing Office; 1994.
30. Golaszewski T, Snow D, Lynch W, Yen L, Solomita D. A benefit-to-cost analysis of a work-site health promotion program. *J Occup Med.* 1992;34:1164–1172.
31. Rosenstock L. *Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders.* Washington, DC: US Government Printing Office; 1997.
32. Melhorn JM. Cumulative trauma disorders: how to assess the risks. *J Workers Compensation.* 1996;5:19–33.
33. Guyatt GH, Kirshner B, Jaeschke R. Measuring health status: what are the necessary measurement properties? *J Clin Epidemiol.* 1992;45:1341–1345.
34. Guyatt GH, Walter SD, Norman G. Measuring change over time: assessing the usefulness of evaluative instruments. *J Chronic Dis.* 1987;40:171–178.
35. Stewart AL, Hays RD, Ware JE Jr. The MOS short-form general health survey: reliability and validity in a patient population. *Med Care.* 1988;26:121–130.
36. Guyatt GH. A taxonomy of health status instruments. *J Rheumatol.* 1995;22: 1188–1190.
37. American Academy of Orthopaedic Surgeons. *DASH Disabilities of the Arm, Shoulder, and Hand Outcomes Data Collection Instrument.* Rosemont, IL: American Academy of Orthopaedic Surgeons; 1996:1–8.
38. Flatow EL, Miniaci A, Evans PJ, Simonian PT, Warren RF. Instability of the shoulder: complex problems and failed repairs—Part II. Failed repairs. *J Hand Surg [Am].* 1998;80:284–298.
39. Melhorn JM. A prospective study for upper-extremity cumulative trauma disorders of workers in aircraft manufacturing. *J Occup Environ Med.* 1996;38: 1264–1271.
40. Melhorn JM. Cumulative trauma disorders and repetitive strain injuries: the future. *Clin Orthop.* 1998;351:107–126.
41. US Bureau of Labor Statistics. *Occupational Injuries and Illnesses: Counts, Rates, and Characteristics, 1994.* Washington, DC: US Department of Labor, US Government Printing Office; 1997.
42. National Institute for Occupational Safety and Health. *Proposed National Strategies for the Prevention of Leading Work-Related Diseases and Injuries.* Washington, DC: US Department of Public Health; 1986:1–12.
43. National Institute for Occupational Safety and Health. *A Proposed National Strategy for the Prevention of Severe*

Occupational Traumatic Injuries. Washington, DC: US Government Printing Office; 1986.
44. Centers for Disease Control. Occupational disease surveillance: carpal tunnel syndrome [see comments]. *JAMA.* 1989; 262:886–889.
45. Deleted in proof.
46. Deleted in proof.
47. American College of Occupational and Environment Medicine. 1997 Labor Day checklist: ergonomic tips to prevent cumulative trauma. *ACOEM Conference.* 1997;9:1–2.
47a. Cohen AL, Gjessing CC, Fine LJ. *Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders.* [NIOSH Publication No. 97–117.] Cincinnati, OH: US Department of Health and Human Services, Public Health Services, Centers for Disease Control, National Institute for Occupational Safety and Health; 1997.
48. Pransky GS, Feuerstein M, Himmelstein JS, Katz JN, Vickers-Lahti M. Measuring functional outcomes in work-related upper extremity disorders: development and validation of the upper extremity function scale. *J Occup Environ Med.* 1997;39: 1195–1202.
49. Turchin DC, Beaton DE, Richards RR. Validity of observer-based aggregate scoring systems as descriptors of elbow pain, function, and disability. *J Bone Joint Surg [Am].* 1998;80:154–162.
50. Amadio PC. Outcomes measurements. *J Bone Joint Surg [Am].* 1993;75:1583–1584.
51. Amadio PC, Silverstein BA, Ilstrup DM, Schleck CD, Jensen LM. Outcome assessment for carpal tunnel surgery: the relative responsiveness of generic, arthritis-specific, disease-specific, and physical examination measures. *J Hand Surg [Am].* 1996;21:338–346.
52. Atroshi I, Johnsson R, Nouhan R, Crain G, McCabe SJ. Use of outcome instruments to compare workers' compensation and non-workers' compensation carpal tunnel syndrome. *J Hand Surg[Am].* 1997;22:882–888.
53. Atroshi I, Breidenbach WC, McCabe SJ. Assessment of the carpal tunnel outcome instrument in patients with nerve-compression symptoms. *J Hand Surg [Am].* 1997;22:222–227.
54. Baker EL, Melius JM, Millar JD. Surveillance of occupational illness and injury in the United States: current perspectives and future directions. *J Public Health Policy.* 1988;9:198–221.
55. Beaton DE, Richards RR. Measuring function of the shoulder. *J Bone Joint Surg [Am].* 1996;78:882–890.
56. Bergner M, Rothman ML. Health status measures: an overview and guide for selection. *Ann Rev Public Health.* 1987; 8:191–210.
57. Bessette L, Keller RB, Liang MH, Simmons BP, Fossel AH, Katz JN. Patients' preferences and their relationship with satisfaction following carpal tunnel release. *J Hand Surg [Am].* 1997;22:613–620.
58. Chung KC, Pillsbury MS, Hayward RA. Reliability and validity testing of the Michigan hand outcomes questionnaire. *Proceedings of the American Society for Surgery of the Hand Annual Meeting,* Denver, CO, September 7, 1977; 1997: 52–53.
59. Franzblau A, Salerno DF, Armstrong TJ, Werner RA. Test-retest reliability of an upper-extremity discomfort questionnaire in an industrial population. *Scand J Work Environ Health.* 1997;23:299–307.
60. Katz JN, Gelberman RH, Wright EA, Lew RA, Liang MH. Responsiveness of self-reported and objective measures of disease severity in carpal tunnel syndrome. *Mass Med Care.* 1994;32:1127–1133.
61. L'insalata JC, Warren RF, Cohen SB, Altchek DW, Peterson MGE. A self-administered questionnaire for assessment of symptoms and function of the shoulder. *J Bone Joint Surg [Am].* 1997; 79:738–748.
62. Laing MH, Fossel AH, Larson MG. Comparisons of five health status instruments for orthopedic evaluation. *Med Care.* 1990;28:632–642.
63. Levine DW, Simmons BP, Koris MJ, et al. A self-administered questionnaire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. *J Bone Joint Surg [Am].* 1996; 75:1585–1592.
64. Wright JG, Young NL. The patient-specific index: asking patients what they want. *J Bone Joint Surg [Am].* 1997;79: 974–983.
65. US Congress. *Occupational Safety and Health Act of 1970 29 USC 651.* Washington, DC: US Government Printing Office; 1970:1–12.
66. Equal Employment Opportunity Commission. *The Americans With Disabilities Act: Your Responsibilities as an Employer from the EEOC.* Topeka, KS: Kansas Department of Human Resources; 1997:1–36.
67. Equal Employment Opportunity Commission. EEOC issues final enforcement guidance on preemployment disability-related questions and medical examinations under the Americans With Disabilities Act. *EEOC News.* 1995;95–10:1–5.
68. Anfield RN. Americans With Disabilities Act of 1990: a primer of Title I provisions for occupational health care professionals. *J Occup Med.* 1992;34: 503–517.
69. Harber P, Hsu P, Fedoruk MJ. Personal risk assessment under the Americans With Disabilities Act: a decision analysis approach. *J Occup Med.* 1993;35:1000–1010.
70. Equal Employment Opportunity Commission. *Job Advertising and Pre-Employment Inquires Under the Age Discrimination in Employment Act.* Washington, DC: US Government Printing Office; 1989:1–12.
71. Equal Employment Opportunity Commission. *ADA Enforcement Guidance: Preemployment Disability-Related Questions and Medical Examinations.* Washington: US Printing Agency; 1998:1–26.

February 1999
Volume 41
Number 2

Journal of Occupational and Environmental Medicine