



# NIOSH Testimony to OSHA

## Comments on the Proposed Ergonomics Program

29 CFR Part 1910  
Docket No. S-777



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Public Health Service  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health





# NIOSH Testimony to OSHA

## Comments on the Proposed Ergonomics Program

29 CFR Part 1910  
Docket No. S-777

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Public Health Service  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health



## Ordering Information

To receive documents or more information about occupational safety and health topics, contact the National Institute for Occupational Safety and Health (NIOSH) at

NIOSH—Publications Dissemination  
4676 Columbia Parkway  
Cincinnati, OH 45226-1998

Telephone: 1-800-35-NIOSH (1-800-356-4674)  
Fax: 513-533-8573  
E-mail: [Pubstaft@cdc.gov](mailto:Pubstaft@cdc.gov)

or visit the NIOSH Web site at [www.cdc.gov/niosh](http://www.cdc.gov/niosh)

*This document is in the public domain and may be freely copied or reprinted.*

---

**Disclaimer: Mention of any company or product does not constitute endorsement by NIOSH.**

**Note to the Reader:** This publication incorporates minor changes in wording for grammar and consistency that were identified in the written testimony to the OSHA docket.

DHHS (NIOSH) Publication No. 2001-108

November 2000

---

## Introduction

**T**he National Institute for Occupational Safety and Health (NIOSH) is pleased to provide testimony in support of the Occupational Safety and Health Administration (OSHA) proposed rule on ergonomics [64 FR 65768]. NIOSH supports this ergonomics program standard addressing the significant risk of work-related musculoskeletal disorders (MSDs) in general industry. The preamble to the proposed rule provides compelling data indicating that work-related MSDs are a very large problem for the U.S. economy. The importance of work-related MSDs is also reflected in NIOSH experience in intramural and extramural research (funded internally and externally) and the health hazard evaluation program (all health hazard evaluation reports are available from the National Technical Information Service). NIOSH is conducting ergonomic research and responding to ergonomic concerns of employers and workers across a wide range of U.S. industries and occupations. Also, through the National Occupational Research Agenda (NORA), NIOSH has identified a strong consensus for work-related MSDs as a top research priority among our diverse stakeholders—a broad range of industry, labor, academia, and government groups.

During our 29 years of existence, NIOSH has amassed research and experience that establishes a clear relationship between specific workplace hazards and specific MSDs. We believe, therefore, that there is a large and more than adequate science base for rulemaking. What OSHA has proposed—a standard that addresses hazard identification, hazard control, training, MSD management, and program evaluation—is strongly supported by this science base and our professional experience. The proposed ergonomics rule includes scientifically valid and feasible requirements, which, if widely implemented, will reduce the economic and human burden of one of the largest occupational health problems in the U.S.

---

*The preamble to the proposed rule provides compelling data indicating that work-related MSDs are a very large problem for the U.S. economy.*

---

---

## Musculoskeletal Disorders

---

*MSDs represent a wide range of disorders, which if not treated can often become severe, chronic, and debilitating. OSHA has appropriately focused on the MSDs that are the most serious in terms of their adverse consequences.*

---

This proposed standard addresses the significant risk of work-related MSDs confronting employees in various jobs in general industry workplaces. MSDs include a group of conditions that involve the muscles, tendons, joints, nerves, ligaments, cartilage, and supporting structures (such as intervertebral discs). Some MSDs have specific diagnostic criteria and clear pathological mechanisms (e.g., carpal tunnel syndrome). Others are defined primarily by the location of pain and have a more variable or less clearly defined pathophysiology (e.g., back disorders). MSDs represent a wide range of disorders, which if not treated can often become severe, chronic, and debilitating. OSHA has appropriately focused on the MSDs that are the most serious in terms of their adverse consequences, i.e., those that involve lost work time, restricted work activity, and medical treatment. Our research has consistently found that the rates of these disorders are higher in heavily exposed workers, such as those in meatpacking, grocery-store checking, newspaper editing, and warehousing, compared to those with lower exposure.

## Magnitude of the Problem

The only source of national information on the magnitude of work-related MSDs is the Annual Survey of Occupational Injuries and Illnesses conducted by the Department of Labor's Bureau of Labor Statistics (BLS). BLS has conducted this annual survey for more than 25 years, and it has provided information on the annual cases of occupational injury or illness that required medical treatment, restricted work activity, or days away from work, for each year since 1972.

---

The preamble includes an overall assessment of risk based on an analysis of cases of MSD-like injuries routinely reported to the BLS. In this analysis, OSHA identified cause-specific injuries and illnesses in the BLS data that included work-related MSDs, finally selecting six categories:

- sprains, strains, and tears
- back pain, hurt back
- soreness, hurt, except back
- carpal tunnel syndrome
- hernia
- musculoskeletal and connective systems diseases and disorders.

Only those injuries and illnesses attributed to overexertion, repetition, or bodily reaction were included in the analysis, thus excluding those caused by acute events. NIOSH concurs with this use of BLS data and the analytical approach used by OSHA in the preliminary risk assessment, and with the preliminary results detailed on pages 65931–65943 of the preamble.

The use of BLS records has the advantage of providing comprehensive coverage of industrial activities with relatively accurate estimates of the populations involved and numbers of cases reported. There are several limitations, however, in the use of BLS records, and these are appropriately discussed in the risk assessment section of the preamble: reported cases (a) are only those that employers have agreed are work-related, (b) are only those that were serious enough to involve at least one day away from work, (c) do not include other work-related MSD cases that never come to the attention of the employer, and (d) do not account for extended or permanent disability that results in employee termination.

---

*The surveillance data presented by OSHA in the preamble and NIOSH's analysis of surveillance data reach the same conclusion—work-related MSDs are one of the largest health problems in the United States.*

---

---

Furthermore, some workers with MSD episodes that represent lost workday cases are reassigned to minimal work activities in order to avoid recording of lost work-days. OSHA has concluded that these limitations result in the underestimation of MSD rates by at least a factor of two. NIOSH agrees that there is a substantial likelihood of underreporting in the BLS system (see Underreporting, page 24), and that the BLS estimates represent a lower bound of the true risks or burdens of work-related MSDs. That is, the true levels of MSD incidence are greater than indicated by the BLS estimates. The surveillance data presented by OSHA in the preamble and NIOSH's analysis of surveillance data reach the same conclusion—work-related MSDs are one of the largest health problems in the United States. These disorders are not only common, but they are often severe, persistent, and disabling. For example, in 1996, median days away from work were highest for carpal tunnel syndrome (25), even when compared to fractures (21) and amputations (18).

Data obtained from NIOSH Health Hazard Evaluations have also documented the serious nature and disability from MSDs. These data have been collected in a variety of industries and occupations from interviews, survey instruments, nursing logs, medical records, and OSHA 200 logs (see discussions of HHEs on pages 24–25).

In addition to the surveillance studies from BLS, workers' compensation data, and other epidemiological studies presented in the preamble, there are a large number of epidemiological studies involving MSDs of the neck, upper limb, hip, and knee, all of which provide evidence that a variety of work-related MSDs in workers with high intensity exposure sometimes lead to prolonged impairment, disability, and early retirement. For example, an epidemiological study by Ålund et al. [1994] found neck impairment in metal grinders resulting in disability or change in jobs. The significantly increased impairment in the grinder workers was attributed

---

to exposure to extremely heavy static loads and indirect impacts to the neck/shoulder region. Follow up showed that all had persistent neck pain, stiffness, and widespread parasthesias. Vertebral foraminal encroachment was significantly worsened both from spondylosis and spondyloarthritis. Videman et al. [1990] found that disability from back pain was directly related to occupational physical loading after controlling for the effects of other covariates, with a zero percent rate in the sedentary group, and 19% rate in the heavy group.

A recent NIOSH-sponsored study by Dillon [1999] found that persons with work-related MSDs reported high levels of impairment in Activities of Daily Living scales. However, only 25% of those injuries had triggered an ergonomic intervention (Summary Grant Report, NIOSH R01 CCR112118). Several other studies reach similar conclusions regarding the severity or disabling nature of the disorders: Aarås [1994], Bergenudd and Nilsson [1988], Chard et al. [1988], Cooper et al. [1998], Feuerstein et al. [1998], Kilbom [1994], Kvarnström [1983], and Viikari-Juntura et al. [1994]. In a case-referent study conducted by Vingård et al. [1992], workers with disability from hip osteoarthritis were seen in a diverse set of occupations and industries. This study compared the last 20 years of work for those with high exposure to those with low exposure; the relative risk for disability pension due to hip osteoarthritis was 12.4. After at least 10 years of work, the occupations with the highest risk of hip osteoarthritis were farmers and forestry workers (RR=13.8), followed by construction workers (RR=5.3). In addition to documenting the disability associated with MSDs of the hip and the role of work factors, this study demonstrates the high risk of these serious disorders in other industries not covered by this standard. Overall, these studies demonstrate the severity of the disability that can occur with these disorders. The disturbances in functional capacity among disabled workers have been documented to result in a considerable increase in

---

*. . . there are a large number of epidemiological studies involving MSDs of the neck, upper limb, hip, and knee, all of which provide evidence that a variety of work-related MSDs in workers with high intensity exposure sometimes lead to prolonged impairment, disability, and early retirement.*

---

---

expense for treatment, medication, and other consequences of illness and injury [Kemmlert et al. 1993; Feuerstein et al. 1998; Dillon 1999]. Several of these studies suggest there are ways to successfully treat workers with disabling MSDs; however, no treatment or intervention program insures total recovery in all disabled workers.

## Literature Reviews

### NIOSH 1997 Critical Review of the Epidemiologic Literature

In 1997, NIOSH published a review of the epidemiologic evidence of the relationship between selected MSDs of the upper extremity and the low back and exposure to physical factors at work in *Musculoskeletal Disorders and Workplace Factors* [NIOSH 1997a]. OSHA used the document as the basis for their review of the epidemiologic evidence. NIOSH conducted the most comprehensive review of the occupational epidemiological literature on MSDs that exists to date. A team of NIOSH researchers systematically reviewed and analyzed more than 2,000 occupational epidemiology studies and ended up focusing on the best 600—conducted in a variety of workplaces ranging from meat packing plants to offices, garment factories to aluminum mills.

The goal of epidemiologic studies is to identify factors that are associated (positively or negatively) with the development or recurrence of adverse medical conditions. The NIOSH evaluation and summary of the epidemiologic evidence focused chiefly on disorders that affect the neck and the upper extremities, including tension-neck syndrome, shoulder tendinitis, epicondylitis, carpal tunnel syndrome, hand-wrist tendinitis, and hand-arm vibration syndrome, which are the most extensively studied disorders in the

---

*A team of NIOSH researchers systematically reviewed and analyzed more than 2,000 occupational epidemiology studies and ended up focusing on the best 600—conducted in a variety of workplaces ranging from meat packing plants to offices, garment factories to aluminum mills.*

---

---

epidemiologic literature. The document also reviewed studies that dealt with work-related back pain and exposure to physical factors and work-related MSDs.

No single epidemiologic study will fulfill all criteria to answer the question of causality. However, results from epidemiologic studies can contribute to the evidence of causality in the relationship between workplace risk factors and MSDs. The framework for evaluating evidence for causality in the NIOSH review included strength of association, consistency, temporality, exposure-response relationship, and coherence of evidence. This is the established framework that is used to evaluate all types of medical/epidemiologic studies.

The NIOSH document underwent a particularly comprehensive review, over and beyond the rigorous review that is normally carried out for all NIOSH documents. Each NIOSH document is scrutinized for scientific accuracy, reliability, and validity through an established review process. This document was also peer-reviewed by 24 reviewers outside of NIOSH, including occupational health and safety specialists, such as medical scientists, epidemiologists, consultants, and experts from private industry and labor.

On the basis of this review, NIOSH concluded that a substantial body of credible epidemiologic research provides strong evidence of an association between MSDs and certain work-related physical factors when there are high levels of exposure, particularly with exposure to more than one physical factor (e.g., repetition and forceful exertion). The factors used as a basis for OSHA's proposed ergonomics rule were clearly identified in the NIOSH review as having sufficient evidence for their role in contributing to work-related MSDs. The strength of the associations reported in

---

*On the basis of this review, NIOSH concluded that a substantial body of credible epidemiologic research provides strong evidence of an association between MSDs and certain work-related physical factors when there are high levels of exposure, particularly with exposure to more than one physical factor.*

---

---

the various studies for specific risk factors, after adjustments for other factors, varies from insufficient to strong (Table 1).

---

*In addition to the epidemiological literature, there is clinical, laboratory, and psychophysical data that provide significant and independent contributions to assessing the causal relationship between work and MSDs.*

---

The consistently positive findings from a large number of cross-sectional studies, strengthened by the available prospective studies, provides strong evidence for an increased risk of work-related MSDs for all but shoulder MSDs. This evidence can be seen from the strength of the associations, lack of ambiguity in temporal relationships from the prospective studies, the consistency of the results in these studies, and adequate control or adjustment for likely confounders. For all of the MSDs studied, there is sufficient epidemiologic evidence for a causal relationship with a combination of job risk factors and, in some cases, with individual job risk factors. In addition to the epidemiological literature, there is clinical, laboratory, and psychophysical data that provide significant and independent contributions to assessing the causal relationship between work and MSDs. The laboratory studies of shoulder posture show that increased activities, subjective fatigue, and electromyographic changes all contribute to the causal association between prolonged overhead work and shoulder disorders [Keyserling forthcoming]. Psychophysical studies conducted by NIOSH investigators [Putz-Anderson and Galinsky 1993; Rosa et al. 1998] provide strong support for the interactive role of force and repetition as significant causal factors associated with shoulder pain severe enough to interfere with work. In a series of NIOSH experiments, some conducted for 8 to 12 hrs, 88 assembly workers performed an overhead assembly task in a controlled environment. All workers experienced significant shoulder muscle fatigue caused by repetitive movement and force. Komoike et al. [1975]; Lascelles et al. [1977]; DeLacerda [1982]; Matsen and Kirby [1982], and Neviasser [1983] also found an association between chronic muscle fatigue from repetitive movement and the onset of MSDs. Similarly, quantitative modeling of the acromion

**Table 1. Summary of evidence for causal relationship between physical work factors and MSDs [NIOSH 1997a]**

Body part and risk factor	Strong evidence (+++)	Evidence (++)	Insufficient evidence (+/0)	Evidence of no effect (-)
Neck and neck/shoulder:				
Repetition		✓		
Force		✓		
Posture	✓			
Vibration			✓	
Shoulder:				
Repetition		✓		
Force			✓	
Posture		✓		
Vibration			✓	
Elbow:				
Repetition			✓	
Force		✓		
Posture			✓	
Combination	✓			
Hand/wrist and Carpal tunnel syndrome:				
Repetition		✓		
Force		✓		
Posture			✓	
Vibration		✓		
Combination	✓			

(Continued)

**Table 1 (Continued). Summary of evidence for causal relationship between physical work factors and MSDs [NIOSH 1997a]**

Body part and risk factor	Strong evidence (+++)	Evidence (++)	Insufficient evidence (+/0)	Evidence of no effect (-)
Tendinitis:				
Repetition		✓		
Force		✓		
Posture		✓		
Combination	✓			
Hand-arm vibration syndrome:				
Vibration	✓			
Back:				
Lifting/forceful movement	✓			
Awkward posture		✓		
Heavy physical work		✓		
Whole body vibration	✓			
Static work posture			✓	

---

supraspinatus interaction helps explain the epidemiological link between shoulder posture and disorders [Kai-Nan 1995].

### **Low Back Disorders**

For low back disorders, NIOSH found strong evidence of an association with lifting and forceful movements. Those studies using objective measures to examine specific lifting activities generally demonstrated risk estimates above 3.0 and found dose/response relationships between exposures and low back pain. These relationships are consistent with biomechanical and other laboratory evidence regarding the effects of lifting and dynamic motion on back tissues. NIOSH also found that bending and twisting in awkward postures and whole body vibration were contributing factors to low back pain.

### **Disorders of the Neck and Shoulders**

The literature showed that working groups are at increased risk for neck/shoulder disorders when they have jobs with extreme working postures (such as working with the hands above the head or arms above shoulder level) or prolonged static loads (such as working overhead holding tools). These studies had consistently high odds ratios. Combinations of highly repetitive and forceful work involving the arm and hand also affect the shoulder and neck regions. These studies provided sufficient evidence for work-relatedness as well.

### **Disorders of the Hand, Wrist, and Elbow**

Combined work factors of forceful and repetitive use of the hand, wrist, and elbow are associated with carpal tunnel syndrome, tendonitis, and epicondylitis. There is substantial evidence that as the intensity and duration of exposure to vibrating tools increase, the risk of developing hand-arm vibration syndrome increases. There is

---

also evidence that an increase in symptom severity is associated with increased exposure.

### The National Academy of Sciences Study

In August 1998, the National Academy of Sciences (NAS) assembled a panel of epidemiologists and medical researchers to examine the scientific literature relevant to work-related MSDs of the lower back, neck, and upper extremities. In their report, published in 1999 [NAS 1999], the NAS concluded that the “associations identified by NIOSH as having strong evidence were well supported by competent research on heavily exposed populations.” In addition, the NAS found that the “NIOSH criteria for study inclusion in the summary were, in general, adequate and that the positive relationship of work and MSDs is clear, especially when restricting the focus to studies with the highest levels of exposure and sharpest contrast in exposure.” Certain limitations in the data in the NIOSH review, due to the large number of cross-sectional studies, the use of self-reported data, and healthy worker bias, were noted in the NAS document and judged to not detract from the overall conclusions of the NIOSH reviews.

---

*. . . the NAS concluded that the “associations identified by NIOSH as having strong evidence were well supported by competent research on heavily exposed populations.” In addition, the NAS found that the “NIOSH criteria for study inclusion in the summary were, in general, adequate and that the positive relationship of work and MSDs is clear, especially when restricting the focus to studies with the highest levels of exposure and sharpest contrast in exposure.”*

---

Finally, the NAS concluded that there is a strong biological plausibility to the relationship between the incidence of MSDs and the causative exposure factors in high-exposure occupational settings. This conclusion is similar to OSHA’s conclusion in the preamble that the scientific assessment of the causal relationship between specific physical factors in the workplace and MSDs is based on laboratory and epidemiological studies as well as modeling. All of these bodies of scientific information are in fundamental agreement with each other. The NAS is currently carrying out a 2-year study that will build on the work of the 1999 NAS report.

---

## OSHA's Examination of the Scientific Literature

OSHA builds on the evidence of the association between workplace risk factors and the development of MSDs provided in the 1997 NIOSH review and strengthens the evidence with the supporting data provided by laboratory and psychophysical studies. In addition to the evidence for the upper extremities and back, the OSHA review includes some of the available evidence for the lower extremities and the hip. NIOSH believes that OSHA's assessment is appropriate, based on the epidemiological studies of the hip and knee MSDs. These studies provide additional support for the relationship of long-term exposure to high levels of physical stresses and significant osteoarthritis disorders of the hip and knee. Studies that examine the relationship between intensity and duration of exposure to workplace risk factors and MSD prevalence are covered in greater detail due to the weight of evidence of exposure-response studies toward determining a causal relationship.

NIOSH concurs with OSHA's conclusion from the discussion of the evidence from the epidemiologic studies. OSHA concludes that "In sum, although not all the epidemiological studies reviewed demonstrate significant associations, the overwhelming majority justify a conclusion that the risk factors noted in this section, with effects adjusted by the four modifying factors, cause or exacerbate work-related MSDs." Thus, the data justify the conclusion that these factors cause or exacerbate work-related MSDs.

The epidemiologic evidence for a causal relationship between workplace exposure and MSDs is strengthened by the laboratory study findings on pages 65873–65882 of the preamble, which provide plausible and demonstrable biological mechanisms. OSHA's review of the laboratory studies substantially strengthens the scientific evidence for the relationship between workplace physical

---

*OSHA builds on the evidence of the association between workplace risk factors and the development of MSDs provided in the 1997 NIOSH review and strengthens the evidence with the supporting data provided by laboratory and psychophysical studies.*

---

---

risk factors and the occurrence and exacerbation of work-related MSDs. These studies reinforce the conclusions in the preamble on the epidemiological literature. The psychophysical evidence on pages 65873–65881 further strengthens the conclusion by linking subjective reports of fatigue, discomfort, and exertion to measurable disease in industry.

## Analysis of Ergonomic Program Effectiveness and Technological Feasibility

---

*NIOSH agrees with OSHA's assessment that there are numerous companies that have reported success in using ergonomic programs as a cost-effective way to prevent or reduce work-related MSDs and reduce lost time by workers with MSDs.*

---

NIOSH agrees with OSHA's assessment that there are numerous companies that have reported success in using ergonomic programs as a cost-effective way to prevent or reduce work-related MSDs and reduce lost time by workers with MSDs. Some of these companies also report increases in productivity and workplace morale. The studies—in part summarized in OSHA's preamble, and reviewed by the NAS panel—illustrate that interventions, including redesign of tools, machines, and work stations, can reduce workplace hazards and the resulting MSDs. Examples of additional effective ergonomic interventions studies are found in Grant and Habes [1995] and the NIOSH publication *Elements of Ergonomics Programs* [NIOSH 1997b]. An article by Kilbom [1988], which reviewed 16 intervention programs for work-related neck and upper limb disorders, found that the most effective approaches emphasized worker training and education and the active contribution from management and employers. Knibbe and Friele [1999] recently published the results of a study in which they implemented patient hoists and reduced manual handling in nurses. NIOSH has conducted or sponsored several studies that add further support for ergonomic program approaches. Examples of these include:

- 
- **An ergonomics team** of manager and employees working for an air conditioner appliance manufacturer developed and identified new tools to assist in repetitive tasks. As a result, the number of new carpal tunnel cases was reduced from four to one over a 2-year period, and service call rates for electrical wiring faults were reduced 32%, saving \$39,800. The company saved \$84,000 per year in decreased medical expenses and reduced service call expenses over this period of time [Villafior et al. 1994].
  - **Fifty workers** involved in hand-sanding typewriter housings experienced 185 lost work days and seven carpal tunnel surgeries over a 2-year period. Engineering controls—a \$14,000 expenditure—consisted of redesigning handles on tools to reduce grip forces and installing a rotating fixture to hold the housings, which reduced exposure to repetitive motions and awkward postures. New carpal tunnel syndrome cases decreased from seven to zero over a 2-year period. Worker turnover, which had been 100% about every 3 weeks prior to the ergonomic intervention, was also reduced [Habe 1996].
  - **Engineering controls** made in the beverage delivery industry, which included external handles on containers, multilevel shelving units on trucks, and counterbalanced delivery hand trucks, reduced worker reports of fatigue, multiple handling of beverage cases, and awkward postures during handling of beverages. The approaches used in this study have served as a model for introducing ergonomic interventions in the beverage delivery industry [McGlothlin and Hales 1996].
  - **At eight nursing home facilities**, “zero-lift programs” were implemented using employee-management advisory teams, replacing manual lifting and transferring of patients with usable hoists and patient transfer assistive devices. Injury statistics were compared pre- and post-intervention for

---

a period ranging from 3 to 5 years: the number of injuries from patient transfers decreased by 62%, lost workdays by 86%, restricted workdays by 64%, and workers' compensation costs by 84%. This program also produced many intangible benefits including improvements in patient comfort and safety during transfers and patient care [Garg 1999].

The effectiveness of ergonomics programs was a resounding message echoed by labor, industry, business, universities, health care, and professional societies at two conferences co-organized by NIOSH and OSHA to stimulate an exchange of information about preventing work-related MSDs (held January 1997 in Chicago, Illinois, and March 1999 in Houston, Texas, co-sponsored with the Institute of Industrial Engineers [IIE 1999]). The conferences, attended by over 1,700 people, featured workshops and presentations by industry, labor, and government representatives sharing their successful ergonomics programs and how they have reduced lost work time and cut costs due to injuries and illnesses in a variety of industries and workplaces (including manufacturing, service, construction, health care, textiles, office, maritime, mining, and small businesses). Examples of practical and cost-effective solutions from the Ergonomics: Effective Workplace Practices and Programs Conference in Chicago, 1997, are presented below. The full text of the Chicago Conference can be found on the NIOSH Web site: <http://www.cdc.gov/niosh/ec3mfg2.html> [NIOSH 1997c].

---

*The effectiveness of ergonomics programs was a resounding message echoed by labor, industry, business, universities, health care, and professional societies at two conferences co-organized by NIOSH and OSHA to stimulate an exchange of information about preventing work-related MSDs.*

---

- **Ford Motor Company** reported major productivity and quality improvements, along with reductions in injuries as a result of their joint ergonomics programs with the United Auto Workers.
- **ConAgra** not only instituted a participatory program, but also designed a red meat cutting machine that automated part of the cutting job. The new machine reduced exposure,

---

increased quality of the product, and was actually paid for by not having to recut the meat to specifications as was previously required.

- **Lunt Silversmiths** experienced a drop in total lost workdays from more than 300 to less than 50 after implementation of an effective ergonomics program. Workers' compensation costs were reduced from \$192,500 to \$27,100. The money saved was greater than the cost of the ergonomic improvements.
- **PPG Industries**, a coatings and resins manufacturer, instituted an ergonomics program that included job analysis, hazard prevention and control, medical management, and training and education. Prior to the institution of their program, they experienced 2,500 workers' compensation claims a year. Following the institution of the ergonomics program, the number of claims was reduced to 1,000.

In summary, NIOSH believes that the evidence in the scientific literature showing the success of an ergonomics program approach to workplace hazards is strong. Likewise, NIOSH's experience in evaluating the risks of MSDs in a variety of workplaces and our review of information from a variety of sizes of industries has generally shown that using ergonomic programs is an effective way to prevent or reduce work-related MSDs. We agree with the conclusions of OSHA's preamble review of the ergonomic intervention case studies. This review provides evidence that interventions can result in substantial reductions in hazardous exposures.

Both OSHA and NIOSH have strongly supported the traditional and widely accepted three-tier hierarchy of controls—engineering controls, administrative controls, and personal protective equipment—for controlling workplace hazards. The 1997 NIOSH publication *Elements of Ergonomics Programs* recommends that the preferred approach to prevention and control of MSDs is to design

---

or redesign the job, including (1) the workstation layout, (2) selection and use of the tools, and (3) work methods to take account of the capabilities and limitations of the workforce [NIOSH 1997b]. This document illustrates NIOSH efforts to advise companies about engineering controls to reduce MSDs and describes more than 20 examples of engineering controls from the scientific and technical literature. Although engineering controls are preferred, administrative controls can be helpful as temporary measures until engineering controls can be implemented, or when engineering controls are not technically feasible. One limitation of administrative controls is that they do not eliminate hazards and, therefore, their success depends on their maintenance as long as the hazardous exposure potential persists. The evidence that braces, wrist splints, back belts, and similar devices are effective in preventing MSDs is inconclusive. Furthermore, we agree with OSHA's position that PPE only be used to supplement engineering, work practice, and administrative controls.

## Overview of Support for the Standard

NIOSH strongly supports OSHA's regulatory initiative to reduce the significant risk of work-related MSDs in general industry workplaces. We agree that a mandatory standard is necessary to reduce the risk for workers in manufacturing jobs, manual handling jobs, and other jobs with MSDs, particularly those workplaces currently without effective ergonomics programs. We are committed to working with OSHA in the future to address the significant risk of work-related MSDs in high-risk, non-general industry sectors of the economy, such as construction, agriculture, and the maritime industry. NIOSH's review of the evidence in the preamble on significance of risk also concurs with OSHA's analysis of the significance of the risk, and the conclusion that workers in these settings are at significant risk of acquiring work-related MSDs that

---

constitute a material impairment of health. We commend OSHA for proposing a flexible standard. Flexibility is important because of the diverse range of employers, workplace conditions, and tasks covered by the scope of the standard.

NIOSH agrees with the proposed requirement that employers implement an ergonomics program that contains the six core program elements specified in the proposed rule (Section 1910.905) and recommended in the 1997 NIOSH publication *Elements of Ergonomics Programs* [NIOSH 1997b]. This is based on the extensive practical experience accumulated by NIOSH in conducting investigations in actual workplace settings, providing technical assistance to employers and workers, and evaluating the scientific and technical literature. Implementation of all of these core elements will allow employers to appropriately identify and systematically control or eliminate MSD hazards.

NIOSH also concurs with the use of an OSHA recordable MSD as one of the initial triggers for coverage by the standard. The use of a covered MSD will allow employers to use their existing recordkeeping system. NIOSH's experience from field studies and HHEs has shown that employers are familiar with this recordkeeping system. NIOSH's experience also demonstrates that the use of one recordable MSD as the initial trigger, rather than multiple MSDs, is important because jobs with a small number of employees may not otherwise be addressed. Not acting on a single initial MSD may discourage other coworkers from reporting symptoms. Because early intervention is important to avoid progression of MSDs towards impairment, every covered MSD should trigger an evaluation.

We also agree that the Quick Fix option (Section 1910.909) is an innovative and useful alternative to job hazard analysis and control for problem jobs where the hazard and solution are easily

---

pinpointed, and implementation can be quickly achieved. It is helpful for employers who have an isolated problem and sometimes may not need an extensive program.

---

*It is appropriate that general industry employers whose employees perform manual handling and manufacturing jobs implement the first two program elements—management leadership and employee participation and hazard information and reporting (Sections 1910.911–1910.916), even before an injury is reported.*

---

It is appropriate that general industry employers whose employees perform manual handling and manufacturing jobs implement the first two program elements—management leadership and employee participation and hazard information and reporting (Sections 1910.911–1910.916), even before an injury is reported. These two preventive steps are needed because 60% of the BLS-identified MSDs occur in manual handling and manufacturing jobs. This will ensure that employers and employees are aware of MSD hazards and will establish a basic surveillance system for MSDs. Management leadership and employee participation are equally important for program success, as noted by OSHA in the preamble. NIOSH’s general experience and the case studies in NIOSH’s publication *Participatory Ergonomic Interventions in Meatpacking Plants* strongly suggests that the failure to have strong management leadership and effective employee involvement often prevents success in ergonomic programs [NIOSH 1994]. It is important that employees report MSD signs and symptoms, and that they do so as early as possible to prevent the progression of MSDs and reduce the development of long lasting disability and substantial impairment, injury, or illness. The proposed reporting system represents an appropriately sensitive approach to secondary prevention of MSDs.

Job hazard analysis and control (Sections 1910.917–1910.922) is the central element of OSHA’s ergonomics program. In order to eliminate or reduce MSD hazards, ergonomic risk factors must be first identified. NIOSH believes that an essential part of this hazard analysis includes discussions with the employee and observation of the job as proposed by OSHA, including identification of the physical work activities and ergonomic risk factors listed in

---

Section 1910.918(c) that might contribute to the MSD hazard. We also concur that the evaluation of identified risk factors must include the duration, frequency, and magnitude of exposure to determine whether an MSD is likely to occur. Continued discussions with employees to identify controls, as proposed by OSHA, recognizes that the individuals doing a job are often the best source of information and will facilitate changes to the job when they become necessary.

We agree that control of MSD hazards can be appropriately achieved through the use of the incremental hazard abatement process proposed in Section 1910.922, allowing employers to implement controls in increments in order to understand which solutions work among all potentially necessary controls and to implement only those controls that are necessary. We believe that it is essential and standard practice in many existing ergonomic programs for the routine reassessment of jobs in which initial control measures fail to reduce the severity or occurrence of MSDs. This reassessment should trigger implementation of additional feasible control measures. This process also allows employers to select the best solutions to eliminate or materially reduce the MSD hazard most efficiently and to periodically check for new controls capable of further material reduction of the hazard.

OSHA has appropriately included a requirement for training (Sections 1910.923–1910.928) in the proposed standard, allowing for training to occur on an as-needed basis, but at least every 3 years; identifying the individuals to be trained and the subjects to be covered; and permitting employers to adjust training to fit their particular needs. NIOSH believes that in order to be most effective, the standard must include requirements for training geared to the specific tasks in that workplace. The overall goal of ergonomics training is to enable managers, supervisors, and employees to identify aspects of their job tasks that may increase a worker's risk of

---

*Our experience shows that sufficient and appropriate training, ensuring that managers, supervisors, and employees are well informed about all aspects of a good ergonomics program often allows the responsible individuals to run the program without outside expert help.*

---

---

*NIOSH agrees with OSHA's assessment that MSD management (Sections 1910.929–1910.935) is an essential element of an effective ergonomics program.*

---

---

developing an MSD, recognize the signs and symptoms of disorders, and participate in the development of strategies to control and prevent them. We believe that training should be mandatory for those who have responsibility for the establishment and management of the ergonomics program. Training objectives are not intended to prepare workers, supervisors, or managers to diagnose or treat MSDs. Rather, the purpose is to instill an understanding of what type of health problem may be work-related and when to refer employees for medical evaluation. Objectives should include recommended ways to control workplace hazards based on job analyses and recommendations from employees, management, and other affected and interested parties. Our experience shows that sufficient and appropriate training ensuring that managers, supervisors, and employees are well informed about all aspects of a good ergonomics program often allows the responsible individuals to run the program without outside expert help.

NIOSH agrees with OSHA's assessment that MSD management (Sections 1910.929–1910.935) is an essential element of an effective ergonomics program. As noted by OSHA in the preamble, MSD management emphasizes early detection and intervention with regards to MSDs, which will reduce their severity and number, reduce the need for surgery, and reduce MSDs through prevention of future problems. Of particular importance to the issue of early reporting and treatment is the provision for work restriction protection (WRP) as part of the proposed MSD management requirement. WRP contributes to the protection of health of both employees' with MSDs and other employees in the same job because it removes a major barrier to employees with MSDs from reporting his/her condition to the employer. A major barrier is the injured employee's fear of adverse consequences of reporting their condition. The protection of both employees with MSDs and their fellow employees on the same job critically depends on their willingness to promptly report the MSDs.

---

With regard to the scope of the standard (Section 1910.901), we believe that OSHA has taken an appropriate first step towards reducing MSD hazards and illnesses in the workplace by limiting the scope of the proposed rule to general industry. The BLS Annual Survey and some of the research and surveillance activities conducted by NIOSH suggest that construction, agriculture, and maritime industries also have high rates of MSDs. NIOSH is prepared to provide assistance to OSHA in developing information for future proposals covering these sectors.

In summary, our support for this proposal is based on data demonstrating the magnitude of work-related MSDs, the relationship between MSDs and work factors, and the effectiveness of ergonomics programs like OSHA's in reducing MSDs. Additional comments on specific issues noted in the *Federal Register* notice are included below.

## Issues on Which OSHA Seeks Comment

### Scope of the Standard

The proposed OSHA standard applies to three types of jobs within general industry: (1) manufacturing production jobs, (2) manual handling jobs requiring forceful exertions, and (3) jobs where "OSHA recordable" MSDs meeting the screening criteria are reported. We commend OSHA for taking this important first step in extending ergonomic protection to the hundreds of thousands of workers in these general industry jobs. As noted in the preamble, the scientific evidence supporting the need for such protection is substantial and strong.

OSHA requests comments and information about whether firms engaged in agriculture, construction, and maritime operations

---

*We agree with OSHA that employees in agriculture, construction, and maritime industries face significant risk of harm due to exposure to MSD hazards. As discussed in the preamble, 10% of all lost-work-day MSDs occurred in these three industry sectors in 1996.*

---

---

should be included in this proposed ergonomics standard. OSHA's decision to limit the scope is explained in the preamble (pages 65786–65788), and we concur with the reasons for limiting the proposed rule. We agree with OSHA that employees in agriculture, construction, and maritime industries face significant risk of harm due to exposure to MSD hazards. As discussed in the preamble, 10% of all lost-work-day MSDs occurred in these three industry sectors in 1996. As a result, the current proposed standard leaves a large number of employees in these excluded industries at significant risk of incurring debilitating injuries. We agree with OSHA that the information gathered in the rulemaking process will support the promulgation of an ergonomic standard in these high risk industries. NIOSH is committed to working with OSHA to address these industries as well.

### **Underreporting**

While it is widely accepted that occupational disease is underestimated in the United States, OSHA is requesting specific information on the underreporting or overreporting of MSDs. The OSHA 200 Logs are the major data source used by BLS to determine the extent of occupational disease in the United States. BLS data underestimate the true magnitude of the problem for two reasons: (1) approximately one-third of industries are not included in the BLS annual survey, and (2) underreporting of the true number of work-related health problems on the OSHA 200 logs occurs [Pollack and Keimig 1987; U.S. House of Representatives 1984].

In addition, several NIOSH health hazard evaluations (HHEs) indicate underreporting of work-related MSDs as reported by OSHA 200 logs. These HHEs compared the OSHA 200 logs with work-related MSDs ascertained via the following mechanisms: (1) confidential medical interviews; (2) review of employee medical records of private health care providers; (3) health surveys

---

utilizing standardized MSD symptom questionnaires; (4) health surveys defining cases as those with work-related symptoms and positive physical findings conducted by physicians performing physical examinations targeted to the musculoskeletal systems. We have no reason to believe that these HHEs are not representative of the likely widespread underreporting of work-related MSDs. NIOSH suggests that OSHA include these HHEs, which are summarized in Table 2 below, in the preamble in Table VII-2, Summary of Underreporting Studies.

In addition to the underreporting noted above, other surveillance systems have also found occurrences of underreporting of work-related MSDs. The NIOSH-sponsored State-based surveillance program in California found that two thirds of the cases of work-related carpal tunnel syndrome did not appear in the California mandated State reporting system (Doctors' First Reports of Occupational Disease) when records were compared to the States's largest HMO (Kaiser Permanente). This missing data is valuable because Doctors' First Reports of Occupational Disease are used to estimate the magnitude of occupational disease in the State for several purposes.

### **Job Hazard Analysis**

NIOSH strongly supports OSHA's conclusion that job hazard analysis is an effective way to identify hazardous exposures. OSHA has requested comments on whether job hazard analysis and control should be limited to jobs with covered MSDs or expanded to include jobs in which employees are exposed to MSD hazards, even if no injuries have been reported. NIOSH believes that a more preventive approach that does not rely solely on the occurrence of an MSD to trigger an initial or preliminary job hazard analysis would strengthen the proposed standard. The GAO *Report to Congressional Requestors: Worker Protection, Private Sector,*

---

*NIOSH believes that a more preventive approach that does not rely solely on the occurrence of an MSD to trigger an initial or preliminary job hazard analysis would strengthen the proposed standard.*

---

**Table 2. Underreporting observed in HHEs**

Study	Measure of underreporting	Extent of underreporting observed	Comments
NIOSH Health Hazard Evaluation Report, HETA, 88-344-2092 [Baron et al. 1991]	Percentage of workers with work-related (W-R) upper extremity (UE) MSD not seeking medical care. W-R UE MSD cases defined by NIOSH standardized symptom questionnaires and positive physical findings from physician-conducted physical examinations.	40% of supermarket checkers with WR UE MSD did not seek medical care.	W-R MSD not brought to the attention of a health care professional (HCP) will not be recorded onto the OSHA 200 logs and therefore underestimate the true magnitude of the MSD problem.
NIOSH Health Hazard Evaluation Report, HETA 90-273-2130 [Hales et al. 1991]	Percentage of workers with W-R UE MSD not seeking medical care and whether they were recorded on the OSHA 200 Logs. W-R UE MSD defined by NIOSH standardized symptom questionnaires.	85% of employees with W-R UE MSD symptoms were not evaluated by a HCP.  A small fraction of those with W-R UE MSD were recorded on the OSHA 200 Logs.	Jewelry manufacturing employees exposed to repetitive, forceful, and awkward postures during job tasks (MSD hazards).
NIOSH Health Hazard Evaluation Report, HETA 89-251-1997 [Hales and Fine 1989]	Percentage of workers with W-R UE MSD not seeking medical care. UE MSD cases defined by NIOSH standardized symptom questionnaires and positive physical findings on physician-conducted physical examinations.	10% of employees with W-R UE MSD did not seek medical care.  14% were refused access to an HCP evaluation by their foreman.	Poultry processing employees exposed to MSD hazards.

(Continued)

**Table 2 (Continued). Underreporting observed in HHEs**

Study	Measure of underreporting	Extent of underreporting observed	Comments
NIOSH Health Hazard Evaluation Report, HETA 92-331 (close-out letter) [Hales et al. 1993]	Evaluation to determine compliance with OSHA corporate settlement agreement. Review of plant's health clinic algorithm to evaluate and treat symptomatic workers.	Large numbers of symptomatic workers evaluated by HCPs and prescribed a temporary job transfer. HCP deemed these as "preventative" job transfers and did not record these on the OSHA 200 Logs.	Red meatpacking plant employees exposed to MSD hazards. BLS requires employees with W-R symptoms and prescribed a job transfer for those symptoms be recorded on the logs.
NIOSH Health Hazard Evaluation Report, HETA 95-0294-2594 [McGlothlin and Hales 1996]	Percentage of workers with W-R UE MSD not seeking medical care and whether they were recorded on the OSHA 200 Logs. W-R UE MSD defined by NIOSH standardized symptom questionnaires.	75% of employees with W-R UE MSD did not seek medical care.  A small fraction of those with W-R UE MSD were recorded on the OSHA 200 Logs.	Research technicians conducting pipetting operations with MSD hazards.
NIOSH Health Hazard Evaluation Report, HETA 96-0101-2476 [Smith et al. 1997]	Employee health records and employee interviews compared with the plant's OSHA 200 Logs.	23% of employees with W-R UE MSD not recorded on the OSHA 200 Logs.	Truck frame assembly employees exposed to MSD hazards.
	Same method used to determine the accuracy of the number of lost and restricted workdays recorded.	The number of actual lost or restricted workdays significantly underreported.	Underreporting the lost or restricted workdays gives the impression of a less serious disorder.

(Continued)

**Table 2 (Continued). Underreporting observed in HHEs**

Study	Measure of underreporting	Extent of underreporting observed	Comments
NIOSH Health Hazard Evaluation Report, HETA 97-0276-2724 [Bernard et al. 1999]	Clinic Employee Report of Injury Illness forms compared with the plant's OSHA 200 Logs.  Employee health records compared with the plant's OSHA 200 Logs.	Many entries listed on the Clinic Employee Report of Injury/Illness forms and many cases from individual employee health records were not recorded on the OSHA 200 Logs.	Fiberglass manufacturing plant employees exposed to MSD hazards.
NIOSH Health Hazard Evaluation Report, HETA 98-0085-2715 [Habes and Wigmore 1998]	Comparison of workers reporting MS symptoms on a body map diagram with the OSHA 200 Logs.	Several discrepancies between these two lists. Employees probably not reporting all W-R symptoms to employer.	Casket manufacturing employees exposed to MSD hazards.

---

*Ergonomics Programs Yield Positive Results* [GAO 1997] (Ex. 26–5), the Joint Chicago NIOSH/OSHA January Conference in 1997 [IIE 1999], NIOSH’s *Elements of Ergonomic Programs* [NIOSH 1997b], and other sources of information all describe a range of job hazard analysis approaches to identify and assess possible problem jobs on a preventive basis [Ex. 26–2, 26–5, <http://www.cdc.gov/niosh/ec3mfg2.html>] [NIOSH 1997c]. This preventive approach serves to identify those jobs that are likely to result in an MSD before an injury occurs and helps to identify those jobs that need a more comprehensive assessment.

## MSD Management

OSHA has requested information on the essential elements of an MSD management program (Sections 1910.929–1910.935). NIOSH agrees with OSHA’s assessment that MSD management is an essential element of an effective ergonomics program and strongly supports the inclusion of MSD management in the ergonomics standard. Our experience (e.g., HHEs, and other studies, Ex. 26–2, 26–5, <http://www.cdc.gov/niosh/ec3mfg2.html>) with successful ergonomic programs is that all have some form of case or MSD management. NIOSH has also found that programs with early evaluation and treatment of MSDs by health care professionals (HCP) have reduced MSD severity and its associated disability. Supporting studies are referenced in the preamble to the proposed rule. Additional supportive studies include the following: A reduction in the MSD incidence rate and a concurrent reduction in medical costs were seen after implementing a comprehensive ergonomics program that encouraged employees “to report symptoms as early as possible” [Lutz and Hansford 1987]. Similarly, a comprehensive medical management program implemented in a meatpacking plant resulted in a 74% reduction in the rate of carpal tunnel release surgery over a 3-year period [Hales et al. 1993]. Finally, an ergonomics program, founded in the “...belief that early

---

*NIOSH agrees with OSHA’s assessment that MSD management is an essential element of an effective ergonomics program and strongly supports the inclusion of MSD management in the ergonomics standard.*

---

---

diagnosis and treatment of upper extremity work-related MSDs, coupled with the continuous identification and correction of poorly designed workplaces, would reduce the number of individuals presenting with upper extremity work-related MSDs...,” was implemented at the Johns Hopkins Hospital and University in 1992. Over a 7-year period, there was an 80% reduction in the upper extremity work-related MSD rate, eliminating the need to use surgical procedures to correct these conditions. Costs went from approximately \$84,000 per year to cover carpal tunnel syndrome surgeries alone, to an average of \$23,760 to medically evaluate, treat, and correct the workplaces of all injured employees [Bernacki et al. 1999].

These three examples strengthen the evidence OSHA has already compiled showing that medical or case management programs that encourage the early evaluation and treatment of MSDs by an HCP reduce the severity, disability, and costs associated with these disorders. It is important to note that these studies used HCPs to evaluate symptomatic workers potentially having a work-related MSD.

Regarding the clinical evaluation of workers, proposed Section 1910.930(c) states, *“When necessary, provide employees with prompt access to a ‘health care professional’ (HCP) for evaluation, management, and ‘follow-up.’”* NIOSH is concerned that inclusion of the phrase “when necessary” implies that OSHA will allow the use of non-HCPs to triage symptomatic employees. While NIOSH supports employers’ efforts to train employees in the early signs and symptoms of MSDs and to seek HCP evaluation when appropriate, we recommend that the standard preclude non-HCPs and non-licensed HCPs from conducting medical evaluations. NIOSH supports OSHA’s proposal that permits the MSD management programs to be administered by a variety of licensed HCPs as defined in Section 1910.945 (Definitions). However, we

---

recommend that the clinical aspects of the program (medical evaluations of symptomatic workers) be performed by licensed HCPs under the supervision of HCPs licensed for independent practice (including physicians, and nurse practitioners and physicians' assistants in those States where they are so licensed).

NIOSH agrees that companies should be able to continue the practice of placing symptomatic workers in temporary positions until a prompt evaluation by an HCP can be performed, understanding that the definition of "prompt" may be determined by the availability of an HCP at the worksite. In situations where an HCP is not available on-site (e.g., small companies or companies located in rural areas), NIOSH agrees with OSHA that the HCP evaluation of symptomatic workers must be provided within 5 days (Section 1010.943). If the symptoms resolve prior to being evaluated by an HCP, and the job is modified to reduce or eliminate the biomechanical hazards, NIOSH agrees with OSHA that, at this point, there would be no need for an HCP evaluation.

NIOSH also agrees with the Agency's decision not to include particular diagnostic tests, treatment protocols, and clinical case definitions in the MSD management section, or anywhere else in the ergonomic standard. Standards of care change over time, evolving with new research, technological innovations, and new therapies. To allow workers to be provided with current, state-of-the-art clinical care, OSHA is correct to leave diagnostic and therapeutic decisions to HCPs and their professional organizations.

## Conclusion

NIOSH strongly supports the promulgation of OSHA's proposed rule *Ergonomics Program* (29 CFR Part 1910). Work-related MSDs remain one of the most serious problems facing the American workforce. A large body of widely accepted, consistent

---

*We believe that this proposed ergonomics program rule will be an effective and scientifically valid way to reduce the large numbers of these disorders occurring in the U.S. workforce.*

---

---

scientific studies from a variety of disciplines has shown that there is a clear relationship between work factors and MSDs. This base of scientific information is much more extensive than that typically available for rulemaking, particularly with regard to the epidemiologic and human data that has been published. Solutions, such as the ergonomics program that OSHA outlines in this proposal, are feasible, available, and already working in many large and small companies in diverse industries around the country. These programs have reduced pain, disability, and workers' compensation costs, while improving productivity in workplaces of all sizes across a broad range of industries.

We know enough now to prevent or reduce the severity of many of these disorders. NIOSH experience leads us to believe, however, that voluntary programs are not enough—the number of workplace MSDs is not declining fast enough. We believe that this proposed ergonomics program rule will be an effective and scientifically valid way to reduce the large numbers of these disorders occurring in the U.S. workforce.

## References

Aarås A [1994]. The impact of ergonomic intervention on individual health and corporate prosperity in a telecommunication environment. *Ergonomics* 37:1679–1696. [OSHA Exhibit No. 26–62].

Ålund M, Larsson SE, Lewin T [1994]. Work-related persistent neck impairment: A study on former steel works grinders. *Ergonomics* 37(7):1253–1260. [OSHA Exhibit No. 26–1108].

Baron S, Milliron M, Habes D, Fidler A [1991]. Hazard evaluation and technical assistance report: Shoprite Supermarkets, New

---

Jersey-New York. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 88-344-2092. [OSHA Exhibit No. 26-697]

Bergenudd H, Nilsson B [1988]. Back pain in middle age. Occupational workload and psychologic factors: an epidemiologic survey. *Spine* 13(1):58-60. [OSHA Exhibit 26-1342]

Bernacki EJ, Guidera JA, Schaefer JA, Lavin RA, Tsai SP [1999]. An ergonomics program designed to reduce the incidence of upper extremity work related musculoskeletal disorders. *J Occup Environ Med* 41(12):1032-1041.

Bernard BP, Waters T, Ting S [1999]. Hazard evaluation and technical assistance report: Owens Corning, Amarillo, TX. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 97-0276-2724.

Chard MD, Sattelle LM, Hazleman BL [1988]. The long-term outcome of rotator cuff tendinitis—a review study. *British J Rheumatol* 27:385-389.

Cooper C, Inskip H, Croft P et al. [1998]. Individual risk factors for hip osteoarthritis: Obesity, hip injury and physical activity. *Am J Epidemiol* 147(6):516-522. [OSHA Exhibit No. 26-100]

DeLacerda FG [1982]. Shoulder girdle myofascial syndrome: A biomechanical analysis. *Occup Health Saf* 45-46.

---

Dillon CF [1999]. Upper extremity RSI: Extent & costs—summary grant report, NIOSH R01 CCR112118. University of Connecticut Health Center, Farmington, Connecticut.

Feuerstein M, Callan-Harris S, Hickey P, Dyer D, Armbruster W, Carosella AM [1998]. Multidisciplinary rehabilitation of chronic work-related upper extremity disorders. Long-term effects. *J Occup Med* 35(4):396–403.

GAO [1997]. Report to congressional requestors: Worker protection, private sector, ergonomics programs yield positive results. United States Government Accounting Office/Health, Education, and Human Services Division Report No. GAO/HEHS–97–163.

Garg A [1999]. Long-term effectiveness of “zero-lift program” in seven nursing homes and one hospital. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. Contract No. U60/CCU512089–02 to University of Wisconsin, Milwaukee. [OSHA Exhibit No. 26–1093]

Gjessing C [1997]. Ergonomics: Effective workplace practices and programs. In: Transcripts of presentations from the conference held January 8 and 9, 1997, Chicago, Illinois. World Wide Web [URL=<http://www.cdc.gov/niosh/ecagenda.html>], accessed October 1999.

Grant KA, Habes DJ [1995]. Summary of studies on the effectiveness of ergonomic interventions, *Applied Occupational and Environmental Hygiene*. In: Schneider S, ed. *Ergonomics* 10(16): 523–530.

---

Habes DJ, Wigmore D [1998]. Hazard evaluation and technical assistance report: Aurora Casket Company, Aurora, IN. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. NIOSH Report No. HHE 98-0085-2715.

Habes DJ [May 1996]. Upper extremity cumulative trauma disorders: Current trends. In: Bhattacharya, McGlothlin, Dekker, eds. Occupational ergonomics: Theory and applications, New York, NY: Marcel Dekker, Inc., pp. 581-603.

Hales T, Habes D, Grant K [1993]. Hazard evaluation and technical assistance report: John Morrell & Company, Sioux Falls, SD. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 92-331.

Hales T, Fine LJ [1989]. Hazard evaluation and technical assistance report: Cargill Poultry Division, Buena Vista, GA. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 89-251-1997. [OSHA Exhibit No. 2-3-PP]

Hales T, Grant KA, Daniels W, Habes DJ [1991]. Hazard evaluation and technical assistance report: FL Thorpe & Co., Inc., Deadwood, SD. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 90-273-2130.

---

IIE [1999]. Applied ergonomics: Case studies. Volume 2. Published by the Institute of Industrial Engineers. Norcross, GA: Engineering and Management Press.

Kai-Nan A [1995]. Overview: Repetitive motion of disorders of the upper extremity. In: Gordon, Stephen L, Blair, Sidney J, Fine, LJ, eds. Rosemont, IL: American Academy of Orthopaedic Surgeons, pp. 3–5.

Kemmlert K, Öreljus-Dallner M, Kilbom Å, Gamberale F [1993]. A three year follow-up of 195 reported occupational over-exertion injuries. *Scand J Rehabil Med* 25:16–24.

Keyserling WM [forthcoming]. Workplace risk factors and occupational musculoskeletal disorders, part 2: A review of biomechanical and psychophysical research on risk factors associated with upper extremity disorders. *Am Ind Hyg Assoc J*.

Kilbom A [1994]. Repetitive work of the upper extremity: Part II—the scientific basis (knowledge base) for the guide. *Int J Ind Ergonomics* 14:59–86. [OSHA Exhibit No. 26–1227]

Kilbom A [1988]. Intervention programmes for work-related neck and upper limb disorders: strategies and evaluation. *Ergonomics* 31(5):735–747.

Knibbe JJ, Friele RD [1999]. The use of logs to assess exposure to manual handling of patients, illustrated in an intervention study in home care nursing. *Int J Ind Ergonomics* 24:445–454.

Komoike Y, Hasegawa T, Nakamura KE [1975]. Etiology and symptoms of four cases of occupational cervicobrachial syndrome developing maladaptation in post. *Sumitomo Bull Ind Health* 11:148–151.

---

Kvarnström S [1983]. Occurrence of musculoskeletal disorders in a manufacturing industry with special attention to occupational shoulder disorders. *Scand J Rehabil Med (Suppl 8)*:1–114. [OSHA Exhibit No. 26–1201]

Lascelles RG, Mohr PD, Neary D, Bloor K [1977]. The thoracic outlet syndrome. *Brain* 100:601–612.

Lutz G, Hansford T [1987]. Cumulative trauma disorder controls: The ergonomics program at Ethicon, Inc. Part 2. *J Hand Surg* 12A(5):863–866.

Matsen FA, Kirby RM [1982]. Office evaluation and management of shoulder pain. *Orthop Clin North Am* 13:453–475.

McGlothlin JD, Hales TR [1996]. Hazard evaluation and technical assistance report: Scientific Application International Corporation, Frederick, MD. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 95–0294–2594.

NAS [1999]. Work-related musculoskeletal disorders. Report, workshop summary, and workshop papers. Washington, DC: National Academy of Sciences, National Research Council. [OSHA Exhibit No. 26–37]

Neviaser JS [1983]. Painful conditions affecting the shoulder. *Orthop Clin North Am* 173:63–69.

NIOSH [1994]. Participatory ergonomic interventions in meat-packing plants. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety

---

and Health, DHHS (NIOSH) Publication No. 94-124. [OSHA Exhibit No. 26-4]

NIOSH [1997a]. 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: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 97-141. [OSHA Exhibit No. 26-1]

NIOSH [1997b]. Elements of ergonomics programs: A primer based on workplace evaluations of musculoskeletal disorders. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 97-117. [OSHA Exhibit No. 26-2]

NIOSH [1997c]. Ergonomics: effective workplace practices and programs. Conference in Chicago. World Wide Web [URL=<http://www.cdc.gov/niosh/ec3mfg2.html>], 2/10/2000.

Pollack ES, Keimig DG eds. [1987]. Counting injuries and illnesses in the workplace; proposals for a better system. Committee of National Statistics, National Research Council. Washington, DC: National Academy Press. [OSHA Exhibit No. 28-4]

Putz-Anderson V, Galinsky T [1993]. Psychophysically determined work durations for limiting shoulder girdle fatigue from elevated manual work. *Int J Ind Ergonomics* 11:19-28. [OSHA Exhibit No. 26-1165]

---

Rosa R, Bonnet M, Cole L [1998]. Work schedule and task factors in upper-extremity fatigue. *Hum Factors* 40:150–158.

Smith SS, McGlothlin JD, Burt SE, Tubbs RL [1997]. Hazard evaluation and technical assistance report: Midland Steel Products Company. Hanesville, WI. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No. HHE 96–0101–2476.

U.S. House of Representatives [1984]. Occupational illness data collection: fragmented, unreliable, and seventy years behind communicable disease surveillance. Sixtieth Report by the Committee on Government Operations, U.S. House of Representatives Report 98–1144, Oct. 5.

Videman T, Nurminen M, Troup JDG [1990]. Lumbar spinal pathology in cadaveric material in relation to history of back pain, occupation, and physical loading. *Spine* 15(8):728–740.

Viikari-Juntura E, Riihimäki H, Tola S, Videman T, Mutanen P [1994]. Neck trouble in machine operating, dynamic physical work and sedentary work: a prospective study on occupational and individual risk factors. *Epidemiol* 47(12):1411–1422. [OSHA Exhibit 26–873]

Villaflor F, Cavallero R, Lumkong W, Banks A [1994]. Wire terminal insertion tool for all wiring operation. Quest project submittal form. Edison, NJ: Frigidaire Home Comfort Products.

Vingård E, Alfredsson L, Fellenius E, Hogstedt C [1992]. Disability pensions due to musculoskeletal disorders among men in heavy occupations. *Scand J Soc Med* 20(1):31–36.

**U.S. Department of Health and Human Services**  
Public Health Service  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health  
4676 Columbia Parkway  
Cincinnati, OH 45226-1998

---

OFFICIAL BUSINESS  
Penalty for private use \$300



Delivering on the Nation's promise:  
Safety and health at work for all people  
through research and prevention

---

To receive NIOSH documents or more information  
about occupational safety and health topics,  
contact NIOSH at 1-800-35-NIOSH (1-800-356-4674)

Fax: (513) 533-8573 ■ E-mail: [pubstaf@cdc.gov](mailto:pubstaf@cdc.gov)  
or visit the NIOSH Web site at [www.cdc.gov/niosh](http://www.cdc.gov/niosh)

DHHS (NIOSH) Publication No. 2001-108