National Institute for Occupational Safety and Health
NIOSH

ELEMENTS OF ERGONOMICS PROGRAMS

A Primer based on Workplace Evaluations of Musculoskeletal Disorders

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

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CENTERS FOR DISEASE CONTROL AND PREVENTION

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A Primer Based on Workplace Evaluations of Musculoskeletal Disorders

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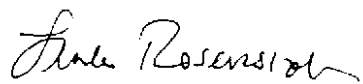
FOREWORD

The National Institute for Occupational Safety and Health (NIOSH) operates an 800-number to provide workers, employers, and organizations information about various workplace safety and health concerns. Over the past several years, the volume of NIOSH 800-number calls concerning work-related musculoskeletal disorders (WMSDs) has grown. They are now second only to questions about chemical hazards. WMSD inquiries, exceeding 3,700 in 1996, have come largely from callers associated with small- and medium-sized businesses, which often have limited resources to deal with occupational safety and health issues. This document has been prepared to respond to the needs of this audience.

This primer describes the basic elements of a workplace ergonomics program. The text is largely built around NIOSH experiences in evaluating risks of WMSDs in a variety of workplaces. Descriptions of these NIOSH experiences provide practical illustrations of ways to identify and evaluate ergonomic hazards and to begin problem-solving efforts.

In response to the widespread concern about WMSDs, and with the knowledge that many workplaces have begun successful programs to control them, a wide variety of organizations have published ergonomics program manuals and primers. We hope that this NIOSH primer will be a useful addition to the existing information.



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ABSTRACT

This primer describes the basic elements of a workplace program aimed at preventing work-related musculoskeletal disorders (WMSDs). Management commitment, worker participation, and training are addressed along with procedures for identifying, evaluating, and controlling risk factors for WMSDs. The text cites NIOSH ergonomics investigations to illustrate practical ways for meeting program needs. The primer includes a "toolbox," which is a collection of techniques, methods, reference materials, and sources for other information that can help in program development.

OVERVIEW

This primer provides basic information that will be useful for employers, workers, and others in designing effective programs to prevent work-related musculoskeletal disorders (WMSDs), one of the most prevalent and costly safety and health problems in the modern workplace. It defines the key elements of an effective program in a format that allows the user to tailor the information to a particular work setting or situation. It also provides a "toolbox" of useful materials for putting a program into place, including reference materials, sources for further information, and generic forms and questionnaires.

The primer is based on the extensive practical experience accumulated by the National Institute for Occupational Safety and Health (NIOSH) in conducting investigations in actual workplace settings, providing technical assistance to employers and workers, and evaluating the latest technical literature.

The seven elements of an effective program comprise a seven-step "pathway" for evaluating and addressing musculoskeletal concerns in an individual workplace. Each step is addressed in more detail in the primer, with examples drawn from actual NIOSH workplace evaluations. The seven steps are as follows:

One: Looking for signs of a potential musculoskeletal problem in the workplace, such as frequent worker reports of aches and pains, or job tasks that require repetitive, forceful exertions.

Two: Showing management commitment in addressing possible problems and encouraging worker involvement in problem-solving activities.

Three: Offering training to expand management and worker ability to evaluate potential musculoskeletal problems.

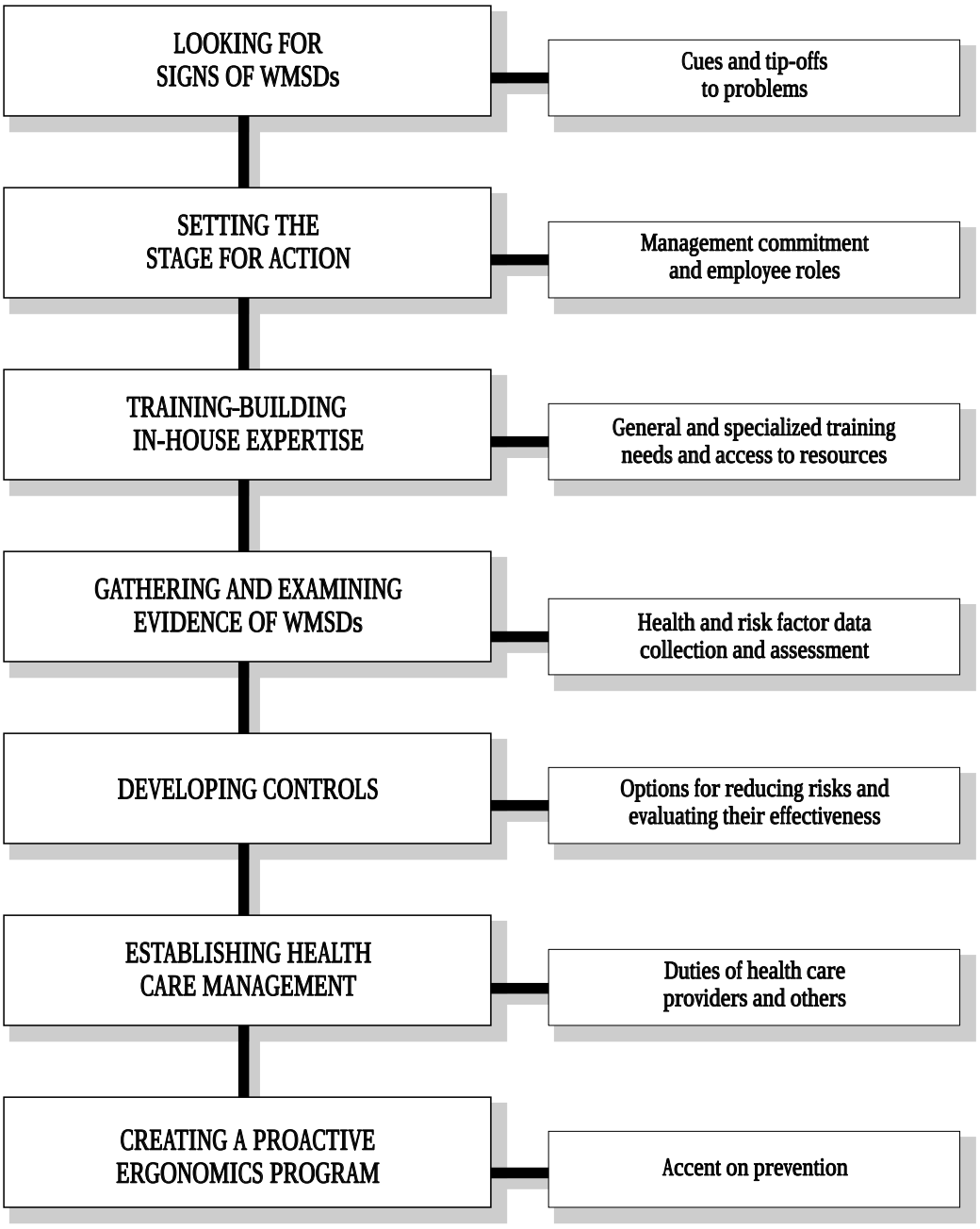
Four: Gathering data to identify jobs or work conditions that are most problematic, using sources such as injury and illness logs, medical records, and job analyses.

Five: Identifying effective controls for tasks that pose a risk of musculoskeletal injury and evaluating these approaches once they have been instituted to see if they have reduced or eliminated the problem.

Six: Establishing health care management to emphasize the importance of early detection and treatment of musculoskeletal disorders for preventing impairment and disability.

Seven: Minimizing risk factors for musculoskeletal disorders when planning new work processes and operations—it is less costly to build good design into the workplace than to redesign or retrofit later.

A Pathway to Controlling Work-Related Musculoskeletal Disorders (WMSDs)



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INTRODUCTION

- **What are Work-Related Musculoskeletal Disorders (WMSDs)?**
- **Why are WMSDs a Problem?**
- **What is Ergonomics?**
- **What is the Purpose of this Primer?**

WHAT ARE WORK-RELATED MUSCULOSKELETAL DISORDERS (WMSDs)?

Although definitions vary, the general term "musculoskeletal disorders" describes the following:

- Disorders of the muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs
- Disorders that are not typically the result of any instantaneous or acute event (such as a slip, trip, or fall) but reflect a more gradual or chronic development (nevertheless, acute events such as slips and trips are very common causes of musculoskeletal problems such as low back pain)
- Disorders diagnosed by a medical history, physical examination, or other medical tests that can range in severity from mild and intermittent to debilitating and chronic
- Disorders with several distinct features (such as carpal tunnel syndrome) as well as disorders defined primarily by the location of the pain (i.e., low back pain)

The term "WMSDs" refers to (1) musculoskeletal disorders to which the work environment and the performance of work contribute significantly, or (2) musculoskeletal disorders that are made worse or longer lasting by work conditions. These workplace risk factors, along with personal characteristics (e.g., physical limitations or existing health problems) and societal factors, are thought to contribute to the development of WMSDs [Armstrong et al. 1993]. They also reduce worker productivity or cause worker dissatisfaction. Common examples are jobs requiring repetitive, forceful, or prolonged exertions of the hands; frequent or heavy lifting, pushing, pulling, or carrying of heavy objects; and prolonged awkward postures. Vibration and cold may add risk to these work conditions. Jobs or working conditions presenting multiple risk factors will have a higher probability of causing a musculoskeletal problem. The level of risk depends on the intensity, frequency, and duration of the exposure to these conditions and the individual's capacity to meet the force or other job demands that might be involved. These conditions are more correctly called "ergonomic risk factors for musculoskeletal disorders" rather than "ergonomic hazards" or "ergonomic problems." But like the term "safety hazard," these terms have popular acceptance.

WHY ARE WMSDs A PROBLEM?

Many reasons exist for considering WMSDs a problem, including the following:

- WMSDs are among the most prevalent lost-time injuries and illnesses in almost every industry [Bureau of Labor Statistics 1995, 1996; National Safety Council 1995; Tanaka et al. 1995].
- WMSDs, specifically those involving the back, are among the most costly occupational problems [National Safety Council 1995; Webster and Snook 1994; Guo et al. 1995; Frymoyer and Cats-Baril 1991].
- Job activities that may cause WMSDs span diverse workplaces and job operations (see Table 1; see also Tray 1-A of the Toolbox).
- WMSDs may cause a great deal of pain and suffering among afflicted workers.
- WMSDs may decrease productivity and the quality of products and services. Workers experiencing aches and pains on the job may not be able to do quality work.
- Because musculoskeletal disorders have been associated with nonwork activities (e.g., sports) and medical conditions (e.g., renal disease, rheumatoid arthritis), it is difficult to determine the proportion due solely to occupation. For example, in the general population, nonoccupational causes of low back pain are probably more common than workplace causes [Liira et al. 1996]. However, even in these cases, the musculoskeletal disorders may be aggravated by workplace factors.

WHAT IS ERGONOMICS?

Ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the working population. Effective and successful "fits" assure high productivity, avoidance of illness and injury risks, and increased satisfaction among the workforce. Although the scope of ergonomics is much broader, the term in this primer refers to assessing those work-related factors that may pose a risk of musculoskeletal disorders and recommendations to alleviate them.

WHAT IS THE PURPOSE OF THIS PRIMER?

Many organizations have published primers and manuals describing programs and techniques to control ergonomic hazards [National Safety Council 1988; Canadian Center for Occupational Health and Safety 1988; Putz-Anderson 1988; UAW-GM Center for Health and Safety 1990; Oxenburgh 1991; American Meat Institute and ErgoTech, Inc. 1990; Occupational Safety and Health Administration 1993]. Some primers are tailored to particular industries; others are more general.

This primer outlines the approach most commonly recommended for identifying and correcting ergonomic problems. This document offers practical information (based on NIOSH experience in a variety of settings) for applying elements of this approach in workplaces. The steps typically used to describe ergonomics programs are used here to tap and organize the NIOSH database of relevant experience.

Information about the techniques, instruments, and methods mentioned in examples of NIOSH work and other reference materials appear in the appendix, referred to as a *Toolbox*. Included in the Toolbox is a master chart listing details of NIOSH evaluations involving WMSDs reported over the past 15 years. Finding work settings or jobs in this chart that are related to the readers' jobs may help the reader capitalize on the information contained in these reports, which are available from the National Technical Information Service (NTIS).

This primer is geared to those who need knowledge of ergonomics because of their roles as employers or as persons responsible for ensuring safe and healthful work conditions in their companies. Use of numerous examples from real workplaces emphasizes practical approaches. Organizations with established ergonomics programs or with a staff having advanced training in ergonomics may find more limited value in this primer.

STEP 1
LOOKING FOR SIGNS OF WORK-RELATED MUSCULOSKELETAL PROBLEMS

- **Recognizing Signs That May Indicate a Problem**
- **Determining a Level of Effort**

What are clues or tip-offs to WMSDs as a real or possible workplace problem? Some signs are obvious while others are more subtle. The first step is to look for these signs or clues.

RECOGNIZING SIGNS THAT MAY INDICATE A PROBLEM

- Company OSHA Form 200 logs or workers' compensation claims show cases of WMSDs such as carpal tunnel syndrome, tendinitis, tenosynovitis, epicondylitis, and low back pain. Sometimes these records contain non-specific entries like "hand pain," which (while not a specific diagnosis) may be an indicator of a significant health problem if severe or persistent.
- Certain jobs or work conditions cause worker complaints of undue strain, localized fatigue, discomfort, or pain that does not go away after overnight rest.
- Workers visiting the clinic make frequent references to physical aches and pains related to certain types of work assignments.
- Job tasks involve activities such as repetitive and forceful exertions; frequent, heavy, or overhead lifts; awkward work positions; or use of vibrating equipment.

Signs like these have triggered requests for NIOSH evaluations of possible ergonomic problems and risks of WMSDs. Some examples of reasons that have been given for requesting NIOSH ergonomic evaluations are described in Exhibit 1. These examples show that WMSDs can occur in a variety of workplaces.

Other signals that could alert employers to potential problems include the following:

- Trade publications, employers' insurance communications, or references in popular literature indicating risks of WMSDs connected with job operations in the employer's business
- Cases of WMSDs found among competitors or in similar businesses
- Proposals for increasing line speed, retooling, or modifying jobs to increase individual worker output and overall productivity

Table 1 illustrates a variety of industries and job tasks in which NIOSH evaluations found evidence of WMSDs. A table listing NIOSH findings for an even larger sample of workplaces is provided in the Toolbox section of this primer (Tray 1-A).

DETERMINING A LEVEL OF EFFORT

Clues that indicate ergonomic problems may also suggest the scope of the effort required to correct them. For example, signs implicating multiple jobs in various departments and involving a large percentage of the workforce would indicate the need for a full-scale, company-wide program. Alternatively, signs that the suspected problems are confined to isolated tasks and relatively few

Exhibit 1: Triggers for NIOSH Evaluations

Manufacturing Work Setting

A plumbing-ware manufacturing company asked NIOSH to assist in an ergonomics evaluation of their production operations after an OSHA inspection found a high number of back injuries at the facility relative to the rates at other manufacturing plants in the same industrial classification. This industry as a whole had the tenth highest OSHA reportable incidence rate in the United States for 1986. The work areas where most back injuries had occurred were identified by the plant's safety director, and the jobs believed most stressful to the workers' backs became the main targets of the evaluation that ensued [HETA 88–237–L1960].

Office Work Setting

NIOSH received a request from a local union representing office and professional employees of a health insurance company to evaluate potential hazards from the use of video display terminals (VDTs) in data entry operations. Numerous, wide-ranging symptomatic complaints had been voiced by the terminal operators, including headaches, general malaise, eyestrain and other visual problems, back pain, and stiffness and soreness in the neck and shoulder areas and upper extremities. A questionnaire used for data gathering during the evaluation verified more complaints of this nature among VDT users than nonusers, and environmental and workstation measurements suggested that certain ergonomic factors contributed to these differences [HETA 79–060–843].

Service Work Setting

The owner and employees of a preschool day care center asked NIOSH to identify possible causes of musculoskeletal problems, chiefly back pain and lower extremity (knee) pain and discomfort, reported by the teachers and aides at the school. Subsequent data collected on symptomatic complaints and observations and analyses of work activities indicated that factors such as frequent lifting of infants and sustained periods of kneeling, stooping, squatting, and trunk bending were responsible for the problems [HETA 93–0995–242].

workers may suggest starting with a more limited, focused activity.

The program elements offered in this primer describe the development of a full-scale ergonomics program for use in a company-wide approach. All companies may benefit from such an approach. However, the intensity of the program may need to be calibrated to the magnitude of the problem. For smaller-scale efforts that are directed at specific problems or situations in which problem jobs or affected workers are quite limited, selected elements of the overall program may be useful. Exhibits in this primer cover a range of efforts and will clarify aspects of both full-scale and more limited approaches. Understandably, a company's initial efforts in ergonomics will be directed toward fixing the most obvious problem jobs. The program elements described here offer a framework for an orderly undertaking of such activities. Moreover, even if the evidence for WMSDs is not clear, implementing the program can have value by enabling early detection of (and more timely interventions in) potential ergonomic problems. Also, an ergonomics program can influence the design of future changes in work processes to reduce the possibility of WMSDs. In these instances, the envisioned efforts have proactive benefits that will help prevent WMSDs.

Table 1. Selected work settings from NIOSH investigations showing evidence of WMSDs

Work setting	Job
Meatpacking	Cleaning metal tubs, shank trimming, removing lard and internal organs
Warehousing	Lifting and carrying containers of assorted weights
Metal fabrication	Cutting, threading, shaping bar stock, and coupling parts to form product
Electronics assembly	Coil winding or trimming wire, circuit board wiring, fastening parts and packing products
Supermarket	Express checkout operations
VDT office and clerical	Sustained data entry and nonadjustable workstations
Clothing manufacture	Sewing tasks
Glass products	Decorating or etching glass
Plumbing fixtures	Lifting and moving toilet bowls weighing 45 to 70 lb
Sheet metal products	Riveting, seaming, assembly work
Plastic products	Parts molding, trimming excess material, filing, and reaming and sanding to finish product
Logging	Extended driving of log stackers or haulers over rough terrain
Film and paper products	Repackaging larger bulk materials into smaller units for distribution
Day care	Lifting and bending in tending to infant needs
Jewelry manufacturing	Waxing, cutting, finishing tasks
Cabinetmaking	Lifting and push-pull tasks
Auto products	Lifting and handling parts weighing 36 to 78 lb
Tool and die making	Grinding, polishing, deburring tasks

STEP 2
SETTING THE STAGE FOR ACTION

- **Ergonomics as Part of a Company Safety and Health Program**
- **Expressions of Management Commitment**
- **Benefits and Forms of Worker Involvement**
  Who Should Participate?

As with other workplace safety and health issues, managers and employees both play key roles in developing and carrying out an ergonomics program.

ERGONOMICS AS PART OF A COMPANY SAFETY AND HEALTH PROGRAM

Ergonomics programs should not be regarded as separate from those intended to address other workplace hazards. Aspects of hazard identification, case documentation, assessment of control options, and health care management techniques that are used to address ergonomic problems use the same approaches directed toward other workplace risks of injury or disease. Although many of the technical approaches described in this primer are specific to ergonomic risk factors and work-related musculoskeletal disorders, the core principles are the same as efforts to control other workplace hazards.

The financial benefits of comprehensive safety and health programs have been well documented. Workplaces safe from hazardous conditions have lower costs due to decreased lost time, absenteeism, worker compensation premiums, etc. [Office of Technology Assessment 1995]. Ergonomics programs have been shown to be cost effective for similar reasons [McKenzie et al. 1985; Lapore et al. 1984]. In addition, ergonomic improvements may result in increased productivity and higher product quality [McKenzie et al. 1985; LaBar 1994; LaBar 1989].

The ergonomics program elements outlined in this primer and the cases used to illustrate them follow a course that is mainly *reactive* in nature. The steps offer a plan to identify current problems that need to be addressed and actions aimed at resolution or control of such problems. This approach recognizes that management's first efforts to deal with ergonomic problems will probably be reactive. However, *proactive* approaches that seek to anticipate and prevent problems should be the ultimate goal. More will be said about proactive ergonomic approaches later in this document.

EXPRESSIONS OF MANAGEMENT COMMITMENT

Occupational safety and health literature stresses management commitment as a key and perhaps controlling factor in determining whether any worksite hazard control effort will be successful [Cohen 1977; Peters 1989; Hoffman et al. 1995]. Management commitment

can be expressed in a variety of ways. Lessons learned from NIOSH case studies of ergonomic hazard control efforts in the meatpacking industry [Gjessing et al. 1994] emphasize the following points regarding evidence of effective management commitment:

- Policy statements are issued that
  - — treat ergonomic efforts as furthering the company's goals of maintaining and preserving a safe and healthful work environment for all employees,
  - — expect full cooperation of the total workforce (managers, supervisors, employees, and support staff) in working together toward realizing ergonomic improvements,
  - — assign lead roles to designated persons who are known to "make things happen,"
  - — give ergonomic efforts priority with other cost reduction, productivity, and quality assurance activities, and
  - — have the support of the local union or other worker representatives.
- Meetings between employees and supervisors allow full discussion of the policy and the plans for implementation.
- Goals are set that become more concrete as they address specific operations. Goals give priority to the jobs posing the greatest risk.
- Resources are committed to
  - — training the workforce to be more aware of ergonomic risk factors for work-related musculoskeletal disorders,
  - — providing detailed instruction to those expected to assume lead roles or serve on special groups to handle various tasks,
  - — bringing in outside experts for consultations about start-up activities and difficult issues at least until in-house expertise can be developed, and
  - — implementing ergonomic improvements as may be indicated.
- Release time or other compensatory arrangements are provided during the workday for employees expected to handle assigned tasks dealing with ergonomic concerns.
- Information is furnished to all those involved in or affected by the ergonomic activities to be undertaken. Misinformation or misperceptions about such efforts can be damaging: If management is seen as using the program to gain ideas for cutting costs or improving productivity without equal regard for employee benefits, the program may not be supported by employees. For example, management should be up-front regarding possible impacts of the program on job security and job changes. All injury data, production information, and cost considerations need to be made available to those expected to make feasible recommendations for solving problems.
- Evaluative measures track the results of the ergonomic efforts to indicate both the progress that has been made and the plans that need to be revised to overcome apparent problems. Reporting results of the program and publicizing notable accomplishments also emphasize the program's importance and maintain the interest of those immediately involved and responsible.

BENEFITS AND FORMS OF WORKER INVOLVEMENT

Promoting worker involvement in efforts to improve workplace conditions has several benefits [Lawler III 1991; Cascio 1991; Schermerhorn et al. 1985; LaBar 1994; Noro and Imada 1991]. They include

— enhanced worker motivation and job satisfaction,

— added problem-solving capabilities,

— greater acceptance of change, and

— greater knowledge of the work and organization.

Worker involvement in safety and health issues means obtaining worker input on several issues. The first input is defining real or suspected job hazards. Another is suggesting ways to control suspected hazards. A third involves working with management in deciding how best to put controls into place. One NIOSH experience of worker involvement with ergonomic issues is illustrated in Exhibit 2.

Employee participation in an organization's efforts to reduce work-related injury or disease in general, and ergonomic problems in particular, may take the form of direct or individual input as described in Exhibit 2. A more common form is participation through a joint labor-management safety and health committee, which may be company-wide or department-wide in nature. Membership on company-wide committees includes union leaders or elected worker representatives, department heads, and key figures from various areas of the organization. At this level, typical committee functions consist of (1) discussing ways to resolve safety and health issues, (2) making recommendations for task forces or working groups to plan and carry out specific actions, and (3) approving use of resources for such actions and providing oversight. Committee make-up and function at the department level are more localized, since they are directed to issues specific to the operations found therein. Composition here can be limited to workers from the department or area engaged in similar jobs who, with their supervisors and select others (e.g., maintenance), propose ways for reducing work-related problems, including those posing injury or disease risks. Because of their smaller size and opportunities for closer contacts among members, such committees may be referred to as a work group [Davis and Newstrom 1985].

The department or area work group approach appears to be a popular one in addressing ergonomic problems. Factors identified in the literature that are influential to success in these efforts

Exhibit 2: Worker Involvement

NIOSH was asked to evaluate musculoskeletal pain and discomfort in the upper neck and shoulder areas as well as the lower back, buttocks, and legs of cashiers. The pain was thought to result from operating registers at express checkout counters in a supermarket. In analyzing workstation design and job task factors that could account for the above problems, the investigators interviewed a number of cashiers. The cashiers related their musculoskeletal complaints specifically to certain design characteristics of the checkout counters. They indicated that

— the far corner of the checkout counter required extended reaching for items, resulting in excessive trunk flexion and bending,

— the register keyboard height and distance induced static stress and shoulder flexion, and

— other tasks performed at the workstations required constant twisting because of the layout.

At a meeting with management and workers, initial interventions that gave priority to these problematic factors were agreed upon. A barrier was placed at the far corner of each checkout counter to reduce the extended reaching and bending for groceries, and height-adjustable keyboards were installed to relieve the static stress and shoulder flexion. Reductions in the number of symptoms associated with these active areas of the intervention were found following the implementation of these measures [HETA 88–345–2031; Orgel et al. 1992].

are identified in Table 2. Also shown in Table 2 are factors that can enhance direct worker inputs in workplace problem solving.

NIOSH assistance to the work of a joint labor-management safety committee is noted in Exhibit 3, which describes the actions of a plant-wide committee dealing with ergonomic hazards and work-related musculoskeletal problems in a piston manufacturing plant. Exhibit 4 outlines the results of work group efforts in a NIOSH study of meatpacking operations that focused on participatory approaches to control ergonomic and musculoskeletal problems. A direct worker input approach was described in Exhibit 2, but another example is offered in Exhibit 5 to reveal a limitation.

As noted in Exhibits 3, 4, and 5 and in Table 2, two factors are critical to the different forms of worker involvement. One is the need for training both in hazard recognition and control and in group problem solving. The second is that management must share information and knowledge of results with those involved.

No single form or level of worker involvement fits all situations or meets all needs. Much depends on the nature of the problems to be addressed, the skills and abilities of those involved, and the company's prevailing practices for participative approaches in resolving workplace issues.

Who Should Participate?

Ergonomic problems typically require a response that cuts across a number of organizational units. Hazard identification through job task analyses and review of injury records or symptom surveys, as well as the development and implementation of control measures, can require input from

- safety and hygiene personnel,
- health care providers,
- human resource personnel,
- engineering personnel,
- maintenance personnel, and
- ergonomics specialists.

In addition, worker and management representatives are considered essential players in any ergonomics program effort.

In small businesses, two or more of the functions noted on this list may be merged into one unit, or one person may handle several of the listed duties. Regardless of the size of the organization, persons identified with these responsibilities are crucial to an ergonomics program. Purchasing personnel in particular should be included, since the issues raised can dictate new or revised specifications on new equipment orders.

How best to fit these different players into the program could depend on the company's existing occupational safety and health program practices. Integrating ergonomics into the company's current occupational safety and health activities while giving it special emphasis may have the most appeal.

Table 2. Factors affecting worker participation in workplace problem solving

Committee or work group approach	Direct worker input
Work group sizes of 7 to 15 afford ample interaction and cohesive actions.	Procedures are in place that facilitate worker direct reporting to responsible officials on real or alleged problems. Both formal and informal channels can be used.
Work group leaders committed to the process of group problem solving increase chances of success, as does prompt recognition and rewards from higher-level management.	Campaigns are undertaken to solicit worker reports of potential problems and suggestions for improvement in job operations or conditions.
Precautions need to be taken to prevent supervisors, managers, or other team members from dominating discussions or intimidating workers.	Periodic surveys are undertaken to obtain worker reactions to workplace conditions that may suggest or confirm problems.
Adoption of orderly procedures in (1) defining problems, (2) data gathering and analysis, and (3) developing proposed remedies and plans for implementation ensure likely acceptance and support.	Timely feedback and indications of actions taken in response to worker inputs have motivating qualities. Publicizing suggestions implemented and results in newsletters are similarly reinforcing.
Training is needed in the technical aspects of the target problems as well as group interaction. For the latter, workers need training in communication skills; supervisors, in feedback and listening skills.	Workers are most likely to detect hazards having physical, structural features or distinct environmental characteristics. They tend to be less aware or more accepting of risks posed by functional or procedural practices. More hazard awareness training is needed.
Work group expectations and goals need to be realistic; solving easier problems first can build confidence to overcome later frustrations.	
Committees that oversee work groups engaged in problem solving should not overextend their roles in dictating or implementing solutions. A top-down approach sends the wrong signal in efforts to promote worker participation.	

Exhibit 3: A Joint Labor-Management Committee Approach

The ergonomics committee at a plant that manufactured pistons and piston sleeves asked NIOSH to conduct an ergonomics evaluation to further their efforts at reducing cases of musculoskeletal disorders. This committee had been formed as a result of contract negotiations with the local union and in recognition of excessive cases of musculoskeletal disorders and increased production demands. The committee consisted of one hourly and one salaried person from each of six plant departments, one industrial engineer, three manufacturing engineers, three department superintendents, and one secretary, who provided input on office ergonomics. The plant manager chaired the committee, which met for 1 to 2 hours each month. Education and training in ergonomics were provided through viewing videotapes and reading literature received from the State safety councils. Selected workers in the plant workforce also viewed this material.

The committee focused on problem areas identified through examining safety logs, talking with the equipment operators, and observing job operations. Linkages between injury patterns, operator reports, and observations served to target major problem areas for priority attention. In one instance, a cluster of upper-limb problems was reported by the milling machine operators who had to open and close the machine doors manually for each piston sleeve being milled. The committee decided to install automatic door openers and closers. Workers suggested these and other ergonomic solutions to apparent problems, and the controls were fabricated in the plant's maintenance department. However, because of their limitations in addressing the less obvious ergonomic problems, the committee asked for NIOSH assistance.

NIOSH recommended specific control measures on the basis of its investigators' observations and acknowledged the need for more on-site training of workers in recognizing ergonomic hazards and risks of musculoskeletal injury in their jobs. In light of the plant safety data and observations of job operations, guidance was offered to create a more proactive effort in preventing WMSDs. A limitation of the committee approach used in this plant was that most of the input came from management. Their preoccupation with production demands could override the time and effort needed to resolve job tasks presenting risks of WMSDs. On the other hand, the committee benefited from their increased knowledge and experience in dealing with ergonomic hazards. One result was that decisions about future procurements of machines and proposed changes in manufacturing processes were to include ergonomic considerations [HETA 94–0040–2496].

Exhibit 4: A Work Group Approach

In 1992, NIOSH commissioned three case studies to demonstrate the efficacy of using "ergonomics teams" in addressing hazards in meatpacking plants. The studies, conducted at three different sites, depicted a variety of contexts and opportunities for observing the merits of this form of worker involvement. The studies showed the following:

- Sustained participatory efforts in ergonomics problem solving require strong in-house direction and support plus significant staff expertise in both team building and ergonomics. In one of the three cases in which the effort was largely driven by an outside investigator, there were indications the program would not be sustained.
- Accomplishments, in terms of number of tasks or jobs analyzed and solutions offered and implemented, were most apparent in those cases showing significant training efforts in both team building (group techniques in task analyses, interpersonal processes, developing consensus) and ergonomics (defining risk factors related to musculoskeletal disorders and techniques for job analyses). The case indicating the least progress had limited formal training in ergonomics and used the team simply to brainstorm possible solutions to problems without much other background preparation.
- Most team progress was evident if teams were kept small and included production workers engaged in the jobs under study, area supervisors, and maintenance and engineering staff who could effect proposed job improvements. In two cases, higher personnel served on second-level groups providing oversight to the team activities and approval of actions as needed.
- Team members in the three case studies shared information (injury and production data) bearing on job problems. In addition, reports about the teams' objectives, progress, and accomplishments were circulated to keep the plant workforce informed. Problem-solving goals, as established by the teams, took more time than anticipated to attain. More realistic goals may need to be set [Gjessing et al. 1994].

Note: In two of the three plants in which these case studies were conducted, worker members were chosen by the unions to serve on the work team. The formation of these teams did not violate the existing collective bargaining process.

Exhibit 5: An Individual Input Approach

NIOSH sponsored a study at a major hospital site in which a plan was followed based on employee hazard recognition and problem solving. A special committee was developed to encourage workers to report unsafe conditions and to make suggestions for corrective measures. The committee provided prompt feedback about actions taken through the hospital-wide posting of bulletins on progress, as well as other forms of publicity.

Measurements taken before and 12 months after the program was implemented showed a 33% increase in the number of hazards reported by workers, with a corresponding drop in injury rates of 25%. These rates suggested an increased safety consciousness among the workers and a consequent reduction in injuries. Relevant to the subject of ergonomics were results found in comparing the content of the hazard reports with the actual agent or injury data. Workers tended to detect more physical hazards (slip and trip hazards, struck by or against hazards) than were accounted for in terms of actual injury, but they clearly underestimated those involving overexertion, such as in patient lifting or other procedural-type situations. These data suggested the need for more worker training devoted to these kinds of concerns [Lin and Cohen 1983].

STEP 3
TRAINING—BUILDING IN-HOUSE EXPERTISE

- **Ergonomics Awareness Training**
- **Training in Job Analyses and Control Measures**
- **Training in Problem Solving**
- **Special Considerations and Precautions**

Identifying and solving workplace WMSD problems require some level of ergonomic knowledge and skills. Recognizing and filling different training needs is an important step in building an effective program.

Training is recognized as an essential element for any effective safety and health program [Colligan 1994]. For ergonomics, the overall goal of training is to enable managers, supervisors, and employees to identify aspects of job tasks that may increase a worker's risk of developing WMSDs, recognize the signs and symptoms of the disorders, and participate in the development of strategies to control or prevent them [Kuorinka and Forcier 1995]. Training employees ensures that they are well informed about the hazards so they can actively participate in identifying and controlling exposures. Common forms of ergonomics training are noted below, along with their objectives. Table 3 lists the categories of employees who should receive the indicated instructions, especially if a team approach is used to analyze job risk factors and develop control measures. Employers may opt to have outside experts conduct these tasks. If so, the outside instructors should first become familiar with company operations and relevant policies and practices before starting to train. Tailoring the instruction to address specific concerns and interests of the worker groups can enhance learning.

ERGONOMICS AWARENESS TRAINING

The objectives for ergonomics awareness training are as follows:

- Recognize workplace risk factors for musculoskeletal disorders and understand general methods for controlling them.
- Identify the signs and symptoms of musculoskeletal disorders that may result from exposure to such risk factors, and be familiar with the company's health care procedures.
- Know the process the employer is using to address and control risk factors, the employee's role in the process, and ways employees can actively participate.
- Know the procedures for reporting risk factors and musculoskeletal disorders, including the names of designated persons who should receive the reports.

Table 3. Ergonomics training for various categories of employees

	All employees	Every employee in suspect problem jobs	Every supervisor of jobs with suspect problems	Every employee involved in job analysis and control development	Ergonomics team or work group members[1]
General ergonomics awareness information[2]	X	X	X	X	X
Formal awareness instruction and job-specific training		X	X	X	X
Training in job analysis and controlling risk factors				X	X
Training in problem solving and the team approach					X

[1]If ergonomics teams are formed, added instruction is needed in team-building and consensus development processes, apart from application of ergonomics techniques.

[2]General ergonomics awareness information for all employees need not require class instruction; it can be disseminated via handouts and all-hands meetings.

TRAINING IN JOB ANALYSES AND CONTROL MEASURES

The objectives for training in job analyses and control measures are as follows:

- Demonstrate the way to do a job analysis for identifying risk factors for musculoskeletal disorders.
- Select ways to implement and evaluate control measures.

TRAINING IN PROBLEM SOLVING

The objectives for training in problem solving are as follows:

- Identify the departments, areas, and jobs with risk factors through a review of company reports, records, walk-through observations, and special surveys.
- Identify tools and techniques that can be used to conduct job analyses and serve as a basis for recommendations.
- Develop skills in team building, consensus development, and problem solving.
- Recommend ways to control ergonomic hazards based on job analyses and pooling ideas from employees, management, and other affected and interested parties.

SPECIAL CONSIDERATIONS AND PRECAUTIONS

Materials for offering awareness training to the workforce are available, including videotapes and pamphlets from NIOSH and other groups (see Trays 3 and 10 of the Toolbox). Employers may prefer to generate their own informational materials tailored to their particular job operations. Persons or groups assigned to or expected to play a key role in ergonomic hazard control work will require added instruction in problem identification, job analyses, and problem-solving techniques. This training is available through short courses publicized in many occupational safety and health publications or through a consultant.

Training objectives are not intended to have workers, supervisors, or managers diagnose or treat WMSDs. Rather, the purpose is to instill an understanding of what type of health problems may be work related and when to refer employees for medical evaluation. The training should include what is known about work and nonwork causes of musculoskeletal disorders and the current limitations of scientific knowledge.

Training should be understandable to the target audience. Training materials used should consider the participants' educational levels, literacy abilities, and language skills. This may mean, for example, providing materials, instruction, or assistance in Spanish rather than English.

Open and frank interactions between trainers and trainees, especially those in affected jobs, are especially important. Employees know their own jobs better than anyone else and often are the source of good ideas for ways to improve them. At a minimum, employees must be given an opportunity to discuss ergonomic problems in their jobs as they see them and engage in relevant problem-solving exercises during the training.

One NIOSH experience in direct worksite training included a demonstration study in which a work group or team approach was adopted for problem solving. Training efforts to prepare the team to perform this function are described in Exhibit 6.

Exhibit 6: Team Training in Ergonomic Problem Solving

University investigators, in partnership with NIOSH, undertook a case study of an ergonomics team approach in implementing control measures to reduce WMSDs at a meatpacking plant. In all, five joint management-labor teams representing different departments, each consisting of 7 to 9 members, were formed. Team-building training consisted of sessions designed to enhance the members' abilities to work together. Team-building activities included

- defining a team,
- determining the goals of an ergonomics team,
- establishing group meeting rules and team roles,
- reviewing guidelines for effective group discussion and constructive feedback, and
- practicing brainstorming exercises and techniques for consensus building.

Consistent with the approaches advocated by experts in team building, the training emphasis throughout was about the way to develop task-oriented skills and positive, interpersonal processes. Forms for documenting team members' responsibilities, records of meetings and actions taken, and other handouts served to reinforce these points.

The ergonomics training given to the teams included using videotaped instruction and practice in job analysis techniques to identify and prioritize jobs needing intervention. The video analysis used a rating technique to determine the extent of hand, wrist, arm, and shoulder movements, as well as the positions of the backs and necks of workers while they performed tasks in their departments. Job analyses used OSHA log entries, observations of job tasks, and worker input about ways to ease the difficulty of those job operations presenting the most stressful problems [Gjessing et al. 1994].

STEP 4
GATHERING AND EXAMINING EVIDENCE OF WMSDs

- **Health and Medical Indicators**
  - **Following up of worker reports**
  - **Reviewing OSHA logs and other existing records**
  - **Conducting symptom surveys**
  - **Using periodic medical examinations**

- **Identifying Risk Factors in Jobs**
  - **Screening jobs for risk factors**
  - **Performing job analyses**
  - **Setting priorities**

Once a decision has been made to initiate an ergonomics program, a necessary step is to gather information to determine the scope and characteristics of the problem or potential problem. A variety of techniques and tools have been used; many provide the basis for developing solutions to identified problems.

HEALTH AND MEDICAL INDICATORS

Following up of Worker Reports

Assuring that employees feel free to report, as early as possible, symptoms of physical stress is a key component of any ergonomics program. Early reporting allows corrective measures to be implemented before the effects of a job problem worsen. As mentioned earlier, individual worker complaints that certain jobs cause undue physical fatigue, stress, or discomfort may be signs of ergonomic problems. Following up on these reports, particularly reports of WMSDs, is essential. Such reports indicate a need to evaluate the jobs to identify any ergonomic risk factors that may contribute to the cause of the symptoms or disorders. Techniques to evaluate jobs are described later.

Reviewing OSHA Logs and Other Existing Records

Inspecting the logs of injuries and illnesses required by OSHA and plant medical records can yield information about the nature of WMSDs, as can workers' compensation claims, insurance claims, absentee records, and job transfer applications. Finding workers in certain departments or operations presenting more of these problems than others (and exhibiting the same types of musculoskeletal disorders) would suggest some immediate areas for study with regard to possible risk factors. Jobs with elevated rates of low back musculoskeletal disorders often also have higher risks for acute injuries due to slips and trips or other safety hazards. In these cases, acute musculoskeletal injuries may also be an important problem.

NIOSH evaluations of alleged work-related musculoskeletal problems begin with an examination of OSHA and medical records to understand the magnitude and seriousness of such problems. These records may also offer leads to jobs or operations that may cause or contribute to musculoskeletal disorders. Exhibits 7 and 8 illustrate the kind of data one might find, the evaluations made to judge the significance of the data, and their use in targeting jobs for ergonomic risk analysis.

Conducting Symptom Surveys

In Exhibit 8, entries from OSHA records and other medical reports documented worker disorders, and information from interviews with workers linked the disorders to workplace factors. Interviews or symptom surveys have been used to identify possible WMSDs that might otherwise go unnoticed. In addition to questions about the type, onset, and duration of symptoms, symptom survey forms may include a body map [Corlett and Bishop 1976; Hales and Bertsche 1992] wherein the respondent is asked to locate and rate the level of discomfort experienced in different areas of his or her body. The assumption is that any discomfort or symptoms may be associated with some increased risk for WMSDs. Compared with OSHA logs, symptom surveys provide a more sensitive way to determine who has symptoms and who does not. A disadvantage of symptom questionnaires is their reliance on self-reports. Other factors besides the presence or absence of WMSDs may influence the reporting of symptoms, and the analysis and interpretation of questionnaire data can be complex.

Hales and Bertsche [1992] offer one example of a symptom survey form (see Tray 4-B of the Toolbox). Such data collection can help identify specific jobs or job elements deserving an ergonomic analysis. Also needed are other questions dealing with the worker's perception of job tasks that induce the discomfort. Exhibit 9 describes a NIOSH health hazard evaluation that used a questionnaire to gather relevant symptom data.

Using Periodic Medical Examinations

A disadvantage of using OSHA logs or company medical information to identify possible cases of WMSDs is the lack of specific or uniform medical information. This limitation

Exhibit 7: Reviewing OSHA Logs

NIOSH was asked to conduct a health hazard evaluation at a plant that fabricates wheels for trucks and busses. Major plant processes involved forming steel stock into the rims and center cores of the wheels, welding them together, and finishing and painting the welded product which was then crated for shipment. One objective of the evaluation was to verify the company's concerns about musculoskeletal problems that seemed related to operations in assembly and disc forming work. NIOSH reviewed the company's OSHA log entries for injuries and illnesses for the past 2 years and found about half (291 of a total of 588 entries) were cases of strains and sprains, carpal tunnel syndrome, tendinitis, bursitis, and other musculoskeletal problems. The musculoskeletal injury rate for the plant was 26.1 injuries per 100 employees. This rate exceeded the expected rate of 10.6 injuries per 100 employees based on the Bureau of Labor Statistics' reports that were then available for the motor vehicle parts industry. Back injury (primarily low back strain) constituted the largest proportion of injuries in the strain and sprain category; the total plant rate for back disorders was 11.3 injuries per 100 workers per year which was 5 times the rate for the industrial workforce as a whole. The rate of back disorders was highest in the Assembly Department (23.7 injuries per 100 workers per year) followed by the Disc Forming Department (20.0 injuries per 100 workers per year). Consequently, job tasks in these two departments became the primary targets for analyzing and controlling risk factors (predominantly repeated, heavy lifting) that could account for the observed musculoskeletal problems [HETA 88-277-2069].

Exhibit 8: Using OSHA Logs and Worker Interviews

On the recommendation of a State occupational safety and health agency and on the basis of their inspection of certain work conditions, the management of a window manufacturing plant asked NIOSH to evaluate the risk of carpal tunnel syndrome among workers engaged in assembling window units. As part of a medical evaluation, NIOSH investigators reviewed OSHA Form 200 logs and pertinent company medical records and held confidential interviews with workers doing the assembly work. Questions asked during the interviews sought information about the symptoms workers experienced since beginning work at the plant, including the date of onset, location, type, severity and timing (during day or night, steady or intermittent), duration, medical and surgical treatment, past medical history, most difficult job tasks, and hobbies. They also asked for suggestions for changes in assembly procedures or tools used to alleviate apparent problems. The following case definition of work-related carpal tunnel syndrome was adopted in assessing these data:

- During the interview, the worker reported pain, numbness, or tingling affecting the median nerve distribution of the hand(s).
- Symptoms lasted at least 1 week or occurred on multiple occasions.
- Symptoms were severe enough to waken the person from sleep.
- Evidence existed of work relatedness in that the symptoms began after starting work at a job involving recognized risk factors for carpal tunnel syndrome (e.g., repetitive hand movements, excessive force, awkward hand positions, pinch grips, etc.).

A medically confirmed case of probable *work-related* carpal tunnel syndrome was said to exist if the above criteria were met, and the employee had sought medical care and was diagnosed as having carpal tunnel syndrome. Medical records were reviewed to confirm the diagnosis.

A review of OSHA Form 200 logs from over a 3-year period indicated no hand/wrist disorder entries the first year, two entries for hand/wrist pain in the second year, and nine entries for either hand/wrist pain or carpal tunnel syndrome in the third year. As the size of the assembly workforce over the 3-year period remained the same (27 to 28 workers), these data suggested a worsening problem. The medical interviews of all 28 assembly workers indicated five confirmed cases of carpal tunnel syndrome (three surgically treated at the time of the evaluation) and five other possible carpal tunnel syndrome cases. Other health effects included numbness in the ulnar nerve (three workers), ganglionic cysts (two workers), tendinitis (three workers), elbow pain (one worker), neck pain (one worker), and shoulder pain (one worker).

The ensuing ergonomics evaluation of assembly work tasks revealed repetitive hand/wrist manipulations (8 of 12 job tasks requiring 20,000+ movements per shift) with varying degrees of force and bent wrist positions—all risk factors commonly associated with carpal tunnel syndrome. The pressure to increase production and working with defective materials which necessitate using added force to assemble parts were believed to worsen the problem [HETA 88-361-2091].

may make the identification of WMSDs difficult. One optional approach to overcome this limitation is to have each worker undergo a periodic standardized examination that includes a history and physical examination. Such an examination program should be designed and administered by a health care provider. NIOSH has undertaken studies in which physical examinations were given to workers to establish the prevalence of upper extremity musculoskeletal disorders and to establish whether evidence of excessive numbers of cases could be related to certain working conditions. One such study is described in Exhibit 10.

IDENTIFYING RISK FACTORS IN JOBS

Screening Jobs for Risk Factors

Health records or medical examinations and symptom surveys may indicate the nature and extent of musculoskeletal problems in the workforce. Efforts to identify jobs or tasks having

Exhibit 9: Symptom Surveys

NIOSH was asked to evaluate the incidence of upper limb disorders among workers engaged in sewing tasks at a uniform manufacturing company. The request was prompted by employee complaints that included aching, numbness, clumsiness, and swelling of the wrists and hands. OSHA log data were nonexistent in this plant at the time of this 1983 investigation. A medical questionnaire was specially designed to gather data on upper limb symptoms, with particular emphasis on hand/wrist problems. Sections of the questionnaire covered the usual background information (age, sex, occupational history), the present job at the plant, the nature of hand motions (lifting and lowering, pushing and pulling, twisting and turning, screwing, bending and rotating wrists, pinching and grasping with fingers), pain and discomfort areas (neck, shoulders, arms, elbows), the nature of symptoms in hands or wrists (swelling, stiffness, cramping burning, tingling), the time of onset (late night awakenings), and any difficulties with hands and fingers in some everyday tasks (e.g., buttoning shirt, turning key in lock or doorknob, holding tools) plus medical history asking about any injury, surgery, or pre-existing diagnostic problem (e.g., arthritis) that could account for apparent problems. A section of the questionnaire also included a picture of both surfaces of the right and left hands with the instruction to shade in those areas where most of the discomfort or difficulty occurs. A total of 64 of 90 sewing machine operators completed this form. Neck, shoulder, and arm pain were commonly reported by these operators, with the symptom reports rarely dropping below 36% and ranging as high as 80%. The most numerous hand/wrist symptoms were numbness, cramping, and tingling sensations (varying from 43% to 60%). Despite the frequent occurrence among sewers of symptoms suggestive of upper limb musculoskeletal disorders, jobs rated high and low in ergonomic risk factors showed only small differences in the rate of the symptoms reported. Possible reasons for the lack of differentiation are given in the report [HETA 83–205–1702].

Exhibit 10: Use of Diagnostic Tests

In response to a union request, NIOSH conducted a study to evaluate whether cashiers in a major supermarket chain were developing upper extremity musculoskeletal disorders because of their jobs. The evaluation had two major components.

- The first component compared the rate of upper extremity musculoskeletal disorders in the cashiers with the rate in other supermarket workers. For this purpose, physical exams were given to both groups of workers, including range of motion, limb bending, and stretching tests. The workers rated the pain experienced for the maneuvers. Positive responses on these tests for a particular part of the body, together with questionnaire data indicating recurring or prolonged discomfort in the same area (which began after starting work at the supermarket) were defined as a WMSD. To ensure objectivity, these determinations were made by a physician who had no prior knowledge of either the existing disease state or the job titles of the workers.
- The second component consisted of direct observation and a videotape analysis of the cashier's job, measuring the number of items processed, the number of scans, and the number of keyboard entries required of the cashier. These data were used to gauge task repetitiveness, posture factors, the force required, and efficiency of movement for different checkout counter designs.

The study results indicated that the cashiers had a higher rate of upper extremity disorders than other supermarket workers for all parts of the upper body and that those cashiers with longer employment or who spent more hours per week in checkout tasks showed more evidence of such problems. Further analyses in this study sought to isolate certain checkout counter design features, tasks, and work practices as possible stress factors in light of the pattern of musculoskeletal problems noted [HETA 88–344–2092].

known risk factors for musculoskeletal problems can provide the groundwork for changes aimed at risk reduction. Even without clear medical evidence, screening jobs for musculoskeletal risk factors can offer a basis for early interventions. (See the "Proactive Ergonomics" section of this primer.)

A great deal of ergonomic research has been conducted to identify workplace factors that contribute to the development of musculoskeletal disorders [Kourinka and Forcier 1995; Riihmaki 1991; Garg and Moore 1992; Silverstein et al. 1986; Salvendy and Smith 1981]. NIOSH has recently summarized the epidemiological scientific studies that show a relationship between specific work activities and the development of musculoskeletal disorders [NIOSH, in press]. A variety of non-epidemiological research, including clinical, biomechanical, and psychophysical studies, supports these findings [Pope et al. 1991; Ranney et al. 1995; Szabo and Chidgey 1989; Waters et al. 1993; Chaffin and Andersson 1984; Fransson-Hall et al. 1995; Ulin et al. 1993].

According to the scientific literature, the following are recognized as important risk factors for musculoskeletal disorders, especially when occurring at high levels and in combination. Figure 1 provides illustrations of some of these risk factor conditions. In general, knowledge of the relationships between risk factors and the level of risk is still incomplete. Also, individuals vary in their capacity to adjust to the same job demands. Some may be more affected than others.

- **Awkward postures**

  Body postures determine which joints and muscles are used in an activity and the amount of force or stresses that are generated or tolerated. For example, more stress is placed on the spinal discs when lifting, lowering, or handling objects with the back bent or twisted, compared with when the back is straight. Manipulative or other tasks requiring repeated or sustained bending or twisting of the wrists, knees, hips, or shoulders also impose increased stresses on these joints. Activities requiring frequent or prolonged work over shoulder height can be particularly stressful.

- **Forceful exertions (including lifting, pushing, and pulling)**

  Tasks that require forceful exertions place higher loads on the muscles, tendons, ligaments, and joints. Increasing force means increasing body demands such as greater muscle exertion along with other physiological changes necessary to sustain an increased effort. Prolonged or recurrent experiences of this type can give rise to not only feelings of fatigue but may also lead to musculoskeletal problems when there is inadequate time for rest or recovery. Force requirements may increase with

  — increased weight of a load handled or lifted,

  — increased bulkiness of the load handled or lifted,

  — use of an awkward posture,

  — the speeding up of movements,

  — increased slipperiness of the objects handled (requiring increased grip force),

  — the presence of vibration (e.g., localized vibration from power handtools leads to use of an increased grip force),

  — use of the index finger and thumb to forcefully grip an object (i.e., a pinch grip compared with gripping the object with your whole hand), and

  — use of small or narrow tool handles that lessen grip capacity.

Figure 1. Illustrations of selected risk factor conditions. (Illustrations adapted from UAW-GM Center for Health & Safety [1990]; Putz-Anderson V [1988]; Grant et al. [1995]; Canadian Center of Occupational Safety and Health [1988]; American Meat Institute and Ergo Tech, Inc. [1990].

- **Repetitive motions**

  If motions are repeated frequently (e.g., every few seconds) and for prolonged periods such as an 8-hour shift, fatigue and muscle-tendon strain can accumulate. Tendons and muscles can often recover from the effects of stretching or forceful exertions if sufficient time is allotted between exertions. Effects of repetitive motions from performing the same work activities are increased when awkward postures and forceful exertions are involved. Repetitive actions as a risk factor can also depend on the body area and specific act being performed. (See Table 4 in the main text and Tray 6-B in the Toolbox.)

- **Duration**

  Duration refers to the amount of time a person is continually exposed to a risk factor. Job tasks that require use of the same muscles or motions for long durations increase the likelihood of both localized and general fatigue. In general, the longer the period of continuous work (e.g., tasks requiring sustained muscle contraction), the longer the recovery or rest time required.

- **Contact stresses**

  Repeated or continuous contact with hard or sharp objects such as non-rounded desk edges or unpadded, narrow tool handles may create pressure over one area of the body (e.g., the forearm or sides of the fingers) that can inhibit nerve function and blood flow.

- **Vibration**

  Exposure to local vibration occurs when a specific part of the body comes in contact with a vibrating object, such as a power handtool. Exposure to whole-body vibration can occur while standing or sitting in vibrating environments or objects, such as when operating heavy-duty vehicles or large machinery.

- **Other conditions**

  Workplace conditions that can influence the presence and magnitude of the risk factors for WMSDs can include

  — cold temperatures,

  — insufficient pauses and rest breaks for recovery,

  — machine paced work, and

  — unfamiliar or unaccustomed work.

In addition to the above conditions, other aspects of organization of work may not only contribute to physical stress but psychological stress as well. Scientific research is examining work factors such as performance monitoring, incentive pay systems, or lack of control by the worker to determine whether these factors have a negative effect on the musculoskeletal system [Moon and Sauter 1996]. Another related area of research is to determine which personal, work, or societal factors contribute to acute musculoskeletal disorders developing into chronic or disabling problems.

Screening jobs for these risk factors may involve the following:

- Walk-through observational surveys of the work facilities to detect obvious risk factors
- Interviews with workers and supervisors to obtain the above information and other data not apparent in walk-through observations, such as time and workload pressures, length of rest breaks, etc.
- Use of checklists for scoring job features against a list of risk factors

Of the above three methods, the checklist procedure provides the most formal and orderly procedure for screening jobs. Numerous versions of checklists exist in ergonomics manuals. When checklist data are gathered by persons

familiar with the job, task, or processes involved, the quality of the data is generally better. Checklist procedures are also typically used in more complete job analyses (described below). Samples of checklists are found in Tray 5 of the Toolbox.

While screening tools such as checklists have been widely and successfully used in many ergonomics programs, most have not been scientifically validated. Combining checklist observations with symptoms data offers a means of overcoming uncertainty.

Integrating efforts to identify risk factors for musculoskeletal disorders with efforts to identify common safety hazards such as slips and trips should be considered. Jobs with risk factors for musculoskeletal disorders also may have safety hazards.

Performing Job Analyses

Job analysis breaks a job into its various elements or actions, describes them, measures and quantifies risk factors inherent in the elements, and identifies conditions contributing to the risk factors [Putz-Anderson 1988; Keyserling et al. 1993; Grant et al. 1995; ANSI 1996].

Job analyses are usually done by persons with considerable experience and training in these areas. While most job analyses have common approaches, such as a focus on the same set of risk factors described on pages 20 to 22, no "standard" protocol exists for conducting a job analysis to assess ergonomic hazards.

Most job analyses have several common steps. A complete description of the job is obtained. Employees are often interviewed in order to determine if the way the job is done changes over time. During the job analysis, the job is divided into a number of discrete tasks. Each task is then studied to determine the specific risk factors that occur during the task. Sometimes each risk factor is evaluated in terms of its magnitude, the number of times it occurs during the task, and how long the risk factor lasts each time it occurs.

The tasks of most jobs can be described in terms of (1) the tools, equipment, and materials used to perform the job, (2) the workstation layout and physical environment, and (3) the task demands and organizational climate in which the work is performed. Job screening, as described above, provides some of these data. More definitive procedures for collecting information on these components can include the following:

- Observing the workers performing the tasks in order to furnish time-activity analysis and job or task cycle data; videotaping the workers is typically done for this purpose
- Still photos of work postures, workstation layouts, tools, etc., to illustrate the job
- Workstation measurements (e.g., work surface heights, reach distances)
- Measuring tool handle sizes, weighing tools and parts, and measuring tool vibration and part dimensions
- Determining characteristics of work surfaces such as slip resistance, hardness, and surface edges
- Measuring exposures to heat, cold, and whole body vibration
- Biomechanical calculations (e.g., muscle force required to accomplish a task or the pressure put on a spinal disc based on the weight of a load lifted, pulled, or pushed)
- Physiological measures (e.g., oxygen consumption, heart rate)
- Special questionnaires, interviews, and subjective rating procedures to determine the amount of perceived exertion and the psychological factors influencing work performance

Exhibits 11 to 14 illustrate the varied approaches that NIOSH has taken in analyzing and evaluating jobs for apparent risk factors.

While a job analysis enables a person to characterize ergonomic risk factors, the question of what level or amount of exposure is harmful to the musculoskeletal system is a difficult one. Some have argued against the overuse of simple guidelines [Buckle et al. 1992; Leamon 1994], while others have recognized that, despite the limitations of current guidelines, many contain sufficiently useful information to identify potentially risky work activities [Karwowski 1993; Waters et al. 1993; Winkel et al. 1992]. While acknowledging the limitations of current knowledge, NIOSH and others conducting job analyses have used a variety of approaches to provide answers best suited for the specific workplaces under study. One approach calculates the muscle strength required to perform a certain job task and estimates the fraction of the working population that possesses the required strength. A second approach asks workers in the laboratory to judge acceptable work conditions by engaging them in tasks that impose different physical demands. A third method compares the forces generated in a part of the body when performing specific work tasks and compares it with a level believed to be harmful. Tray 6 of the Toolbox section contains references to and information about these and other approaches.

NIOSH recommends the use of the NIOSH lifting equation as one useful approach in both the design of new lifting tasks and in the evaluation of existing lifting tasks [Waters et al. 1993; Waters et al. 1994]. Other assessment tools are also available for evaluating such tasks [Chaffin and Andersson 1991; Marras et al. 1993, 1995; Hidalgo et al. 1995]. Population data depicting human strength capacities can be helpful in designing and evaluating jobs [Snook and Ciriello 1991]. Tables indicating standing and seated height and reach distances that can accommodate various proportions of the worker population [Kroemer and Kroemer-Elbert 1994] can also be helpful. Comparing job analysis results with such references can yield estimates of the percentage of the population that may be especially affected by these job conditions. In some NIOSH evaluations, efforts have been made to duplicate the specific stresses observed in the job to calculate forces on joints and limbs and to arrive at risk determinations [Habes and Grant, in press]. Computerized 2- and 3-dimensional biomechanical models can predict the percentage of males and females capable of exerting static forces in certain postures [Chaffin and Andersson 1991]. Westgaard and Winkel [1996, p. 87] recently summarized the strengths and weaknesses of current guidelines by concluding that "at present, guidelines to prevent musculoskeletal disorders can only give directions, not absolute limits." These authors believe the best guidelines must consider the level, duration, and frequency of exposure.

Table 4 presents the reference levels or limiting conditions used by NIOSH to rate risk factors of consequence to the musculoskeletal problems under investigation. (For the scientific justification of each guideline or approach, the reader is referred to the references indicated in Table 4.) In some instances these determinations were based on more than one rating procedure. For example, judgments of problematic lifting conditions in many NIOSH investigations have been derived both from use of the NIOSH lifting equation [Waters et al. 1993; Waters et al. 1994] as well as the Michigan computerized 2- and 3-dimensional analyses [Chaffin and Andersson 1991].

The entries in Table 4 are offered as illustrative examples of reference levels or guidelines. The actual risk to each worker depends not only on the current level of exposure to risk factors, but also on their physical capability, their past medical history, concurrent nonwork exposures, and

Exhibit 11: Cabinet Manufacturing Work Setting

The site was a cabinet manufacturing company in which basic work processes involved sawing rough lumber, planing cabinet panels and parts, sanding and painting, assembly, and packing and shipping. A total of 17 jobs representing one full production of a kitchen cabinet were first screened on the basis of job descriptions and walk-through observations for risk of both musculoskeletal disorders and traumatic injury. Five job tasks (three lifting tasks and two pushing and pulling tasks) were selected for more in-depth analyses because of their linkage with excessive back strain and sprain reports among the workers. Videotapes and still photos were taken of the job tasks, along with workstation measurements. (NIOSH protocols for analyzing videotapes of job operations are described in Tray 5-H of the Toolbox.) Frequencies, weights, and heights of loads lifted were noted together with measurements of initial and sustained push forces. Applying the NIOSH 1980 lifting equation formula for defining lift weight limits and the Michigan 2-dimensional static strength prediction program showed that the three lifting jobs presented conditions warranting control actions to reduce risk of overexertion or back injury. (Information about these two techniques is included in Tray 6 of the Toolbox.) Initial and sustained push forces for the other two jobs were rated against maximal acceptable values reported in the literature for 50% of the male and female population. One of these two tasks (pushing stacking bunks) exceeded these values and was judged potentially hazardous; recommendations for risk reduction were offered [HETA 88–384–2062].

Exhibit 12: Window Balance Systems Manufacturing Work Setting

The site was a plant that produced window balance systems. The product was made from either stamped, roll-formed aluminum or extruded vinyl. Both metal fabrication and extrusion operations were performed at the plant. All 12 jobs in the assembly department were targeted for analyses on the basis of earlier State inspection reports describing conditions associated with the development of carpal tunnel syndrome. These jobs were observed in a plant walk-through and videotaped for later analyses. Information was collected concerning the number of employees engaged, the task elements, the number of pieces assembled per work shift, the tools used, the difficulties workers perceived in the job, and worker suggestions for improvements. Measurements were also taken of work surface heights (both worktable and conveyor). A review of the videotape in real time and slow motion yielded data on repetitiveness of movements, awkward hand/wrist and shoulder postures, and indicators of muscular force requirements. The task cycle times were derived from these observations, along with the number of hand/wrist motions (flexion, extension, ulnar and radial deviation, pinching) and the number of unnatural shoulder positions. Particularly extreme postures were noted in the videotape analyses as one means for rating muscular force exerted. Other bases for rating force were the number of forceful manipulations in a given job cycle, the size and type of tool used, and the weight of the product handled.

Jobs were rated for ergonomic stress to prioritize interventions needed to eliminate the stress. The job ratings were determined by combining the observed level of repetitiveness or movements per day with the level of force. Three levels of repetitiveness were defined and assigned values. A value of "1" was given for jobs with low (fewer than 10,000) movements per day, "2" for jobs with medium (10,000–20,000) movements per day, or "3" for high (more than 20,000) movements per day. Average and peak levels of force were also judged by the investigators and given ratings of "1" or "2" (low force), "3" (medium force), or "4" or "5" (high force).

The total stress score for each job was determined by adding the assigned values for the repetition and force. Two jobs (pulling springs to attach them to window liners and hooking springs into window liners) were found to represent the greatest musculoskeletal stress when rated in this way. However, all of the assembly jobs were found to pose problems requiring ergonomic hazard control actions [HETA 88–361–2091].

Exhibit 13: Grocery Warehouse Setting

The site was a large grocery warehouse with the focus on order selector jobs. Order selectors load cases of grocery items from warehouse shelves to pallets according to a "picking order" (a listing of the items and quantities to be picked), the order of picking the items, and their locations (aisle and slot numbers) in the warehouse. In terms of job tasks, the order selector routine is to drive a pallet jack to the location of the items in the warehouse, lift the items from the shelves, carry them to the pallet, and lift or lower the items onto the pallet and place labels on the items. The order selector then proceeds to the next item on the order list, and the procedure is repeated. After the entire list of orders is picked, the order selector wraps or tapes the stacked cases together and places the loaded pallet on the loading dock for transport from the warehouse. Order selection is known as a physically demanding job. One objective of the NIOSH evaluation was to assess the potential risk associated with the manual lifting tasks just described. Before the evaluation, a standard incentive program was installed at this warehouse to establish a "fair amount of time" for order selecting activities. Achieving 100% of the standard was considered a "day's work." Order selector performance was averaged over a week, and employees were disciplined for performance that fell below 95% of the standard. Workers who exceeded the standard were rewarded with additional pay or paid time off.

Techniques used to assess the potential risk associated with the manual lifting tasks performed by the order selectors included the following:

- Weight measurements of the objects lifted
- Videotape, still photos, and angular measurements of the body postures of workers carrying out the lifting tasks
- Use of a motion monitor to record the motion of the trunk as it may affect the forces on the intervertebral joints of the spinal column
- Time activity analysis of the manual lifting routines of the order selectors, including work-rest cycles
- Use of portable heart monitors and oxygen consumption meters to measure the energy expenditure in the course of carrying out regular order selector activities

Information on load weights and body postures were systematically recorded for five representative lifting tasks that workers and the NIOSH investigators judged as having a high risk of potential for injury. These data served as input to the Michigan 3-Dimensional Static Strength Prediction Program for estimating compressive forces on the lower back and muscle strength requirements for designated lifts. The data were also used in the NIOSH revised lifting formula for recommending weight limits based on the characteristics of a specific lifting task. The evaluations for the five tasks by both the Michigan and NIOSH procedures found all loads to be clearly excessive. In addition, the lumbar movements constituting these tasks, as analyzed and measured in terms of flexion angle of the trunk and lateral and twisting velocity, combined with lifting rate and other factors, indicated a high risk of low back injury based on the models developed by Marras [Marras et al. 1993].

The mean metabolic rates as measured by oxygen consumption were above the value (5.0 kcal/min) recommended in the literature as an upper limit for young male workers during an 8-hour workday. Observed heart rates were also high. Two of the three workers had average heart rates exceeding 110 beats/min, the suggested maximum acceptable for the majority of healthy workers [Astrand and Rodahl 1986].

Time-motion analyses of the data collected indicated that the average frequency of lifts during the normal activities of the selectors was 4.1 lifts/min. This lifting rate, coupled with observed loads averaging 30.4 lb, would probably result in fatigued muscles, especially since a high percentage (53%) of the lifts required extreme trunk flexion and reaches above shoulder height. Calculations for these lifting conditions were well above the upper limits recommended by the NIOSH lifting equation [Waters et al. 1993].

Data collected in this evaluation provided for workers' perceptions of the physical effort required by their jobs and the job demand versus the control they felt they had in their work routines. Findings here indicated "hard physical effort" as the average response, which correlated well with the heart rate and oxygen consumption monitoring already described. Responses to the job demand and control questions, when compared with other worker groups, showed order selecting to be a high demand and low control job. Informal interviews with workers revealed their concern over the work standards and their inability to control the pace of their jobs. The literature associates this combination of job attributes with increased stress and job dissatisfaction [HETA 91–405–2340].

Exhibit 14: Office Setting

The sites were offices in two State governmental agencies in which more than 500 workers performed data entry tasks using VDTs. Questionnaires administered to the total sample of workers indicated a significant prevalence of constant musculoskeletal discomfort, with the greatest number localized to the trunk area, followed by the neck, buttocks, arm/shoulders (particularly on the right side), and, lastly, the lower legs. The specific design features of 40 workstations, representing a subsample of those used by this worker group, were analyzed to determine the extent to which they could account for the complaints. In all cases, the keyboard in these units was positioned immediately in front of the worker, with the document placed either to the left or right or between the keyboard and the display. Documents were manipulated mostly with the left hand, with the right hand used exclusively for keyboard operation. Wrist rests were not available, and flexibility in keyboard and video display placements was limited. Work tables and chairs lacked adjustable features. Various measurements and observations were made at these workstations during actual VDT work, including seat pan heights and compression seat back height, keyboard height, seated postures of the workers, upper arm angles, document distances, head tilt, gaze angle, and chair tilt and swivel. Statistical techniques were used to predict the amount of musculoskeletal discomfort from the aforementioned ergonomic variables. This analysis was performed by the region of the body affected and indicated the ergonomic factors, both singly and in combination, that could account for significant amounts of the reported discomfort in that area. The results showed, for example, that leg discomfort increased when the lower leg length exceeded the seat pan height and when the seat pan was soft. With regard to arm/shoulder discomfort, height discrepancy between the positions of the elbow and the keyboard proved to be a significant predictor as did long reaches to documents with the left arm. Less neck and trunk discomfort was found for erect sitting postures compared with stooped or slouched positions and as the height of the backrest was lowered in relation to the length of the operator's back. These and other findings served as the basis for offering suggestions about workstation configurations that could alleviate the discomfort problems [Sauter et al. 1991].

many other factors. These reference levels have varying degrees of scientific justification. Each was useful in a specific NIOSH workplace investigation aimed at reducing WMSDs.

Setting Priorities

In Exhibits 11 to 14, certain job tasks were targeted for more intensive analysis to verify the existence of risk factors for musculoskeletal disorders.

- In Exhibits 11 and 12, finding *cases of musculoskeletal disorders* prompted the followup analysis.
- In Exhibit 14, complaints of *musculoskeletal discomfort*, established through questionnaires, were the basis for sorting out possible work-related causes.
- The physical demands or *risk factors* of the job described in Exhibit 13, even without medical or symptom data, presented strong risk implications for potential WMSDs, thus triggering the analysis.

These three scenarios offer a basis for setting priorities for undertaking risk factor analyses and implementing control measures. Specifically, jobs associated with cases of musculoskeletal problems deserve the highest consideration in followup efforts to identify risk factors and implement control actions. Jobs in which current cases have been identified should receive immediate attention, followed by those in which past records have noted a high incidence or severity of WMSDs despite the lack of current cases. Priority for job analysis and intervention should be given to those jobs in which most people are affected or in which work method changes are going to be taking place anyway.

Jobs associated with worker complaints of fatigue and discomfort should be ranked next in

deciding needs for followup job analysis and possible interventions.

Finally, where screening efforts suggest the presence of significant risk factors for musculoskeletal disorders, more detailed job analyses should be done to assess the problem potential. Ratings of high or extreme levels of risk factors, especially occurring in combination, may indicate a need for control actions. While appearing last in the priority order, taking steps to reduce apparent risk factors for musculoskeletal disorders is a preventative approach.

Table 5 summarizes the priority considerations in deciding about the need for job analyses and consequent control interventions for addressing WMSDs.

Table 4. Reference levels used in rating job risk factors for musculoskeletal disorders

Risk factor or risk condition	Reference levels used in NIOSH evaluations
Excessive reach	Based on body measurement data indicating comfortable or normal seated and standing arm reach distances for the majority of the male and female population (see Tray 6 of the Toolbox).
Lifting loads	*NIOSH Work Practices Guide* first used in defining acceptable loads to be lifted [NIOSH 1981]. Revised NIOSH lifting equation for recommended weight limits proposed in 1993 [Waters et al. 1993; Waters et al. 1994]. Applies to standing, two-handed, smooth lifting and lowering of stable objects in unrestricted spaces. Calculations take account of the horizontal distance of load from the body, vertical locations of hands at the beginning and end of lift, vertical distance of the load moved, frequency rate of lifting, balance, and coupling factors (see Tray 6 of the Toolbox).
	Michigan 2- and 3-Dimensional Static Strength Prediction Program which estimates, for lifting tasks, the amount of compressive force at the lumbo-sacral disc [Chaffin and Andersson 1991] (see Tray 6 of the Toolbox).
	Model of risk of low back disorders as a function of workplace characteristics and trunk motion characteristics (e.g., lift rate, trunk bending, twisting motion) [Marras et al. 1993, 1995] (see Tray 6 of the Toolbox).
Pushing or pulling loads	Initial and sustained forces of loads pushed or pulled at variable rates that are judged acceptable for 90% of the female work population [Snook and Ciriello 1991] (see Tray 6 of the Toolbox).
Whole-body vibration	International Standards Organization (ISO) Dose System for Whole Body Vibration indicating vibration levels in three dimensions with limiting times for fatigue decreased proficiency [ISO 2631/1, 1985] (see Tray 6 of the Toolbox).
Hand/arm vibration	American National Standards Institute (ANSI) daily exposure limits [ANSI S3.34. 1986] and American Conference of Governmental Industrial Hygienists (ACGIH) [ACGIH 1996] values for judging whether estimated worker task exposure levels are excessive (see Tray 6 of the Toolbox).
Repetition rate	Both the number of hand manipulations per 8-hour work shift and the task cycle time have been used to rate this factor. Task cycle times of 30 sec or less were defined as high repetition; cycle times greater than 30 sec as low repetition. For hand manipulations, high repetitiveness was described as more than 20,000 manipulations per 8-hour work shift; medium repetitiveness as between 10,000 and 20,000 manipulations per 8-hour work shift, and low repetitiveness as less than 10,000 manipulations per 8-hour work shift [HETA 88–361–2091; HETA 88–180–1958]. A recent proposed repetition guideline believed to be more protective is cited by Kilbom [1994] (see Tray 6-B of the Toolbox). This guideline also considers other areas of the upper extremity. Each area may have a different ability to tolerate repetitious activity. At the same rate of repetitions some specific acts such as pinching may be less well tolerated than others. This is an example of complexities that current guidelines may not address adequately.
Force and energy demands of work tasks	Relative ratings on a 5-point scale used to classify task performance as requiring high, medium, and low levels of force [HETA 88–180–1958; HETA 88–361–2091].
	Criterion of 5.0 kcal/min as measured by oxygen consumption used as a limit for energy expenditure [Astrand and Rodahl 1986] (see Tray 6 of the Toolbox).

Table 5. Determining priorities for job analyses and control actions

Priority and action	Nature of available information			
	Current cases of WMSDs for persons in select jobs	**No current cases, but past plant records indicate WMSDs in select jobs or departments that have not changed**	**No current or past cases, but worker complaints and symptom surveys suggest WMSDs in select jobs or departments**	**No cases, reports of WMSDs, or complaints, but job screening and checklists suggest high risk factor potential in select jobs**
Priority for followup analyses and control actions	Immediate need	Priority is second only to the need to address more current cases	Third in priority; resolving problems at an early stage is commendable	While last in priority, this effort is preventive; most positive of all actions
Type of followup job analyses needed	Perform job analyses to sort out and rate job risk factors for observed cases	Perform job analyses to sort out and rate risk factors for jobs with highest number or severity of past WMSDs and largest work group at risk	Perform job analyses to sort out and rate risk factors for jobs having frequent WMSD complaints and symptoms	Perform job analyses to sort out and rate risk factors for jobs with the highest problem potential (based on screening observations)
Focus needed for control actions	Control actions should be focused on reducing the highest rated risk factors in current jobs linked with the greatest number of cases	Control actions should be focused on reducing the highest rated risk factors in jobs with the highest number or greatest severity of past WMSDs for the largest work group at risk	Control actions should be focused on reducing the highest rated risk factors in jobs having frequent WMSD complaints and symptoms	Control actions should be focused on reducing the highest rated risk factors for WMSDs before any are reported

STEP 5
DEVELOPING CONTROLS

- **Types of Controls**
  - **Engineering Controls**
  - **Administrative Controls**
  - **Personal Equipment—Is It Effective?**
- **Implementing Controls**
- **Evaluating Control Effectiveness**

Analyzing jobs to identify factors associated with risks for WMSDs, as discussed in Step 4, lays the groundwork for developing ways to reduce or eliminate ergonomic risk factors for WMSDs. A variety of approaches can help to control these risk factors.

TYPES OF CONTROLS

A three-tier hierarchy of controls is widely accepted as an intervention strategy for controlling workplace hazards, including ergonomic hazards. The three tiers are as follows:

- Reducing or eliminating potentially hazardous conditions using engineering controls
- Changes in work practices and management policies, sometimes called administrative controls
- Use of personal equipment

Engineering Controls

The preferred approach to prevent and control WMSDs is to design the job—including (1) the workstation layout, (2) selection and use of tools, and (3) work methods—to take account of the capabilities and limitations of the workforce. A good match (meaning that the job demands pose no undue stress and strain to the working population as a whole) helps ensure a safe work situation. On the other hand, the presence of risk factors as described in Step 4 represents departures from this goal and would indicate the need for control measures. Engineering control strategies to reduce ergonomic risk factors include the following:

- Changing the way materials, parts, and products can be transported—for example, using mechanical assist devices to relieve heavy load lifting and carrying tasks or using handles or slotted hand holes in packages requiring manual handling
- Changing the process or product to reduce worker exposures to risk factors; examples include maintaining the fit of plastic molds to reduce the need for manual removal of flashing, or using easy-connect electrical terminals to reduce manual forces
- Modifying containers and parts presentation, such as height-adjustable material bins
- Changing workstation layout, which might include using height-adjustable workbenches or locating tools and materials within short reaching distances

- Changing the way parts, tools, and materials are to be manipulated; examples include using fixtures (clamps, vise-grips, etc.) to hold work pieces to relieve the need for awkward hand and arm positions or suspending tools to reduce weight and allow easier access
- Changing tool designs—for example, pistol handle grips for knives to reduce wrist bending postures required by straight-handle knives or squeeze-grip-actuated screwdrivers to replace finger-trigger-actuated screwdrivers
- Changes in materials and fasteners (for example, lighter-weight packaging materials to reduce lifting loads)
- Changing assembly access and sequence (e.g., removing physical and visual obstructions when assembling components to reduce awkward postures or static exertions)

Figure 2 applies a number of these options for controlling the risk factor situations illustrated earlier in Figure 1. Exhibits 15 and 16 illustrate NIOSH efforts to advise companies about engineering control strategies to reduce WMSDs.

Administrative Controls

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to ergonomic risk

Exhibit 15: Engineering Controls—Beverage Delivery

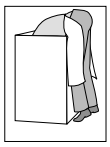
NIOSH staff conducted an ergonomic study of soft beverage driver-sales jobs. Such job tasks as handling beverage cases for delivery were problematic for two reasons: the stacking of cases in the truck bay exceeded the normal reach limit of workers, and most of the beverage lifting tasks also exceeded the recommended weight limit of the 1993 NIOSH lifting equation. Heart rate measurements, as an indicator of the physical effort required for this work, were found to be high among the driver-sales workers, especially during peak periods. Estimates indicate that more than 35,000 lb of beverage products were handled daily by these driver-sales workers. The rate of musculoskeletal injuries for the affected workforce, in terms of days lost, was twice that of workers in general manufacturing jobs.

To relieve the above-mentioned problems, the following engineering controls were implemented:

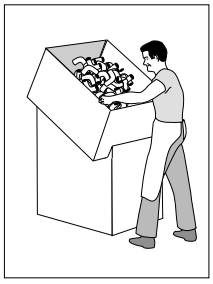
- Pullout platform steps in the bay floors enabling the drivers to step up and work at bay level
- External handles between the bays for workers to grab to give them better mechanical leverage during removal of the beverage product
- Multilevel shelving units that provided compartments for different products, gave easier direct access, and eliminated the problem of having to lift or move different products around to find the ones slated for delivery to a customer
- Lubricated two-wheel hand trucks with proper tire pressure maintained to make pushing and controlling the load easier
- Plastic beverage containers instead of glass ones to reduce package weight
- Improved beverage cartons designed with larger handles and smooth, contoured bases that make them easier to handle when removing stacked cartons from the truck

Changes in work risk factors were documented through videotaping, modeling the stresses imposed on the body by the materials handling tasks, continuous monitoring of heart rate, and analyzing discomfort surveys. Data were compared before, during, and after the ergonomic interventions were implemented.

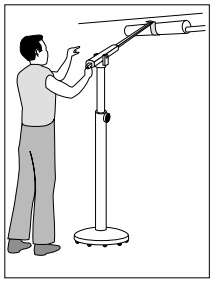
The benefits of the ergonomic interventions were in proportion to the amount of time such controls were used. Reductions in stressors for the back and shoulders were observed when pullout steps, external handles, and multilevel shelving were used. Heart rates decreased for six of nine driver-sales workers during the study period, despite an increase in the product volume handled. The ergonomic interventions reduced the multiple handling of beverage cases and the awkward postures during beverage handling, resulting in a reduced number of reports of fatigue [McGlothlin 1995; NIOSH 1996].



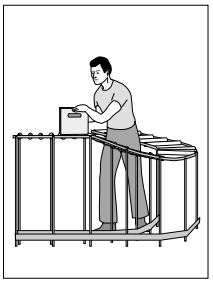
Raise and tilt the container for easier access and to reduce bending and lifting burdens.



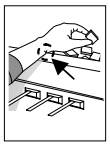
Extend and support tool to reduce stress on arm and shoulder.



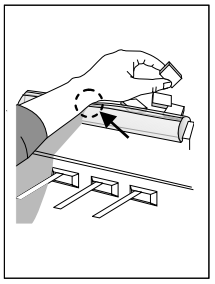
Use conveyors to reduce twisting and eliminate lifting and carrying.



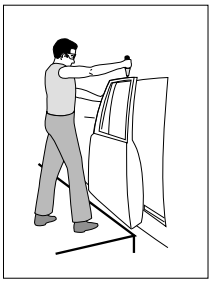
Use a turntable with fixture to hold the work; select a tool that reduces wrist deviations.



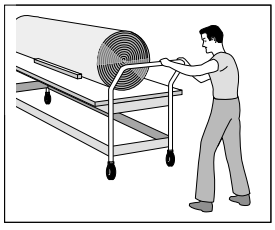
Round or pad edges of guards, containers, or work tables.



Raise worker with platform and use in-line tool to reduce wrist bending.



Use mechanical assist devices for less stressful handling.



Select power tools with anti-vibration properties. Use handle coatings that suppress vibrations; increase coefficient of friction to reduce force requirements.

Use balancers, isolators and damping materials to reduce vibrations at the source or along transmission path. Make driving surface smooth.

Figure 2. Illustrations of some basic ways for controlling selected risk factor conditions.

Exhibit 16: Engineering Controls—Motorcycle Manufacturing

NIOSH researchers conducted initial and follow-up evaluations of musculoskeletal disorders of the upper limbs and back at a motorcycle manufacturing company. The objectives of this evaluation were to identify the job tasks in the flywheel milling department thought to cause musculoskeletal injuries and to provide recommendations to decrease and prevent such injuries. NIOSH researchers reviewed OSHA Form 200 logs and workers' compensation data and conducted an ergonomic evaluation of four jobs in this department (two flywheel milling jobs, one flywheel truing job, and one flywheel balancing job). Data gathered on the initial site visit in the flywheel milling area showed that repeated manual transport, placement, and removal of the flywheels between milling processes resulted in more than 28,000 lb handled per 8-hour shift. In addition, repeated use of a handheld power grinder to remove metal burrs from milled flywheels proved to be inefficient and presented other accident risks. Analysis of data from the flywheel truing job showed that impact forces from the 5-lb brass hammer repeatedly striking the flywheel ranged from 25,000 to 92,000 lb. Using the NIOSH 1993 lifting equation to analyze the flywheel balancing job showed potential risk for back injury. NIOSH recommended engineering controls to reduce risk factors for musculoskeletal disorders, and the company effected a number of them through establishment of a management/labor ergonomic committee. The engineering controls included the following:

- Upgrading forging and milling machine processes and improving product flow to reduce the burden of flywheel handling from 28,000 to 17,500 lb per 8-hour shift
- Installing a customized 40-ton press to eliminate the use of brass hammers for truing the flywheels
- Using an overhead lift to eliminate manual handling of the 35-lb assembled flywheel unit, further reducing the total weight that had to be handled each day

During a 5-year period from 1989 through 1993, the efforts of the plant's management, engineers, and workers resulted in a reduction of WMSDs involving lost or restricted workdays from 27.6 per 100 workers in 1989 to 12.5 per 100 workers in 1993. The severity of musculoskeletal disorders decreased from 610 lost or restricted-activity workdays per 100 workers in 1989 to 190 workdays in 1993 [HETA 91-0208-2422].

factors. Administrative control strategies include (1) changes in job rules and procedures such as scheduling more rest breaks, (2) rotating workers through jobs that are physically tiring, and (3) training workers to recognize ergonomic risk factors and to learn techniques for reducing the stress and strain while performing their work tasks.

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. Since administrative controls do not eliminate hazards, management must assure that the practices and policies are followed. Common examples of administrative control strategies for reducing the risk of WMSDs are as follows:

- Reducing shift length or curtailing the amount of overtime
- Rotating workers through several jobs with different physical demands to reduce the stress on limbs and body regions
- Scheduling more breaks to allow for rest and recovery
- Broadening or varying the job content to offset certain risk factors (e.g., repetitive motions, static and awkward postures)
- Adjusting the work pace to relieve repetitive motion risks and give the worker more control of the work process
- Training in the recognition of risk factors for WMSDs and instruction in work practices that can ease the task demands or burden

Two examples of administrative measures are described in Exhibits 17 and 18.

Personal Equipment—Is It Effective?

One of the most controversial questions in the prevention of WMSDs is whether the use of personal equipment worn or used by the employee (such as wrist supports, back belts, or vibration attenuation gloves) are effective. Some consider these devices to be personal protective equipment (PPE). In the field of occupational safety and health, PPE generally provides a barrier between the worker and the hazard source. Respirators, ear plugs, safety goggles, chemical aprons, safety shoes, and "hard hats" are all examples of PPE. Whether braces, wrist splints, back belts, and similar devices can be regarded as offering personal protection against ergonomic hazards remains open to question. Although these devices may, in some situations, reduce the duration, frequency, or intensity of exposure, evidence of their effectiveness in injury reduction is inconclusive. In some instances they may decrease one exposure but increase another because the worker has to "fight" the device to perform his or her work. An example is the use of wrist splints while engaged in work that requires wrist bending. In the health care management section (Step 6), the use of wrist splints or immobilization devices is also briefly discussed.

On the basis of a review of the scientific literature completed in 1994, NIOSH concluded that insufficient evidence existed to prove the effectiveness of back belts in preventing back injuries related to manual handling job tasks [NIOSH 1994]. A recent epidemiological study credits mandatory use of back belts in a chain of large retail hardware stores in substantially reducing the rate of low back injuries [Kraus 1996]. Although NIOSH believes this study provides evidence that back belts may be effective in some settings for preventing back injuries, NIOSH still believes that evidence for the effectiveness of back belts is inconclusive. This area is being researched, and the questions about the effectiveness of most personal equipment remain open. Less controversial types of personal equipment are vibration attenuation gloves [NIOSH 1989] and knee pads for carpet layers [Bhattacharya et al. 1985]. But even here, there can be concerns. For example, do the design and fit of the gloves make it harder to grip tools?

Exhibit 17: Administrative Controls—Jewelry Manufacturing

NIOSH investigators were asked by a jewelry manufacturer to evaluate upper extremity musculoskeletal disorders among employees. Questionnaire surveys of employees indicated that 66% reported work-related upper extremity musculoskeletal symptoms. In the 2 years before the NIOSH evaluation, physicians diagnosed seven employees with carpal tunnel syndrome.

Besides making numerous specific engineering control recommendations, the NIOSH investigators also suggested the following administrative control strategies:

- Training new employees in proper craftsmanship, tool use, and maintenance—for example, emphasizing the need to keep cutting tools sharp to reduce force requirements and the need to keep power tools balanced and lubricated to minimize vibration
- For new employees, providing more frequent rest breaks at the outset to relieve fatigue and overexertion
- Rotating employees to jobs that require the use of different muscle or tendon groups (for example, NIOSH investigators suggested that employees using small handtools be rotated to inspection tasks)
- Providing more frequent breaks for those employees doing polishing, buffing, etching, and engraving tasks because they are engaged in manual tasks for long periods [HETA 90-273-2130]

Exhibit 18: Administrative Controls—Meatpacking

In one meatpacking case, an administrative control approach was used to address ergonomic problems in boning and trimming tasks. Physical stressors of this job included awkward wrist postures, high grip forces, and a high workload. Observations showed that the total boning task workload was 96% of the total task cycle, allowing 4% for rest. In contrast, the trimming task workload was 80% of the total task cycle, allowing 20% for rest. One suggestion was that the trimmers could trim more of the lean shank, reducing the boners' workload. A better balance was struck between these two tasks, and an increase in lean shank yield from this modified job was documented [Gjessing et al. 1994].

IMPLEMENTING CONTROLS

Ideas for controls can be derived from a variety of sources:

- Trade associations may have information about good control practices for addressing different problem operations within an industry
- Insurance companies that offer loss control services to their policyholders
- Consultants and vendors who deal in ergonomic specialty services and products
- Visits to other worksites known to have dealt with similar problem operations

Ideas from these sources are in addition to those ideas gained from brainstorming with employees who perform the jobs or from work teams engaged in such problem solving.

Implementing controls normally consists of

— trials or tests of the selected solutions,

— making modifications or revisions,

— full-scale implementation, and

— follow up on evaluating control effectiveness.

Testing and evaluation verify that the proposed solution actually works and identifies any additional enhancements or modifications that may be needed. Employees who perform the job can provide valuable input into the testing and evaluation process. Worker acceptance of the changes put into place is important to the success of the intervention.

After the initial testing period, the proposed solution may need to be modified. If so, further testing should be conducted to ensure that the correct changes have been made, followed by full-scale implementation. Designating the personnel responsible, creating a timetable, and considering the logistics necessary for implementation are elements of the planning needed to ensure the timely implementation of controls.

A good idea in general is that ergonomic control efforts start small, targeting those problem conditions which are clearly identified through safety and health data and job analysis information. Moreover, the control actions can be directed to those conditions which appear easy to fix. Early successes can build the confidence and experience needed in later attempts to resolve more complex problems.

EVALUATING CONTROL EFFECTIVENESS

A followup evaluation is necessary to ensure that the controls reduced or eliminated the ergonomic risk factors and that new risk factors were not introduced. This followup evaluation should use the same risk factor checklist or other method of job analysis that first documented the presence of ergonomic risk factors. If the hazards are not substantially reduced or eliminated, the problem-solving process is not finished.

The followup may also include a symptom survey, which can be completed in conjunction with the risk-factor checklist or other job analysis method. The results of the followup symptom survey can then be compared with the results of the initial symptom survey (if one was performed) to determine the effectiveness of the implemented solutions in reducing symptoms.

Because some changes in work methods (and the use of different muscle groups) may actually make employees feel sore or tired for a few days, followup should occur no sooner than 1 to 2 weeks after implementation, and a month is preferable. Recognizing this fact may help avoid discarding an otherwise good solution.

In addition to the short-term evaluations using job analysis methods and symptom surveys, long-term indicators of the effectiveness of an ergonomics program can include

— reduction in the incidence rate of musculoskeletal disorders,

— reduction in the severity rate of musculoskeletal disorders,

— increase in productivity or the quality of products and services, or

— reduction in job turnover or absenteeism.

The above-mentioned indicators offer bottom-line results in evaluating interventions that have been put into place. Other indicators may also be used that represent in-process or interim accomplishments achieved on the path to building an ergonomic program—for example, the extent of the ergonomic training given the workforce, the number of jobs analyzed for potential problems, and the number of workplace solutions being implemented. While bottom-line results are most telling in terms of defining a successul program, the interim measures allow the total development to be monitored.

Exhibit 19 describes evaluation techniques used in ergonomic programs at meatpacking plants.

Exhibit 19: Evaluating Ergonomics Programs in Meatpacking Plants

A variety of techniques were used in meatpacking plant ergonomic case studies to evaluate and gauge the effectiveness and benefits of the ergonomic hazard control efforts:

- **Symptom surveys** Two of the case studies described administering symptom surveys to workers before implementation of the demonstration ergonomics programs. The symptom surveys were used to confirm findings from records, help identify problem jobs, and establish baseline data. These baseline data were compared with data from identical surveys administered after controls were implemented. Reductions in the number and severity of symptoms identified during the time period between the first and second survey would be expected if the controls implemented are effective.

  In one case, symptom surveys indicated a decline in the number of people reporting pain and a decline in pain severity. In the other case, symptom surveys showed an increase in the number of reported discomfort areas over the project period. The investigator in this case attributed the rise to increased employee knowledge of ergonomic hazards and WMSDs, as well as to seasonal increases in production.

- **OSHA Form 200 Logs** As with symptom surveys, two of the case studies referred to company-maintained OSHA Form 200 logs to identify problem jobs and establish incidence rates of WMSDs. Data maintained in these logs were used to gauge the plant-wide effects of the ergonomic interventions on overall and job-specific incidence rates of reportable WMSDs. In one case, plant-wide rates were calculated for the two 1-year periods before the study and for two 6-month periods after the interventions. The rates per 200,000 work hours were 55, 75, 80, and 59, respectively. The incidence rates continued to rise in the first 6 months of the post-intervention period, but they fell more than 27% in the second post-intervention period. Reductions in rates of 19%, 33%, and 42% for the second 6-month period were shown in three of the four departments, whereas the rate in the fourth department remained the same.

- **Other records** In these meatpacking case studies, employee absenteeism rates, employee turnover rates (both overall and job-specific), and workers' compensation costs were used to judge ergonomics program effectiveness. In one of the cases, the investigators studied a plant for 7 years. During this period, workers' compensation costs declined to 20% of the pre-ergonomic program costs.

- **Productivity and quality** In one case study, an administrative control for a trimming job resulted in a $14,000 increase in product yield over 6 months. In the same case study, changes in the hog shackling task to reduce back injuries in workers were calculated to yield a $436,000 annual savings from reduced product (hog) loss.

- **Task analysis and checklists** The same techniques used to identify and evaluate the ergonomic risk factors of jobs and tasks were used to gauge the benefits of implemented controls. These were analyzed in terms of the risk factors that were reduced or eliminated from the original, unmodified job. In one case, risk factors such as awkward postures and heavy lifting were reduced or eliminated when mechanized lifts were installed to handle the 250-lb metal tubs while they were being washed [Gjessing et al. 1994].

STEP 6
HEALTH CARE MANAGEMENT

- **Employer Responsibilities**
- **Employee Responsibilities**
- **Health Care Provider Responsibilities**
- **Issues**
  Job Familiarity and Job Placement Evaluations
  Early Reporting and Access to Health Care Providers
  Treatment

Company health care management strategies and policies and health care providers can be an important part of the overall ergonomics program.

In general, health care management emphasizes the prevention of impairment and disability through early detection, prompt treatment, and timely recovery [Hales and Bertsche 1992; Parker and Imbus 1992; American National Standards Institute 1996]. Medical management responsibilities fall on employers, employees, and health care providers.

EMPLOYER RESPONSIBILITIES

The employer can create an environment that encourages early evaluation by a health care provider by taking the following steps:

- Providing education and training to employees regarding the recognition of the symptoms and signs of WMSDs (see Step 3, *Training—Building In-House Expertise*) and the employers' procedures for reporting WMSDs
- Encouraging employees' early reporting of symptoms and prompt evaluation by an appropriate health care provider
- Giving health care providers the opportunity to become familiar with jobs and job tasks
- Modifying jobs or accommodating employees who have functional limitations secondary to WMSDs as determined by a health care provider
- Ensuring, to the extent permitted by law, employee privacy and confidentiality regarding medical conditions identified during an assessment

EMPLOYEE RESPONSIBILITIES

Employees should participate in the health care management process by

— following applicable workplace safety and health rules,

— following work practice procedures related to their jobs, and

— reporting early signs and symptoms of WMSDs.

Employees may be faced with conflicting job demands or requirements. Safe work practices or rules may conflict with pressures or incentives to be more productive.

HEALTH CARE PROVIDER RESPONSIBILITIES

The health care provider should do the following:

- Acquire experience and training in the evaluation and treatment of WMSDs.
- Seek information and review materials regarding employee job activities.
- Ensure employee privacy and confidentiality to the fullest extent permitted by law.
- Evaluate symptomatic employees including:
  - — medical histories with a complete description of symptoms,
  - — descriptions of work activities as reported by the employees,
  - — physical examinations appropriate to the presenting symptoms and histories,
  - — initial assessments or diagnoses,
  - — opinions as to whether occupational risk factors caused, contributed to, or exacerbated the conditions, and
  - — examinations to follow up symptomatic employees and document symptom improvements or resolutions.

ISSUES

Job Familiarity and Job Placement Evaluations

Health care providers who evaluate employees, determine employees' functional capabilities, and prepare opinions regarding work relatedness should be familiar with employee jobs and job tasks. With specific knowledge of the physical demands involved in various jobs and the physical capabilities or limitations of employees, the health care provider can match the employees' capabilities with appropriate jobs. Being familiar with employee jobs not only assists the health care provider in making informed case management decisions but also assists with the identification of ergonomic hazards and alternative job tasks.

One of the best ways for a health care provider to become familiar with jobs and job tasks is by periodic plant walk-throughs. Once familiar with plant operations and job tasks, the health care provider should periodically revisit the facility to remain knowledgeable about changing working conditions. Other approaches that may help the health care provider to become familiar with jobs and job tasks include reviewing job analysis reports, detailed job descriptions, job safety analyses, and photographs or videotapes that are accompanied by narrative or written descriptions of the jobs.

Early Reporting and Access to Health Care Providers

Employees reporting symptoms or signs of potential WMSDs should have the opportunity for prompt evaluation by a health care provider. In general, the earlier that symptoms are identified and treatment is initiated, the less likely a more serious disorder will develop. Employers should not establish policies that discourage employees from reporting symptoms. For example, programs that link a manager's earnings to the number of employees reporting symptoms may discourage supervisors from allowing symptomatic employees to be evaluated by the health care provider. Employees should not fear discipline or discrimination on the basis of such reporting.

Treatment

- Health care providers are responsible for determining the physical capabilities and work restrictions of the affected workers.
- The employer is responsible for giving an employee a task consistent with these restrictions.
- Until effective controls are installed, employee exposure to ergonomic stressors can

be reduced through restricted duty and/or temporary job transfer.

- Complete removal from the work environment should be avoided unless the employer is unable to accommodate the prescribed work restrictions.
- Immobilization devices, such as splints or supports, can provide relief to the symptomatic area in some cases. These devices are especially effective off-the-job, particularly during sleep. They should not be used as prophylactic PPE to prevent the development of WMSDs. Therefore, these devices should be dispensed to individuals with WMSDs only by health care providers who have knowledge of the benefits and possible negatives of these devices. Wrist splints, typically worn by patients with possible carpal tunnel syndrome, should not be worn at work unless the health care provider determines that the employee's job tasks do not require wrist bending. Employees who struggle to perform a task requiring wrist bending with a splint designed to prevent wrist bending can exacerbate symptoms in the wrist because of the increased force needed to overcome the splint. Splinting may also cause other joint areas (elbows or shoulders) to become symptomatic as work techniques are altered. Recommended periods of immobilization vary from several weeks to months depending on the nature and severity of the disorder. Any immobilization should be monitored carefully to prevent complications (e.g., muscle atrophy caused by nonuse).
- The health care provider should advise affected employees about the potential risk of continuing hobbies, recreational activities, or other personal habits that may adversely affect their condition as well as the risk of continuing work without job modifications.
- Oral medications such as aspirin or other nonsteroidal anti-inflammatory agents (NSAIA) are useful to reduce the severity of symptoms. However, their gastrointestinal and kidney side effects make their use among employees who have no symptoms inappropriate and may limit their usefulness among employees with chronic symptoms. In short, NSAIA should not be used preventively.

NIOSH activities in health care management of work-related health problems have included efforts to assess the implementation of such programs. One case is illustrated in Exhibit 20.

Exhibit 20: Medical Management—Poultry Processing Plants

At the request of a State labor department, NIOSH determined the prevalence of WMSDs of the neck and upper extremities in workers employed at two poultry processing plants. OSHA reports and symptom data obtained via questionnaires and physical exams found workers in jobs requiring highly repetitive, forceful motions and awkward postures to have significantly more hand and wrist disorders than those employed in less physically demanding work. In the course of this study, NIOSH also assessed the medical management practices in the two plants with regard to injured workers and the company's WMSD prevention program. Based largely on the questionnaire data and other sources of information, the following areas were suggested as needing improvement or change:

- **Increased nurse access**: From 23% to 29% of employees in one plant who met the various case definitions of upper extremity musculoskeletal symptoms indicated that their foreman or supervisor refused to allow them to leave their workstation to see the plant nurse at some point during the course of the year.
- **More efficient job rotation schemes**: Nearly 30% of the workers in the high exposure jobs in one plant and almost 27% in the second were involved in a job rotation plan. Both plant groups reported spending at least 2 days a week in jobs other than their base jobs. The rotation, however, did not necessarily place them in less ergonomically stressful tasks. Rather, the jobs they temporarily filled were often vacancies on the production line in the same high exposure area.
- **Questionable use of vitamins and anti-inflammatory drugs**: The policy of one plant required all new hires to take ibuprofen tablets and Vitamins E and C several times a day during their probationary periods. Although use of these substances has been advocated as a way to prevent WMSDs, valid, scientific evidence to establish their effectiveness is not available. More importantly, this approach does not substitute for effective engineering or administrative controls. Also, consumption of therapeutic amounts of these drugs (e.g., ibuprofen) can pose a risk of other adverse health effects [HETA 89-307–2009].

STEP 7
PROACTIVE ERGONOMICS

- **Proactive versus Reactive Approaches**
- **Essential Considerations**

Proactive approaches to workplace ergonomics programs emphasize prevention of WMSDs through recognizing, anticipating, and reducing risk factors in the planning stages of new work processes.

PROACTIVE VERSUS REACTIVE APPROACHES

To this point, the elements outlined in this primer and illustrated by NIOSH experiences have represented *reactive* approaches to dealing with workplace ergonomic problems. The steps have offered a plan for identifying problems, specifically WMSDs and job risk factors linked to them, and selecting and implementing measures for controlling them. In contrast, *proactive* approaches are geared to preventing these kinds of problems from developing in the first place. Proactive ergonomics emphasize efforts at the design stage of work processes to recognize needs for avoiding risk factors that can lead to musculoskeletal problems (in effect, to design operations that ensure proper selection and use of tools, job methods, workstation layouts, and materials that impose no undue stress and strain on the worker). One set of guidelines for this purpose can be found in Tray 9 of the Toolbox. Others are illustrated in various ergonomic manuals listed in Tray 10 of the Toolbox.

ESSENTIAL CONSIDERATIONS

- Ergonomics issues are identified and resolved in the planning process. In addition, general ergonomic knowledge, learned from an ongoing ergonomics program, can be used to build a more prevention-oriented approach. Management commitment and employee involvement in the planning activity are essential. For example, management can set policy to require ergonomic considerations for any equipment to be purchased, and production employees can offer ideas on the basis of their past experiences for alleviating potential problems.

- Decision-makers planning new work processes, especially those involved in the design of job tasks, equipment, and workplace layout, must become more aware of ergonomic factors and principles. Designers must have appropriate information and guidelines about risk factors for WMSDs and ways to control them. Studying past designs of jobs in terms of risk factors can offer useful input into their deliberations about needed improvements.

- Design strategies emphasize fitting job demands to the capabilities and limitations of workers. Deciding which functions can be done best by machines and which by people is a primary objective. For example, for tasks requiring heavy materials handling and transport, ready use of mechanical assist devices to reduce the need for manual

handling would be designed into the process. Large-sized units could be broken into smaller, more manageable ones, and equipment could be selected that most helps the workers using it.

- Design strategies try to target the causes of potential musculoskeletal problems. For this reason, engineering approaches are preferred over administrative ones because they eliminate the risk factors as opposed to simply reducing exposure to them. For example, having machines do monotonous, repetitive, forceful work is better than subjecting workers to these risk factors. Administrative controls (such as worker rotation or allowing more rest breaks) remain stop-gap measures. They are not permanent solutions.

An example of a proactive approach to ergonomic concerns is illustrated in Exhibit 21.

Exhibit 21: Proactive Ergonomics at an Appliance Manufacturer

NIOSH, as a demonstration project, is assisting an appliance manufacturer in designing a new assembly line that, by incorporating ergonomic factors, can prevent musculoskeletal disorders without limiting production output. Steps in the project include the following:

- Evaluating musculoskeletal injury patterns associated with work on existing production lines, observing related risk factors, and determining engineering solutions for these risk factors
- In-house training of assembly line workers, engineers, and management to recognize, evaluate, and provide solutions to job risk factors
- Applying the above training information in the planning of a new assembly line with the goal of preventing musculoskeletal disorders
- Conducting a symptom survey of the assembly line workers at the beginning of the new line's production to establish baseline morbidity rates
- Fine tuning the production line with ergonomic controls as production increases and as workers become more knowledgeable and skilled in their jobs
- Conducting periodic follow-up symptom surveys to determine injury trends and outcomes

NIOSH interactions with the plant's design, manufacturing, and production engineers are aimed at shifting the engineers' thinking from just production issues to include ergonomic concerns. The following are some benefits resulting from these interactions:

- The design and use of a tool-balanced, in-line screw gun with torque control. The torque control is achieved by attaching an "L"-shaped handle called a "cheater bar" to the tool. This design allows the torque resulting from driving screws with this tool to be transferred to the bar, which is stabilized by holding it against the edge of the metal cabinet of the washer or dryer. In so doing, the torque force is not absorbed by the tool user.
- Using a pneumatic tool to open the hose clamps needed to attach hoses to the drain valves of washing machines. The original task was performed with a pair of pliers. This change reduces the static forces and awkward postures required for attaching the hose to the valve.
- Using height-adjustable worktables and height-adjustable shelving units, allowing workers of different heights and arm lengths to assemble parts with more ease and comfort.
- Using a pneumatic lift and rotation table to lift the washers to the desired standing height of the worker so they can drive in screws without stooping over, and rotating the tables so that all screws can be fastened from one workstation.
- Building an assembly line with these ergonomic workstation features may be less costly than retrofitting existing lines. Another advantage is that the worker is learning to do the job in ways that are more healthful and more productive [Estill and McGlothlin 1994].

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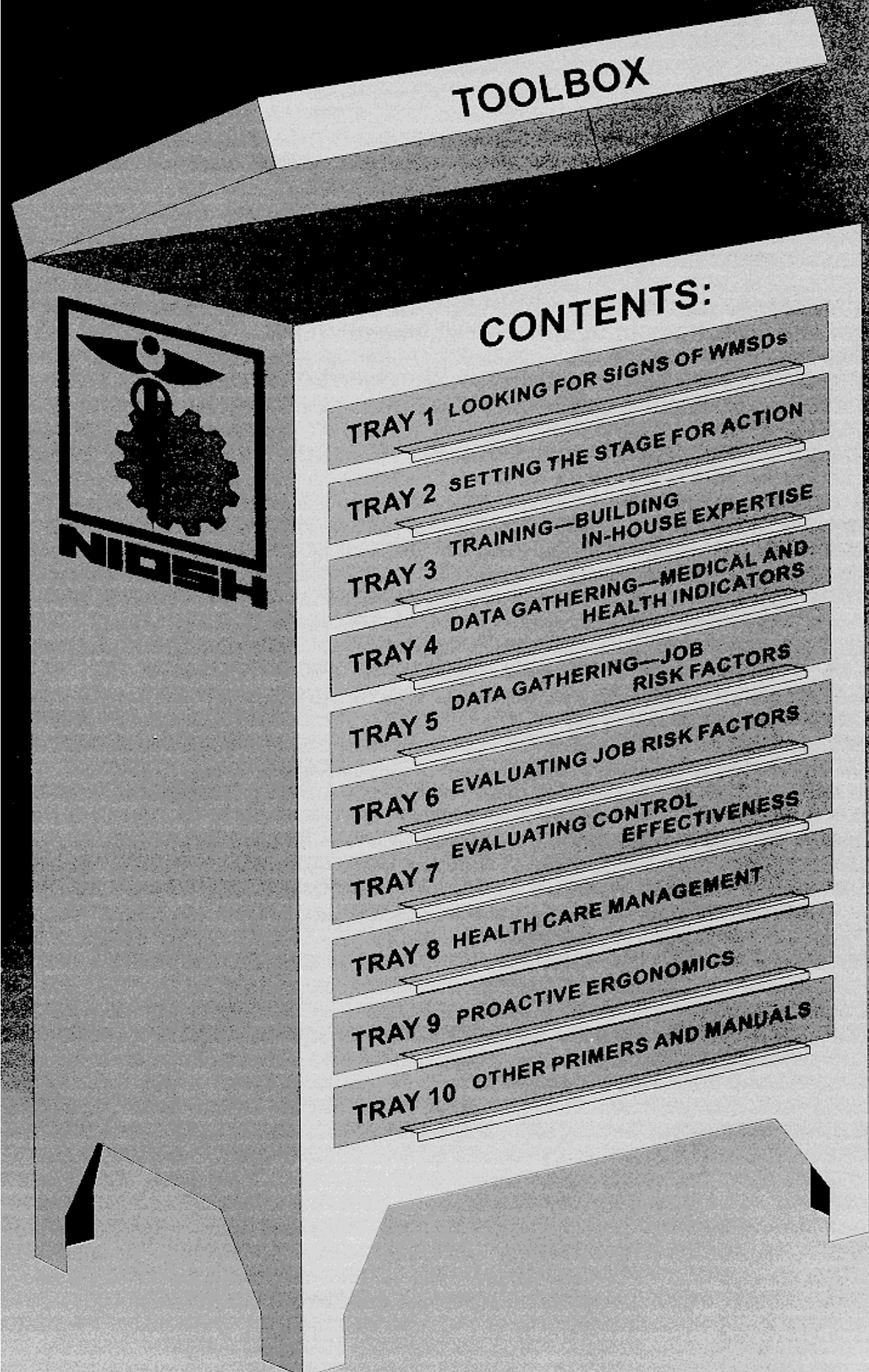
TOOLBOX
NIOSH
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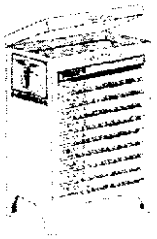
TOOLBOX

DESCRIPTION OF CONTENTS

The "tools" in this Toolbox are the assorted techniques mentioned throughout this primer for identifying, analyzing, and ultimately controlling WMSDs. Reviews of company health records, symptom surveys, or physical examinations for diagnostic purposes are "tools" to help identify musculoskeletal disorders. Similarly, checklists, time-motion analyses, and other methods used to sort job demands and workplace conditions that pose risks for musculoskeletal problems are tools. Also, information sources and other opportunities for learning more about ergonomic issues can help fill individual needs.

This Toolbox contains examples of various data gathering techniques and procedures along with reference materials for elaborating on their use. Also included are information guides and lists of reports that can prove helpful in efforts to address specific problems. The material is organized into sections or "trays." Most of the tools and techniques described are easy to use and adaptable for many purposes. Procedures are stressed that do not require special equipment or laborious data collection and analyses. Some of these tools are based on professional practice, others on scientific research, and still others on a combination of both. While few have been extensively validated and have other limitations, NIOSH has found these tools to be useful. Even with their shortcomings, they should enable readers to take some first steps in determining whether workplace conditions pose a risk of WMSDs and in suggesting remedial actions. Where problem-defining and problem-solving steps prove more formidable, referrals to sources of more in-depth information are provided throughout the Toolbox.



TRAY 1
LOOKING FOR SIGNS OF WMSDs

LOOKING FOR SIGNS OF WMSDs

NIOSH investigations have determined that a wide variety of work settings and job operations have the potential for ergonomic hazards. A log of these NIOSH investigations, included here, provides examples of problem work settings and job operations and the recommendations that were suggested to solve these problems. Readers may find similarities between their businesses and those listed.

The log included in Tray 1–A describes the work settings, the job tasks in question, the findings, and the recommended control measures. Various data collection procedures were used in these investigations. Medical information was largely collected by reviewing OSHA logs, other case records, use of special questionnaires, and surveys. In some instances, physical examinations were given with diagnostic tests added to better assess any apparent musculoskeletal problem. Data on ergonomic stress factors were obtained by walk-through and checklist observations, analyses of videotapes of workers engaged in their jobs, and workstation measurements. Forces involved in certain tasks such as lifting were subjected to biomechanical evaluation as needed.

While the entries in Tray 1–A only offer clues, the information contained in the investigative reports is fairly detailed. Many of these reports can be ordered from the National Technical Information Service (NTIS). (NTIS order numbers are listed for each available report and an order form is provided. Prices for these reports vary; please check with NTIS for current pricing information.)

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
0171 Agriculture (Berry crops)	**Harvesting** wild blueberries. Task involves **combing through bushes with a hand-held rake** to scoop up berries.	Upper extremities (hand/wrist and elbow) and back.	Awkward (stooped) postures, repetitive deviations of the wrist, and repetitive and forceful motions of the hand/arm and shoulder.	Recommended engineering controls included using mechanized harvesting where feasible, and redesigning the rake (substitute material to make the rake lighter). Better work practices, work conditioning, and reducing the loads in buckets were also recommended.	HETA 93–1031–2521 NTIS order no. PB–96–115–472
1752 Construction (Floor work)	**Carpet Installation**. Tasks include use of the '**knee kicker**' to stretch carpet.	Lower limb	Forceful exertions and contact stress	Control recommendations included using knee pads and more use of a hand-operated power stretcher.	HETA 82–065–1664 NTIS order no. PB–86–225–661

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
2011 Manufacturing (Meat products)	Plant **processing beef and pork products.** Tasks studied were **cutting and dissecting cattle and hogs with saws, straight knives, powered hand knives, clippers, and hooks.**	Upper extremity disorders (mainly hand/wrist but also elbows, shoulder, and neck).	Vibration and force found to correlate highest with problem cases. Data on repetitive actions and awkward postures were judged insufficient for analysis.	Engineering changes included reorientation of tools, adjustable fixtures, better layout of workstations and delivery bins, and automating aspects of the work process to relieve workload demands. Train new employees in proper work methods, use of job rotation, and rest breaks suggested along with better maintenance of cutting knives to reduce vibrations. Improved medical management stressed, such as educating workers to report early signs of problems, allowing adequate time off for symptomatic cases to heal, and a slower paced return to work policy after surgery.	HETA 88–180–1958 NTIS order no. PB–90–128–992
2015 Manufacturing (Poultry processing)	**Turkey processing.** Jobs include **eviscerating and boning tasks.**	Upper limb and neck	Repetitive and forceful exertions, awkward postures, low temperature	Engineering control recommendations include use of better designed knives and adjustable workstations. Also recommended were a comprehensive knife and scissor sharpening program and improving the work load distribution throughout the plant. Administrative control recommendations were work practice training and decreasing line speeds.	HETA 86–505–1885 NTIS order no. PB–89–106–546

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
2016 Manufacturing (Poultry products)	**Poultry processing** plant. Focus on workers engaged in **tasks of cutting, eviscerating, and deboning** carcasses as compared with those in lesser manual stress jobs.	Upper extremity (hand/wrist and elbow) disorders as well as tension neck problems.	Repetitive and forceful motions extreme and awkward postures of the upper extremities. Machine-paced work.	Engineering controls included restructuring jobs, use of mechanical devices to aid deboning and cutting tasks, and workstation changes to accommodate workers of varying sizes. New worker training, practice in proper cutting techniques, use of job rotation, and rest breaks to relieve fatigue were underscored. Suggested ways to improve medical management practices included better medical surveillance, employee education in symptom recognition, and cautions on treatment regarding use of drug therapy, splints, and restricted duty.	HETA 89–307–2009 NTIS order no. PB–91–104–620
2092 Manufacturing (Fish products)	**Filleting, fillet trimming, and "sliming" fish** at a packing plant.	Upper limb and neck	Repetitive and forceful exertions, awkward postures	Engineering control recommendations include workstation modifications to adjust work table height to fit workers and to reduce reach distances, texturing cutting table to reduce the force needed to hold fish, and modifying knife handle design. As administrative controls, work practice training and reduced emphasis on speed were recommended for new hires.	HETA 83–251–1685 NTIS order no. PB–87–108–312

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
2328 Manufacturing (Clothing, furnishings)	Various **sewing** tasks at a **uniform maker**.	Upper limb and neck	Repetitive and forceful exertions, awkward postures	Plant-wide workstation modifications were suggested such as providing foot rails, floor mats, adjustable chairs, and padding the edges of tables to reduce contact stress. Improvement in work layout also noted to facilitate access to materials or parts. Job specific engineering control recommendations were also made.	HETA 83–205–1702 NTIS order no. PB–87–106–498
2421 Manufacturing (Sawmills)	Driving and **operating highway and off-highway logging trucks** and stackers.	Upper limb, neck, and back	Whole body vibration	Replacing truck seats with seats offering greater vibration isolation was recommended. Work practice changes, such as driving slower and not lifting loads that are so heavy as to lift the rear wheels off the ground, were recommended. Job rotation and shorter work shifts were suggested to reduce exposures to whole body vibration.	HETA 83–349–1901 NTIS order no. PB–89–107–239

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
2653 Manufacturing (Paperboard containers)	**Corrugating, finishing operations** in **producing cardboard boxes.**	Upper extremity disorders, low back problems.	Repetitive, forceful hand/wrist movements, localized contact stresses, awkward back and upper extremity postures.	Furnish lift tables or load leveling systems to feeder and stacking machines and raise conveyor height to ease materials handling tasks. Add padding to edges and sharp corners of workstations to relieve contact stress. Consider options for reducing travel distance for materials access and disposal and more efficient stacking. Train total workforce on reporting early signs of WMSDs and one person on each shift in risk factor analysis and control.	HETA 96–0062–2588 NTIS order no. (in process)
2711 Manufactuing (Periodicals)	Information processing jobs using **VDTs** at a **newspaper.**	Upper limb and neck, lower limb, eyestrain	Repetitive exertions, awkward postures, glare	Engineering controls recommended included adjustable workstations (chairs, keyboard position) and controlling glare. For administrative controls, a work break schedule was recommended. Vision testing was suggested.	HETA 79 061–844 NTIS order no. PB-84-241- 801
2711 Manufacturing (Periodicals)	Multiple departments of a **newspaper. Computer terminal tasks** included writing, editing, communicating through e-mail, and developing graphics.	Upper extremities (e.g., hand/ wrist, elbow, forearm, shoulder, and neck).	Repetition, sustained awkward postures, extended work periods at computer keyboard, and job pressures.	Establish and train a joint ergonomics committee to develop and implement interventions. Furnish adjustable chairs and other workstation equipment, and train employees in its proper use. Institute appropriate health care management.	HETA 89 250 2046 NTIS order no. PB–91–116–251

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
2711 Manufacturing (Periodicals)	Printing layout work in a **newspaper composing room**. Tasks involve long periods of **standing and walking**.	Lower limb	Static standing postures	Recommendations were made to reduce static standing requirements through the installation of footrests and to provide the option to sit. Added recomendations to pad edges of surfaces that workers lean against, install floor mats, and provide well-cushioned shoes.	HETA 90–251–2128 NTIS order no. PB–92–124–437
2711 Manufacturing (Periodicals)	**VDT tasks** at a **newspaper** company.	Upper limb and neck, eyestrain, headaches	Poor illumination, glare, poor workstation layout	Survey conducted that sought to define relationships between VDT-user symptoms and ergonomic aspects of VDT use. Main finding— increasing reports of being bothered by glare, brightness of screen, flicker, fuzziness of characters related to postural discomfort, headaches, and blurred vision.	HETA 80–127–1337 NTIS order no. PB–94–207 776
2711 Manufacturing (Periodicals)	A major **newspaper setting** with tasks involving **use of video display terminals (VDT).**	Upper extremity disorders (neck, hand/wrist, shoulder, and elbow).	Increased hours typing at a VDT keyboard, job deadline pressures, and varying workload demands.	Emphasized that a control plan must address job design, work organization, and psychosocial factors which were all correlated with symptoms reported. Employer's beginning efforts to use work breaks and document workload factors were acknowledged as a start.	HETA 90–013–2277 NTIS order no. PB–93–188–456

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3069 Manufacturing (Fabricated rubber products)	Various tasks such as **cutting, cementing, and finishing** rubber and nylon fabrics in a plant manufacturing **fuel cells for aircraft.**	Upper limb and neck	Repetitive and forceful exertions, static exertions, contact stress, awkward postures, vibration	Engineering controls recommended include use of power scissors for cutting fabrics, modifying workstations, reducing vibration of powered handtools, providing footrests and floor mats, and securing razor blades used for cutting in handles.	HETA 90–246–2314 NTIS order no. PB–93–234–037
3070 Manufacturing (Plastics, metal products)	Manufacturer of **plastic and metal pails**. Tasks include **inserting gaskets into lids, trimming, attaching handles.**	Upper limb and neck	Repetitive and forceful exertions	Numerous specific engineering and work practice controls were suggested, ranging from workstation modification and automation to assuring trim knives are sharp. Job rotation and identification of light duty jobs were recommended as administrative controls, plus close medical monitoring of workers in identified high risk jobs.	HETA 89–146–2049 NTIS order no. PB 91 115 758
3079 Manufacturing (Fabricated rubber products)	**Manufacturer** of industrial, automotive, and garden **hoses.** Tasks include **loading and unloading hoses into molds, trimming, and attaching couplings.**	Upper extremity (e.g., hand/wrist disorders).	High repetition and force.	Redesign parts delivery bins for easier access, adjust height of work surfaces, and provide easier access to machine controls. Develop job rotation schemes and assign an additional worker to supply and load materials.	HETA 87–428–2063 NTIS order no. PB 91 151 720

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3079 Manufacturing (Fabricated fibrous products)	**Press operations** and **finishing and assembly** tasks in a plant manufacturing thermo- formed **fibrous glass reinforced products.**	Upper limb and neck	Repetitive and forceful exertions, contact stress, awkward postures	Engineering controls were suggested for using fixtures to hold work, modifying tools (such as adding handles on files), and using power shears for cutting. Worker and supervisor training in the recognition of risk factors for WMSDs was recommended. Textured gloves were recommended for operators of hand sanders to minimize the grasping forces required.	HETA 81-143-1041 NTIS order no. PB 83-201-426
3089 Manufacturing (Plastic products)	**Operating presses and finishing parts** in a plant manufacturing **plastic and fibrous glass products.**	Upper limb and neck	Static and forceful exertions, awkward postures	Provide stool or sit or stand bar, foot rail to relieve back and foot fatigue in jobs requiring standing work. Reposition press control buttons and tilt material bins to reduce reach distances. Furnish rounded, properly sized handles to finishing tools to distribute grip forces.	HETA 91-003-2232 NTIS order no. PB 93-119-360

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3134 Manufacturing (Leather products)	**Shoe manufacturer.** Tasks investigated included **nailing heels, trimming, hand application of inks and dyes, and waxing.**	Upper extremities (hand/wrist and elbow), shoulder, back, and neck.	Awkward postures of the trunk, shoulder, and wrist; repetition; static exertions; and use of pinch grip.	Engineering ideas to augment ongoing efforts to reduce ergonomic stressors were offered. These included (1) installation of height-adjustable swivel chairs and anti-fatigue mats, (2) use of air-powered shears instead of scissors, (3) raising and tilting machinery with added fixtures to relieve extreme work postures, and (4) improve lighting.	HETA 94–0245–2577 NTIS order no. PB–96–209–747
3231 Manufacturing (Glass products)	Specialty **glass and mirrors. Grinding, buffing, polishing, and buffing tasks.**	Upper limb and neck	Repetitive and forceful exertions, awkward postures	Engineering control recommendations ranged from automating aspects of certain jobs to using special fixtures to hold the products. Continued job rotation for workers involved in certain tasks was suggested as an administrative control.	HETA 89-137-2005 NTIS order no. PB–91–108–134
3261 Manufacturing (Pottery products)	**Ceramic plumbing fixture manufacturing**. The machine-paced tasks include repeated **lifting and moving of toilet bowls weighing up to 70 lb.**	Back	Repetitive and forceful exertions, awkward postures, heavy lifting, and paced work	Arrange for two-worker lifts of heavy product loads Modify height of conveyor and adjoining workstations to facilitate access, ease transfer of product in the course of the manufacturing process. Consider alternatives to the paced work and incentive system that would moderate and more evenly distribute the physical effort.	HETA 88-237-L1960 NTIS order no. PB–89–230–270

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3261 Manufactuing (Pottery products)	**Lifting and loading** jobs (as much as 73 lb) in a plant manufacturing ceramic **plumbing fixtures.**	Back	Repetitive exertions, awkward postures, heavy lifting	Furnish mechanical lift devices to relieve manual handling of heavy product loads. Redesign carts and workstations to facilitate transfer of product in course of manufacturing process.	HETA 82-229-1286 NTIS order no. PB-84-209-741
3291 Manufacturing (Nonmetal mineral products)	**Abrasive products** manufacture with focus on **press operating tasks.**	Limited to evaluation of potential ergonomic risk factors.	Repetition, sustained awkward postures, forceful exertions, and contact forces.	Guardrails should be adjustable and padded. Prohibit use of hand as "hammer." Modify press to reduce awkward postures. Furnish training to employees about ergonomic hazards. Establish a medical surveillance program.	HETA 92-0001-2444 NTIS order no. PB-95-146-429
3442 Manufacturing (Fabricated structures)	**Assembly tasks** at a **window balance system manufacturer.**	Upper limb and neck	Repetitive and forceful exertions, awkward postures, paced work	Engineering controls are recommended including work layout improvements to facilitate parts assembly tasks, and assuring the fit of parts to reduce assembly forces required. New employees should be given adequate "break-in" times.	HETA 88-361-2091 NTIS order no. PB-91-197-368

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3442 Manufacturing (Fabricated structural products)	Various production jobs such as **welding, grinding and press operations** in an **automobile components** fabrication plant.	Upper limb, neck, and back	Repetitive and forceful exertions, static exertions, awkward postures, vibration	Engineering controls are recommended including adjustments to workstations, using larger wheels on part carts to reduce pushing forces, and using light beam controls to activate machinery. Vibration-absorbing gloves were recommended as personal equipment.	HETA 91-086-2235 NTIS order no. PB-93-119-915
3444 Manufacturing (Fabricated structural products)	Sheet metal forming **(riveting, swedging, seaming, assembly)** tasks in a plant manufacturing combustion **exhaust systems.**	Upper limb and neck	Repetitive and forceful exertions, contact stress, awkward postures	General engineering control recommendations included finding ways to reduce pinch grips and reach distances. Suggestions made to implement an employee awareness program and encourage early reporting of WMSD symptoms.	HETA 80-109-974 NTIS order no. PB-83-157-933
3463 Manufacturing (Metal forging and stamping)	Aluminum **forging operations.** Focus on tasks performed in **pressing area.**	Musculoskeletal strain and tendinitis dominated injury reports.	Repetitive lifting and pulling actions from awkward positions in handling aluminum pieces. Deviated wrist in use of tools (tongs), hand/wrist strains from extended holding, and kickback of lubrication guns when activated.	Engineering controls were suggested to (1) improve conveyor systems and lift devices to ease heavy load handling, (2) add adjustable height features to presses to relieve awkward postures, and (3) redesign tong handles and use counterbalanced suspension of lubrication guns to reduce upper extremity strains. Job rotation, added training, and medical monitoring also proposed for risk reduction.	HETA 95-0109-2520 NTIS order no. PB-96-115-415

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3483 Manufacturing (Ordinance)	Inspection of charges in a **munitions plant**. Tasks involve **lifting and manipulation** of charges weighing as much as 40 lb.	Upper limb, neck, and back	Repetitive and forceful exertions and heavy lifting	Engineering controls were suggested to provide adjustable chairs and fixtures to minimize load handling. Administrative and work practices proposals made to improve lifting methods, extend training in ergonomic risk factors, and improve medical monitoring by logging location and type of work performed.	HETA 83-142-1431 NTIS order no. PB 85-184-125
3499 Manufacturing (Fabricated metal products)	Various metal forming jobs such as **cutting, shaping, and threading, and assembly** tasks at a manufacturer of hand-held **lubrication equipment.**	Upper limb and neck, back	Repetitive and forceful exertions, awkward postures, heavy lifting	Engineering controls were suggested for better presentation of stock and parts to eliminate excessive reaches (by using power lifts and better positioned racks), redesign of workstations, and repositioning of machine tools. It was recommended that the company continue to alert workers to ergonomic hazards and encourage early reporting of WMSD complaints.	HETA 81-375-1277 NTIS order no. PB 84-209-717
3544 Manufacturing (Metalworking machinery)	**Grinding, polishing, and deburring** tasks at a **manufacturer of molds** used in glass container production.	Upper limb and neck	Vibration	Recommendations for a medical monitoring program to identify early signs of hand-arm vibration syndrome. Rest breaks, job rotation, and use of gloves were also recommended.	HETA 93-0510-2462 NTIS order no. PB-95-171-294

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3592 Manufacturing (Industrial machinery)	**Machine shop** and **foundry** of a piston manufacturing company. Piston sleeve and piston **machining** and **casting operations studied.**	Upper limbs and back.	Repetitive, awkward postures in manual handling of products in machining. Awkward postures and static loading in casting tasks.	Suggested use of rotating/lifting devices, gravity feed racks, and positioning palletizers to reduce manual handling risks and back problems in machinists. Use a support device to hold ladle and relieve static strain in molding operations.	HETA 94–0040–2496 NTIS order no. PB–96–106–448
3612 Manufacturing (Electric distribution equipment)	**Manufacture** of high voltage and instrument **transformers. Winding, wrapping, taping, and paper pulling operations** were tasks under study.	Upper extremities (hand/wrist, shoulder, neck), low back and hip.	Awkward postures causing extreme bending and reaching, static standing, and forceful pulling actions.	Provide more height adjustable features to equipment and adjustable fixtures to relieve postural stresses. Reconfigure work areas to ease materials access and handling tasks. Design job rotation and rest break schedules to relieve most fatiguing work tasks. Educate workers in early signs of WMSDs.	HETA 93 0233 2498 NTIS order no. PB 95 269 973
3621 Manufacturing (Electrical industrial)	The tasks include **hammering, crimping, wrapping, winding, soldering, painting,** and various **assembly operations** at an electric **motor and generator plant.**	Upper limb and neck	Repetitive and forceful exertions, awkward postures, contact stress	Engineering controls were suggested such as a raised standing surface, a modified mallet handle, and low-force clamps. Job rotation and training programs were suggested as administrative controls. Early reporting of symptoms was recommended.	HETA 81–369–1591 and HETA 81–466 1591 NTIS order no. PB–86–133 758

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3631 Manufacturing (Household appliances)	**Producing microwave ovens.** Jobs of **grinding** and **mounting** parts, **wiring, leakage testing** along a moving assembly line.	Hand/wrist and shoulder tendinitis, epicondylitis, and carpal tunnel syndrome.	Repetitive, forceful work (cycle time of 20 seconds), awkward postures, pinch grips, static muscle loading in use of handtools, time pressures, hand/arm vibration, and lifting.	Engineering controls proposed for reducing forces were to use low insertion terminals, screws needing less push force in mounting, and tools with nonmetal handles, sized to minimize overgripping. Also recommended were adjustments to conveyor height and realignments in work flow to ease lifting. Administrative measures offered to slow down the line and adopt more job rotation and work changes that can broaden worker skills. Ergonomics training of all workers suggested as first step in meeting needs.	HETA 94-0214-2508 NTIS order no. PB-95-270-013
3699 Manufacturing (Electrical equipment)	Manufacturer of **garage door openers, antenna rotors, and motorized remote control switches.** The many tasks included various **hand-intensive assembly jobs, press operations, and use of pneumatic handtools.**	Upper limb and neck	Repetitive, static, and forceful exertions, awkward postures, paced work	Numerous specific engineering controls were recommended to reduce manual handling of parts and ways to adapt foot pedals to assembly equipment.	HETA 85-480-1771 NTIS order no. PB-87-205-951

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3699 Manufacturing (Electrical)	**Manufacturing electrical cords.** Tasks include **winding and trimming** wire, **assembly** of cord sets, and **packing.**	Upper limb and neck	Repetitive and forceful exertions, static exertions, and awkward postures	Numerous task specific engineering, administrative, and work practices controls were suggested. Recommendations were made for implementing an ergonomics awareness program for workers and early reporting of injuries and symptoms.	HETA 81–217–1086 NTIS order no. PB–83–202–119
3714 Manufacturing (Motor vehicles)	**Assembly tasks** at a bus and truck **wheel manufacturer.**	Back, upper limb, and neck	Repetitive and forceful exertions, static exertions, awkward postures, heavy lifting	Install tilt, lift, and rotating tables in select jobs to ease manual materials handling tasks. Redesign work methods and workstation layout to minimize pulling and pushing tasks, handling loads, above shoulder height.	HETA 88–277–2069 NTIS order no. PB 91 184 523
3721 Manufacturing (Aircraft parts)	**Manufacture and assembly of jet aircraft. Use of air-driven, hand-held tools** (drills, routers, sanders, rivet guns, screw guns).	Limited to evaluation of tool properties.	Vibration levels in use of tools exceeded recommended exposure limits for typical work shift durations.	Continue effort to purchase new vibration reduced pneumatic tools. Maintain or replace tools producing high vibration levels due to wear and tear. Institute health care management practices ensuring early detection of hand/arm vibration disorders. Allow more rest breaks when using tools with highest vibration levels.	HETA 94–0425–2513 NTIS order no. PB–961–106 943

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3751 Manufacturing (Motorcycles)	**Flywheel milling and assembly tasks** in a **motorcycle manufacturing** plant.	Upper limb, neck, and back	Repetitive, static, and forceful exertions, contact stress, awkward postures, heavy lifting, vibration	Specific engineering control recommendations include reducing the weight of the flywheel forging to reduce milling time and the weight handled, and improving the work layout to reduce manual material handling and excessive reaches. Work practice controls include training in better lifting techniques. Administrative controls, specifically job rotation, were recommended until engineering controls can be implemented.	HETA 90-134-2064 NTIS order no. PB-91-184-531
3751 Manufacturing (Motor vehicle parts)	**Manufacture of flywheels** in motorcycle plant. **Milling, assembly, truing, and balancing jobs** were focus of evaluation.	Hand/arm, back, and shoulder musculoskeletal disorders.	Excessive manual materials handling and lifting, awkward postures, hand/ arm vibration, and repetitive, forceful hammering.	Pre-post evaluations show that engineering controls recommended earlier have reduced risk factors and the number and severity of WMSD cases. Further controls include gravity conveyors, added hoists, and optimal workstation layouts to further reduce manual materials handling loads. Enhance efforts for early detection, awareness training of WMSDs, and risk factors.	HETA 91-0208-2422 NTIS order no. PB-95-147-294

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
3843 Manufacturing (Medical instruments)	**Grinding, buffing, polishing, and lifting** of metal assemblies in a plant manufacturing **dental equipment**.	Upper limb and neck, back	Repetitive and forceful exertions, awkward postures, increased production with reduced manpower	Use of added fixtures to relieve need to hold product items in different positions in finishing process. Installation of movable crane to assist in lifting and handling heavier loads. Use of pedestals under machines and platforms under workers to accommodate varying body sizes of workers and reduce need for undue stretching and bending.	HETA 83–233–1410 NTIS order no. PB–85–179–158
3861 Manufacturing (Photo supplies)	**Wrapping, packing, and lifting** tasks in a plant that converts bulk **photographic products** into consumer-size packages.	Upper limb and neck	Repetitive and forceful exertions, production quotas	A variety of engineering controls were suggested including tool redesign, workstation modification, and the use of new mechanical devices. Job rotation and work practice training, as well as clarification of expected production goals, were recommended as administrative measures.	HETA 76–93 NTIS order no. PB–96–115–431
3911 Manufacturing (Miscellaneous)	**Jewelry manufacturing** where tasks include **soldering, grinding, casting, stamping**, and **packing**.	Upper limb and neck	Static and forceful exertions, awkward postures, and vibration	Recommended engineering controls include adjustable workstations and chairs, added and improved fixtures, and tool redesign. Suggested administrative controls include training, job rotation, and rest pauses, plus a medical management program.	HETA 90–273–2130 NTIS order no. PB–92–133–321

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
4311 Public utilities (Postal service)	Large **sack sorting** and **small parcel bundle sorting** operations at a major airport **mail facility.**	Back and leg discomfort; injuries from being struck with mail exiting chutes; overexertion.	Prolonged standing, heavy lifting, extended reach.	Furnish floor mats, step rails, and sit and stand stools to relieve prolonged standing postures. Design loading procedures and utility carts to eliminate unassisted manual lifts of mail sacks weighing up to 70 lb. Add diverters in chutes to funnel packages within easy reach of worker.	HETA 93–1145–2529 NTIS order no. PB–96–191–770
4311 Public utilities (Postal service)	The work setting was a **mail processing facility.** Job tasks were those involved with **feeding mail** to several automated mail processing machines and **removing such mail once it has been sorted.**	Limited to study of ergonomic risk factors in job tasks.	Frequent stooping to retrieve mail trays for feeding the machines, extended reach, and trunk flexion in sweeping and stacking sorted mail. High volume capacity of sorting machines makes these actions more repetitive.	Automated options for relieving manual operations with the processing machines need consideration. Examples would be a weight sensitive stacker bin that would eject its contents into a container either below or beside the bin where a moving conveyor could carry the mail away. Another would be spring-controlled leveling systems that raise the feeder trays as others are removed. Other measures would be to limit the time spent on these machine tasks or to provide added breaks.	HETA 92–0073–2337 NTIS order no. PB–94–133–824

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
4311 Public utilities (Postal service)	**Mail processing** facility with workers engaged in **loading mail into automated sorting machines and transferring the sorted mail once it is collected in bins.**	Limited to an assessment of ergonomic risk factors in job tasks.	Prolonged standing postures and walking on hard floor surfaces.	Provide for a sit/stand option for those operating the loader and furnish foot rests to rest one leg while standing. Install cushioned mats to run the length and width of the loading and sweeping areas. Mats should have a beveled edge to reduce a tripping hazard and should be kept in place by velcro or some other method.	HETA 92–019–2188 NTIS order no. PB-92–193–887
4441 Transportation (Water)	**Operation, repair and maintenance** tasks at **river locks and dams.**	None reported	Repetitive and forceful exertions, awkward postures, heavy lifting, vibration	The major recommendation is to develop an ergonomics program. Three jobs were analyzed, yet these represent only a fraction of the jobs performed at the various sites. Specific engineering control recommendations for the jobs studied include adjustable workstations, use of hoists and lifts for shop work and extending the height of rope tie-off posts for lock operation work.	HETA 90 385 2173 NTIS order no. PB-92-176 809
4510 Transportation (Air)	**Key entry** at computer workstations at a central **airline reservation** office.	Posture, muscular discomfort	Cramped work areas, noise interference, poor lighting, heat	Suggested engineering controls included improved workstations and lighting. Suggested administrative control included 15-min breaks every 2 hours for workers.	HETA 78–134–630 NTIS order no. PB 80 193 030

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
4813 Public utilities (Communi-cators)	**Telecommunications** work setting; **directory assistance operators, using VDTs.**	Upper extremities (hand/wrist, elbow, shoulder, and neck).	Use of bifocal glasses were associated with neck disorders. Work organization and psychosocial factors (e.g., fear of being replaced by computers, lack of supervisor support, and increasing work pressure) linked with musculo-skeletal disorders. Workstation and postural measurements were taken but not analyzed due to methodologic limitations.	Continue joint ergonomics committee and consider equipment purchases based on their recommendations. Conduct visual testing of employees to ensure adequate corrected vision. Address concerns of job security and provide job diversity. Reduce information processing loads. Require prompt examinations of employees with musculoskeletal symptoms.	HETA 89–299–2230 NTIS order no. PB–93–119–329
5411 Retail trade (Food stores)	**Grocery store cashiers** working at express **checkout stands** that involved **frequent reaching, scanning, and keying tasks.**	Neck, upper back, shoulder, lower back, buttocks, and legs.	Repetition, awkward postures, excessive reach, and trunk flexion.	Changes made included adding a barrier at the far corner of the checkstand to reduce excessive reach and trunk flexion and providing an adjustable keyboard to relieve other postural stress. Videotape training was provided. Follow up showed a decrease in some symptoms after implementing these changes based in part on employee input. Other checkstand modifications recommended.	HETA 88–345–2031 NTIS order no. PB–91–117–234

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
5411 Wholesale trade (Food stores)	**Grocery warehouse** setting with jobs involving **order selecting (i.e., locating orders for selection, manual handling, and loading of orders for delivery).**	Back injuries and back pain.	Repeated lifting of heavy loads requiring extended reach. Need to meet incentive standards. Thermal stress further aggravated problems.	Design of storage racks and physical layout should be rearranged to allow ready access to orders, and the grocery items (cases) should be restricted in size to ease handling. Performance standards should be reexamined or worker rotation and restrictions on overtime provisions to minimize risks of overexertion. Measures to reduce heat stress should be considered (e.g., cooling fans, ample, easily accessible cool drinking water, and increasing rest breaks in cool locations).	HETA 91–405–2340 NTIS order no. PB–94–131–638
5411 Trade (Food stores)	**Check-out tasks** at a **grocery store.**	Ergonomics evaluation only	Repetitive and forceful exertions, awkward postures	The major recommendation was to eliminate the practice of having the checker unload the grocery cart by proposing design changes to facilitate customer unloading of the grocery cart in checkout. In the interim, other engineering and work practice recommendations were made ranging from improving the mating between the grocery cart and the checkout counter by changing the height of checkout counters or grocery carts to discourage customers from placing items on the bottom shelf of the cart. Improved training of cashiers was recommended.	HETA 92–294–2301 NTIS order no. PB–94–110–376

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
5712 Wholesale Trade (Furniture)	**Wood kitchen cabinet manufacturer**. Jobs include **sanding, planing, painting, packing, shipping** and **lifting, pushing and pulling** tasks.	Upper limb, neck, back, and lower limb	Repetitive, static, and forceful exertions, awkward postures, and heavy lifting	Numerous specific engineering control recommendations were made to minimize or eliminate risk factors associated with sustained postures, lifting and carrying, and repetitive exertions. In addition, it was recommended that new employees start at slower rates so they can be conditioned and that frequent rest breaks be allowed.	HETA 88–384–2062 NTIS order no. PB–91–152–082
7349 Services (Business services)	Janitorial employees **using a back-pack vacuum cleaner in typical office cleaning** work.	Shoulder, back, and neck discomfort.	Increased muscle force and disc compression owing to weight of unit and typical forward leaning postures assumed when working with the vacuum unit.	Train the workers in proper use of the vacuum unit, and periodically monitor its use and fit and any complaints. Allow the workers some flexibility in choice of equipment for a cleaning task. Use of the unit can prove difficult in a confined space. An upright unit can resolve such problems.	HETA 93–0805–2387 NTIS order no. PB–94–176–450
7699 Services (Repair)	Missile and aircraft **guidance system maintenance and repair** work conducted using low power microscopes at an Air Force facility.	Upper limb and neck, back	Awkward postures	Engineering controls recommended included using improved adjustable chairs, tables, and work jigs. Work practice suggestions included better microscope use techniques such as more frequent lens cleaning and looking away from the lens frequently. Reducing the time spent at the microscope each day by job enlargement and work practices training were suggested as administrative controls.	HETA 84–082–1713 NTIS order no. PB–87–114–682

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
8351 Services (Child care)	Caring for children at a **day care facility**. Tasks involve **lifting** children and frequent **kneeling and squatting**.	Upper limb, neck, back, and lower limb	Repetitive exertions, static exertions, awkward postures, and heavy lifting	Suggested engineering controls were to provide furniture and fixtures at appropriate adult heights. Proposed administrative and work practices controls included use of lifting techniques to minimize back stresses.	HETA 93–0995–2442 NTIS order no. PB 95 129 235
8731 Services (Biological research)	**Research laboratory** conducting anticancer research. **Numerous laboratory tasks.**	Upper extremities	Sustained awkward and static postures of the hand/arm, repetition, use of pinch grips, contact with sharp edges of workstations.	Engineering controls included retrofitting pipettes with finger trigger strips and pipette foot switches and modifying biosafety cabinets (e.g., padding sharp edges, providing height-adjustable turntable for easier access). Administrative controls were changing job protocols to reduce repetitions, job rotation, and frequent micro-breaks.	HETA 95 0294 2594 NTIS order no. (in process)
9190 Services (Government)	**Data entry** and other tasks involving video-display units at a Federal government **office.**	Upper limb and neck, back, eyestrain	Repetitive exertions, awkward postures, glare and poor illumination	Various recommendations were made to improve lighting and reduce glare and to improve workstation design (keyboard height, viewing distance and angle, chair features, wrist rests, detachable keyboards). A visual testing program and a rest-break schedule were recommended.	HETA 83 463 1642 NTIS order no. PB 86 206 059

Tray 1–A. NIOSH Investigations of WMSDs in Work Settings (Continued).

Standard industrial classification (SIC)	Work setting and tasks	Work-related musculoskeletal problems found	Ergonomic risk factors found	Recommendations	HETA/NTIS reference no.
9999 Non-classifiable	**Sign language interpreters for the deaf.**	Upper extremities (e.g., shoulder, elbow, fingers, neck, and hand) disorders and back problems.	Repetition and awkward and static postures.	Include rest breaks in interpreting sessions. Maintain signing motions between the shoulders and within the area bounded by the chest and waist. Avoid forceful contacts between the hands.	HETA 92–0268–2447 NTIS order no. PB–95–219–465

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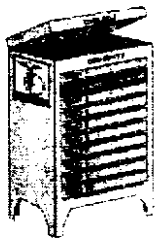


TRAY 2
SETTING THE STAGE FOR ACTION

SETTING THE STAGE FOR ACTION

Step 2 of the main text, Setting the Stage for Action, acknowledged three points. First, actions taken to define and control ergonomic hazards can be treated as part of a company's overall workplace safety and health program. Thus, approaches found successful in controlling other forms of workplace hazards should have value in coping with ergonomic problems as well. The second and third points made this clear by emphasizing the importance of management commitment and the value of employee participation in such undertakings. Noted below in Tray 2–A are literature references elaborating on these three points. The following NIOSH report discusses much of the available data contained in the other listed sources:

> NIOSH [1994]. Participatory ergonomic interventions in meatpacking plants. DHHS (NIOSH) Publication No. 94–124, National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.

This report can be obtained by calling 1–800–35–NIOSH (1–800–356–4674).

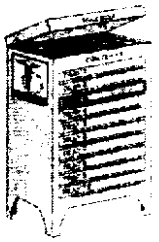
Tray 2–A. Literature References to Successful OS&H Program Practices, Management Commitment, and Worker Involvement

Cohen A [1977]. Factors in successful occupational safety programs. J Safety Res *9*(4):168–178. (Available from the National Safety Council, 112 Spring Lake Drive, Itasca, IL 60143–3201.)

Peters RH [1989]. Review of recent research on organizational and behavioral factors associated with mine safety. Information Circular 9232, Bureau of Mines, U.S. Department of the Interior, 2401 E Street N.W., Washington, DC 20241.

Lawler EE Jr. [1991]. High involvement management—participative strategies for improving organizational performance. Jossey-Bass, 350 Sansome Street, San Francisco, CA 94104.

Noro K, Imada AS [1991]. Participatory ergonomics. Taylor & Francis Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007.



TRAY 3
TRAINING—BUILDING IN-HOUSE EXPERTISE

TRAINING—BUILDING IN-HOUSE EXPERTISE

Employee training complements efforts to address workplace safety and health problems, including those focused on ergonomic hazards and related concerns. As presented in the main text (Step 3), ergonomics training may take different forms for various categories of employees. It can range from awareness training for all employees, especially those in suspected problem jobs, to more specialized, intensive training for those expected to undertake job analyses and problem-solving work. The ergonomics primers and manuals listed at the end of this document (see Tray 10–A) provide material for use in this training. Information on videotapes, publications, databases, and other resources that can be helpful in developing a training plan are also available from NIOSH (call 1–800–35–NIOSH or 1–800–356–4674).

Training Elements

The effectiveness of training greatly depends on the way it is designed and delivered to the target audience. A 1988 OSHA publication (Training Requirements in OSHA Standards and Training Guidelines. Washington, DC: U.S. Department of Labor, OSHA Publication No. 2254) offers a model or set of steps to follow in these efforts. The steps are as follows:

1. **Determine if training is needed.** If the evidence gathered from checking health records and results of the job analysis indicates a need to control ergonomic risk factors, then employees must be provided with the training necessary for them to gain the knowledge to implement control measures.

2. **Identify training needs.** As already mentioned, different categories of employees will require different kinds of ergonomics instruction.

3. **Identify goals and objectives.** The important point here is that the objectives of training must be defined in clear, directly observable, action-oriented terms.

4. **Develop learning activities.** Whatever the mode of training—live lectures, demonstrations, interactive-video programs, use of varied instructional aids—learning activities should be developed that will help employees demonstrate that they have acquired the desired knowledge or skill.

5. **Conduct training.** Training should take into account the language and educational level of the employees involved. Trainees should be encouraged to ask questions that address their particular job concerns, and hands-on learning opportunities should be encouraged.

6. **Evaluate training effectiveness.** A common tool for training evaluations is the use of questions about whether they found the instruction interesting and useful to their jobs and if they would recommend it to others. More important, however, are measures of the knowledge gained or improvements in skills, as may be specified in the course objectives. Knowledge quizzes, performance tests, and behavioral observations can be used for this purpose. One exercise recommended here is for the class to propose improvements in workplace conditions on the basis of information learned in class for presentation to management for their review. This relates to another level of evaluation which is whether the training produces some overall change at the workplace. The latter measure is complicated by the fact that such results require time before they are apparent, and training may be one of several factors responsible for such results.

7. **Improving the program.** If the evaluations indicate that the objectives of the training were not achieved, a review of the elements of the training plan would be in order and revisions should be made to correct shortcomings.

For a discussion of ergonomics training issues, see the following reference:

Kuorinka I, Forcier L, eds. [1995]. Work-related musculoskeletal disorders (WMSDs): a reference book for prevention. Chapter 8. WMSD-related training. Taylor and Francis (1900 Frost Road, Suite 101, Bristol, PA 19007).

Although the above-mentioned steps can help employers develop ergonomics training activities without having to hire outside help, much depends on the existing capabilities of the staff. If in-house expertise in ergonomics is limited, start-up activities could necessitate the use of consultants or outside special training for those employees who would ultimately assume responsibility for ergonomic activities within the workplace. Continuing education courses at NIOSH Educational Resource Centers, located throughout the United States, can furnish this instruction. Their addresses are listed in Tray 3–A. Each year NIOSH publishes schedules for ergonomics courses and other offerings from these Centers. Copies can be obtained free of charge by calling 1–800–35–NIOSH (1–800–356–4674). NIOSH Educational Resource Centers, according to their charter, are expected to offer outreach services in addressing occupational safety and health problems in their respective regions. Contacting them could be a source for gaining help on ergonomic matters. A list of university locations where NIOSH is supporting ergonomics training projects is located in Tray 3–B. These too may be sources for obtaining assistance. In addition, regional offices of OSHA offer free consultation on ergonomic problems as do State agencies concerned with occupational safety and health issues.

Tray 3–A. NIOSH Educational Resource Centers for Continuing Education Courses (1997 listing)

Deep South Center for Occupational Safety and Health
University of Alabama
School of Public Health MJH117
Birmingham, Alabama 35294–2010
Phone: 205–934–7178; Fax: 205–975–7179

Southern California Educational Resource Center
Institute of Safety and Systems Management
927 West 35th Place, Room 102
Los Angeles, California 90089–0021
Phone: 213–740–3995; Fax: 213–740–8789

Johns Hopkins Educational Resource Center
School of Hygiene and Public Health
615 Wolfe Street, Room 6001
Baltimore, Maryland 21205
Phone: 410–955–0423; Fax: 410–614–4986

Michigan Educational Resource Center
Center for Occupational Health and Safety Engineering
University of Michigan
1205 Beal, IOE Building
Ann Arbor, Michigan 48109–2117
Phone: 313–936–0148; Fax: 313–764–3451

New York/New Jersey Educational Resource Center
EOHSI Centers for Education and Training
45 Knightsbridge Road, Brookwood II
Piscataway, New Jersey 08854–3923
Phone: 908–235–5062; Fax: 908–235–5133

University of Cincinnati Educational Resource Center
P.O. Box 670056
Cincinnati, Ohio 45267–0056
Phone: 513–558–1730; Fax: 513–558–1756

Rocky Mountain Center for Occupational Safety and Health
Building 512—University of Utah
Salt Lake City, Utah 84112
Phone: 801–581–4055; Fax: 801–585–5275

Northern California Center for Occupational Safety and Environmental Health
1310 South 46th Street, Building 102
Richmond, California 94804
Phone: 510–231–5645; Fax: 510–231–5648

Great Lakes Center for Occupational and Environmental Health and Safety
School of Public Health
2121 Taylor Street, Room 216A
Chicago, Illinois 60612–7260
Phone: 312–996–6904; Fax: 312–413–7369

Harvard Educational Resource Center
Harvard School of Public Health
Office of Continuing Education
677 Huntington Avenue
Boston, Massachusetts 02115
Phone: 617–432–1171; Fax: 617–432–1969

Minnesota Educational Resource Center
Midwest Center for Occupational Health and Safety
640 Jackson Street
St. Paul, Minnesota 55101
Phone: 612–221–3992; Fax: 612–292–4773

North Carolina Educational Resource Center
109 Connor Drive, Suite 1101
Chapel Hill, North Carolina 27514
Phone: 919–962–2101; Fax: 919–966–7579

Southwest Center for Occupational Safety and Health
P.O. Box 20186, RAS W1026
Houston, Texas 77225–0186
Phone: 713–500–9463; Fax: 713–500–9442

Northwest Center for Occupational Health and Safety
Department of Environmental Health
University of Washington
4225 Roosevelt Way NE, Suite 100
Seattle, Washington 98105–6099
Phone: 206–543–1069; Fax: 206–685–3872

Tray 3–B. NIOSH Ergonomic Training Project Grant Locations (1997 listing)

University of Massachusetts—Lowell
Department of Work Environment
One University Avenue
Lowell, Massachusetts 01854
Phone: 508–934–3272; Fax: 508–934–3050

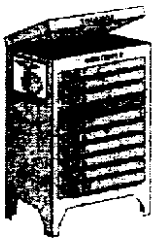
University of Miami
Department of Industrial Engineering
1251 Memorial Drive
Coral Gables, Florida 33146
Phone: 305–284–4154; Fax: 305–284–5441

Texas A & M University
Nuclear Engineering Department
College Station, Texas 77843–3133
Phone: 409–845–5574; Fax: 409–845–6443

Texas Tech University
Department of Industrial Engineering
Mail Stop 3061
Lubbock, Texas 79409–3061
Phone: 806–742–3543; Fax: 806–742–3411

Virginia Polytechnic Institute and State University
Department of Industrial and Systems Engineering
302 Whittemore Hall
Blacksburg, Virginia 24061–0118
Phone: 540–231–6656; Fax: 540–231–3322

West Virginia University
Department of Industrial and Management
Systems Engineering
727 Engineering Sciences Building
P.O. Box 6107
Morgantown, West Virginia 26506–6107
Phone: 304–293–3693, Ext. 707; Fax: 304–293–5024



TRAY 4
DATA GATHERING—MEDICAL AND HEALTH INDICATORS

DATA GATHERING—MEDICAL AND HEALTH INDICATORS

Determining whether work-related musculoskeletal problems are apparent and whether job conditions exist that pose a significant risk for such disorders involves different but interrelated data collection methods. As noted in the main text, entries of musculoskeletal problems in company medical records and OSHA Form 200 logs can be tallied for use in calculating incidence and prevalence measures. These measures, in turn, may be compared with those from other departments or those reported for the industry as a whole in making judgments concerning excess cases. The incidence rate (IR) is defined as the number of *new* cases per 100 worker years (which is equivalent to 200,000 work hours). It may be computed for all musculoskeletal disorders and by disorders of body part (i.e., disorders specific to the wrist, back, shoulders, etc.) The following formula is used in these IR calculations:

$$\mathbf{IR} = \frac{\text{Number of new cases during a time period} \times 200{,}000 \text{ hr}}{\text{Total hours worked by all workers for the time period}}$$

The prevalence rate (PR) calculation is similar, except that all *existing* numbers of cases for a given time period are used in the formula. Hence,

$$\mathbf{PR} = \frac{\text{Number of all cases during a time period} \times 200{,}000 \text{ hr}}{\text{Total hours worked by all workers for the time period}}$$

Examples of computations of IR and PR are shown in Tray 4–A.

Tray 4–A. Examples of IR and PR Calculations

A manufacturer of small electronic products employed an average of 125 full-time production employees—75 working on circuit board assembly tasks and 50 on product assembly tasks. A check of the company medical records in 1994 indicated a total of 20 workers had entries reflecting hand/wrist disorders; 14 of these cases were workers engaged in circuit board wiring; 6 were in assembly work. Medical records for 1995 indicated 5 new cases—4 in circuit wiring board and 1 in product assembly.

Calculating the IRs: Five new cases for the total plant were reported in 1995. Time sheets for the workforce indicated a total of 250,000 hours of work time for that year. Thus, the IR for the total plant is:

$$\frac{5 \text{ (new cases)} \times 200{,}000}{250{,}000} = \frac{1{,}000{,}000}{250{,}000} = 4.0$$

Calculating the PRs: The existing 20 cases of WMSDs noted in 1994 and the 5 new cases for 1995 would indicate a total of 25 cases for the 2-year time period. The total number of work hours time expended by the workforce, based on time sheets for the 2-year time period, equaled 500,000 hours. Thus the PR for the total plant for the 2-year period would be:

$$\frac{25 \text{ (existing + new cases)} \times 200{,}000}{500{,}000} = \frac{5{,}000{,}000}{500{,}000} = 10.0$$

Several different decision rules concerning what constitutes excessive numbers of musculoskeletal problems have been proposed. The following reference suggests that more than one work-related case of musculoskeletal disorders per 200,000 hours or more than a twofold difference in either IR or PR between departments indicates a need for evaluations to determine the basis for the problem:

> Kuorinka I, Forcier L eds. [1995]. Health and risk factor surveillance for work-related musculoskeletal disorders. Chapter 5. Work-related musculoskeletal disorders (WMSDs): a reference book for prevention. Taylor and Francis (1900 Frost Road, Suite 101, Bristol, PA 19007).

California is in the process of enacting an ergonomic rule which would require interventions when at least two workers doing the same job develop similar forms of musculoskeletal disorders within a 12-month period (Occupational Safety and Health Standard, Title 8, Chapter 4, Group 15, Article 106, Section 5110, Ergonomics, California Occupational Safety and Health Board, Sacramento, CA, October 1, 1996). For a discussion of decision rules, see Chapter 5 above.

Evidence that excessive numbers of cases of musculoskeletal problems are due to workplace factors will invariably require other forms of data collection. As noted in the main text (Step 4), interviews and questionnaire surveys can furnish added information about the onset and nature of such problems as related to the worker's job. Symptom surveys and special tests can also offer a means for detecting problems that may be missed in more general medical exams and reports.

Workers completing a symptom survey form such as shown in Tray 4–B can identify parts of their bodies that are experiencing increased levels of discomfort as a result of poor job design. Although this survey is fairly easy to administer, the following procedures should be followed for best results:

- No names should be required on the forms, and the collection process should ensure anonymity.
- Survey participation should be voluntary in nature.
- Workers should fill out the form on their own (but if needed, the surveys should be administered to groups by a trained person offering explanations).
- The survey should be conducted on work time.

Unless the company is prepared to act on the results of a symptom survey, it should not be conducted. Analysis of the information from a symptom survey is complex. One of the major difficulties is deciding what responses on the questionnaire indicate a problem that may need further evaluation. One approach for scoring results from a survey of this type is to rank-order the number and severity of complaints by body part from the highest to the lowest in frequency and severity. Those jobs linked with the body part showing the most complaints or the highest severity ratings would become the primary candidates for followup efforts at analyzing job risk factors and determining needs for risk reduction measures. A second survey, using the same form, completed after ergonomic changes have been made to correct problem jobs, can indicate whether the intended benefits have been achieved. Comparisons of the worker survey data gathered before and after ergonomic changes can furnish this information. One caution here is to allow sufficient time after the intervention to permit the workers to become accustomed to the job change and allow other novelty effects to subside. The second survey should be made no less than 2 weeks (and preferably 1 month) after the changes and should be made at the same time and day of the week as the initial survey. Comparisons of Monday morning results with those obtained on Friday afternoon may give faulty results because of differences in employee motivation.

The health care professional providing medical services to an employer may use special tests for medical screening or more in-depth diagnostic purposes to confirm suspected cases of musculoskeletal disorders. These may involve the worker moving his or her limbs through a range of motions or various maneuvers, with or without resistance applied by the examiner, to determine whether distinctive signs of pain occur. By pressing their fingers against a body part, examiners can also determine areas of tenderness. Range of motion tests for upper extremity disorders are described in the articles listed in the Health Care Management section of the Toolbox (Tray 8–A).

Tray 4–A. Symptoms Survey Form

Symptoms Survey: *Ergonomics Program*

Date _____/_____/_____/

_____ Plant _____ Dept #

Job Name _____

_____ Shift

_____ Hours worked/week

_____ years _____ months Time on THIS Job

Other jobs you have done in the last year (for more than 2 weeks)

_____ Plant _____ Dept # _____ Job Name _____ months _____ weeks Time on THIS Job

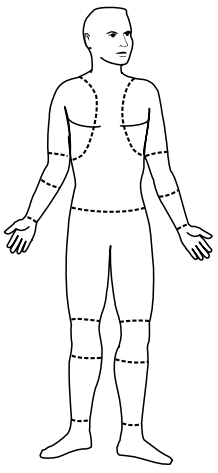
_____ Plant _____ Dept # _____ Job Name _____ months _____ weeks Time on THIS Job

(If more than 2 jobs, include those you worked on the most)

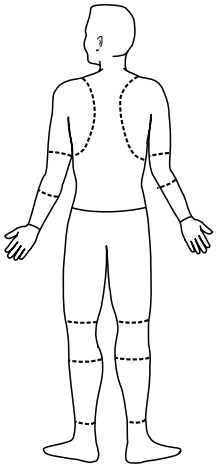
Have you had any pain or discomfort during the last year?

☐ Yes ☐ No (If NO, stop here)

If YES, carefully shade in area of the drawing which bothers you the MOST.



Front



Back

(Continued)

Tray 4–A (Continued).

(Complete a separate page for each area that bothers you)

Check Area: ☐ Neck ☐ Shoulder ☐ Elbow/Forearm ☐ Hand/Wrist ☐ Fingers
☐ Upper Back ☐ Low Back ☐ Thigh/Knee ☐ Low Leg ☐ Ankle/Foot

1. Please put a check by the words(s) that best describe your problem

☐ Aching	☐ Numbness (asleep)	☐ Tingling
☐ Burning	☐ Pain	☐ Weakness
☐ Cramping	☐ Swelling	☐ Other
☐ Loss of Color	☐ Stiffness	

2. When did you first notice the problem?_____ (month)_____ (year)

3. How long does each episode last? (Mark an X along the line)

_____/_____/_____/_____/_____/
1 hour 1 day 1 week 1 month 6 months

4. How many separate episodes have you had in the last year?_____

5. What do you think caused the problem?_____

_____

6. Have you had this problem in the last 7 days? ☐ Yes ☐ No

7. How would you rate this problem? (mark an X on the line)

NOW

_____
None Unbearable

When it is the WORST

_____
None Unbearable

8. Have you had medical treatment for this problem? ☐ Yes ☐ No

8a. If NO, why not?_____

8a. If YES, where did you receive treatment?

☐ 1. Company Medical Times in past year _____

☐ 2. Personal doctor Times in past year _____

☐ 3. Other Times in past year _____

Did treatment help? ☐ Yes ☐ No _____

9. How much time have you lost in the last year because of this problem?____ days

10. How many days in the last year were you on restricted or light duty because of this problem?
____ days

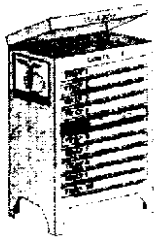
11. Please comment on what you think would improve your symptoms

_____

_____

_____

_____



TRAY 5
DATA GATHERING—JOB RISK FACTORS

DATA GATHERING—JOB RISK FACTORS

Tying indications of musculoskeletal disorders to identifiable job risk factors is important to establish work relatedness and to define the basis for a control plan. As described in Step 4, walk-through observational surveys of the work facilities, interviews with workers and supervisors, and checklists can all be useful for identifying risk factors. Checklists can offer an orderly procedure for screening jobs for risk factors of consequence to musculoskeletal disorders, although there is scientific debate over the ability of checklists to differentiate hazardous from non-hazardous tasks or conditions. Indeed, some checklist items, as written, are vague or call for judgments that defy simple observations for a lack of concrete references (e.g., Are materials moved over minimum distances? "What are minimum distances?"). Common practice is to follow up checklist observations with more precise techniques to confirm problem risk factors.

When using checklists or other more in-depth job analysis techniques, it is important to observe several workers doing a particular job to see if workers of different body sizes use different postures or practices to accomplish the task. One worker will not provide a representation of the way all workers perform the task or of the potential risk factors present.

Various forms and types of checklists exist. The University of Utah Research Foundation has published several on their ERGOWEB Internet site (http://ergoweb.mech.utah.edu/). One of these checklists is for undertaking a general ergonomic risk analysis to identify basic categories of job demands and workplace conditions that may pose a problem. An adaptation of this general checklist form is included in Tray 5–A. "Yes" answers given to questions within each category determine which areas may require followup, using more detailed types of analyses. NIOSH staff has also used a general checklist as a first means for localizing potential problems. It is described in Tray 5–B and focuses on primary job activities.

No one checklist can fit all situations, and it is suggested that checklists be customized for use with different job tasks or types of work so that problems will not be overlooked. Five additional checklists are included, each focusing on different workplace conditions and job task factors. The checklists cover:

Workstation Layout (Tray 5–C)
Task Analysis (Tray 5–D)
Handtool Analysis (Tray 5–E)
Materials Handling (Tray 5–F)
Computer Workstation (Tray 5–G)

One or more of the checklists or items within several checklists can be used or combined to compose a form that is most appropriate for the particular work situation. These five checklists

are written so that a "No" response indicates potential problem areas deserving more investigation.

Other versions of checklists are located in the following references:

Lifshitz Y, Armstrong T [1986]. A design checklist for control and prediction of cumulative trauma disorders in hand intensive manual jobs. Vol. 2. Proceedings of the 30th Meeting of the Human Factors Society, Daytona, Florida, pp. 837–841.

Bhattacharya A, McGlothlin JD, eds. [1996]. Occupational ergonomics. Appendix B. New, York, NY: Marcel Dekker, Inc., pp. 783–802.

Keyserling WM, Brouwer M, Silverstein BA [1992]. A checklist for evaluating ergonomic risk factors resulting from awkward postures of the legs, trunk and neck. Int J Ind Ergonomics *9*:283–301.

Keyserling WM, Stetson BA, Silverstein BA, Brouwer ML [1993]. A checklist for evaluating ergonomic risk factors assocated with upper extremity disorders. Ergonomics *36*(7):807–831.

Checklists can help provide an initial identification of problem jobs or tasks which in some cases may be solved with quick fixes by easy-to-make workstation changes (e.g., the removal of a barrier that may be causing awkward twisting and lifting postures in handling materials). However, the checklist findings must be viewed as a whole to see if individual problem signs do not suggest the same underlying root cause. Targeting interventions to the basic cause in this situation, as opposed to addressing each problem sign, offers a much more effective solution.

Most frequently, followup activities obtain more definitive information on the suspect problems first identified through use of a checklist. As explained in the main text (see Step 4, Identifying Risk Factors in Jobs), added data collection can include (1) time-motion studies to furnish job task and cycle data, (2) measures of workstation layouts, (3) measures of tool handle sizes, weights, and vibration levels, (4) measures of exposures to whole-body vibration and thermal conditions, and (5) biomechanical and physiological determinations. Time-motion study and analyses remain a fundamental procedure in assessing potential problem jobs, and videotaping is typically used for this purpose. Tray 5–H describes a protocol used by NIOSH in videotaping jobs. Its aim is to assure sufficient job cycles, adequate angles of viewing, and variations in worker characteristics so as to offer a representative picture of the work situation for analyses. The analyses of the videotape itself requires special techniques, and much judgment can be needed in determining whether the job conditions present an increased risk of WMSDs. Analytical procedures can be prescribed for rating repetitiveness, force, and postural factors, but it is advisable that persons knowledgeable and experienced be consulted about doing this work.

Tray 5–A. General Ergonomic Risk Analysis Checklist*

Check the box (❑) if your answer is "yes" to the question. A "yes" response indicates that an ergonomic risk factor may be present which requires further analysis.

Manual Material Handling

- ❑ Is there lifting of loads, tools, or parts?
- ❑ Is there lowering of tools, loads, or parts?
- ❑ Is there overhead reaching for tools, loads, or parts?
- ❑ Is there bending at the waist to handle tools, loads, or parts?
- ❑ Is there twisting at the waist to handle tools, loads, or parts?

For further analysis, refer to checklist 5–F.

Physical Energy Demands

- ❑ Do tools and parts weigh more than 10 lb?
- ❑ Is reaching greater than 20 in.?
- ❑ Is bending, stooping, or squatting a primary task activity?
- ❑ Is lifting or lowering loads a primary task activity?
- ❑ Is walking or carrying loads a primary task activity?
- ❑ Is stair or ladder climbing with loads a primary task activity?
- ❑ Is pushing or pulling loads a primary task activity?
- ❑ Is reaching overhead a primary task activity?
- ❑ Do any of the above tasks require five or more complete work cycles to be done within a minute?
- ❑ Do workers complain that rest breaks and fatigue allowances are insufficient?

For further analysis, refer to checklist 5–F.

Other Musculoskeletal Demands

- ❑ Do manual jobs require frequent, repetitive motions?
- ❑ Do work postures require frequent bending of the neck, shoulder, elbow, wrist, or finger joints?
- ❑ For seated work, do reaches for tools and materials exceed 15 in. from the worker's position?
- ❑ Is the worker unable to change his or her position often?
- ❑ Does the work involve forceful, quick, or sudden motions?
- ❑ Does the work involve shock or rapid buildup of forces?
- ❑ Is finger-pinch gripping used?
- ❑ Do job postures involve sustained muscle contraction of any limb?

For further analysis, refer to checklists 5–C, 5–D, and 5–E.

Computer Workstation

- ❑ Do operators use computer workstations for more than 4 hours a day?
- ❑ Are there complaints of discomfort from those working at these stations?
- ❑ Is the chair or desk nonadjustable?
- ❑ Is the display monitor, keyboard, or document holder nonadjustable?
- ❑ Does lighting cause glare or make the monitor screen hard to read?
- ❑ Is the room temperature too hot or too cold?
- ❑ Is there irritating vibration or noise?

For further analysis, refer to checklist 5–G.

*Adapted from The University of Utah Research Foundation "Checklist for General Ergonomic Risk Analysis," available from the ERGOWEB Internet site (http://ergoweb.com/).

Tray 5–A (Continued). General Ergonomic Risk Analysis Checklist

Environment

- ❑ Is the temperature too hot or too cold?
- ❑ Are the worker's hands exposed to temperatures less than 70 degrees Fahrenheit?
- ❑ Is the workplace poorly lit?
- ❑ Is there glare?
- ❑ Is there excessive noise that is annoying, distracting, or producing hearing loss?
- ❑ Is there upper extremity or whole body vibration?
- ❑ Is air circulation too high or too low?

General Workplace

- ❑ Are walkways uneven, slippery, or obstructed?
- ❑ Is housekeeping poor?
- ❑ Is there inadequate clearance or accessibility for performing tasks?
- ❑ Are stairs cluttered or lacking railings?
- ❑ Is proper footwear worn?

Tools

- ❑ Is the handle too small or too large?
- ❑ Does the handle shape cause the operator to bend the wrist in order to use the tool?
- ❑ Is the tool hard to access?
- ❑ Does the tool weigh more than 9 lb?
- ❑ Does the tool vibrate excessively?
- ❑ Does the tool cause excessive kickback to the operator?
- ❑ Does the tool become too hot or too cold?

For further analysis, refer to checklist 5–E.

Gloves

- ❑ Do the gloves require the worker to use more force when performing job tasks?
- ❑ Do the gloves provide inadequate protection?
- ❑ Do the gloves present a hazard of catch points on the tool or in the workplace?

Administration

- ❑ Is there little worker control over the work process?
- ❑ Is the task highly repetitive and monotonous?
- ❑ Does the job involve critical tasks with high accountability and little or no tolerance for error?
- ❑ Are work hours and breaks poorly organized?

Tray 5–B. Ergonomic Hazard Identification Checklist

Answer the following questions based on the primary job activities of workers in this facility.

Use the following responses to describe **how frequently** workers are exposed to the job conditions described below:

Never (worker is never exposed to the condition)
Sometimes (worker is exposed to the condition less than 3 times daily)
Usually (worker is exposed to the condition 3 times or more daily)

	Never	Sometimes	Usually	If *USUALLY*, list jobs to which answer applies here
1. Do workers perform tasks that are externally paced?				
2. Are workers required to exert force with their hands (e.g., gripping, pulling, pinching)?				
3. Do workers use handtools or handle parts or objects?				
4. Do workers stand continuously for periods of more than 30 min?				
5. Do workers sit for periods of more than 30 min without the opportunity to stand or move around freely?				
6. Do workers use electronic input devices (e.g., keyboards, mice, joysticks, track balls) for continuous periods of more than 30 min?				
7. Do workers kneel (one or both knees)?				
8. Do workers perform activities with hands raised above shoulder height?				

Tray 5–B (Continued).

	Never	Sometimes	Usually	If *USUALLY*, list jobs to which answer applies here
9. Do workers perform activities while bending or twisting at the waist?				
10. Are workers exposed to vibration?				
11. Do workers lift or lower objects between floor and waist height or above shoulder height?				
12. Do workers lift or lower objects more than once per min for continuous periods of more than 15 min?				
13. Do workers lift, lower, or carry large objects or objects that cannot be held close to the body?				
14. Do workers lift, lower, or carry objects weighing more than 50 lb?				

GLOSSARY OF TERMS

Facility: The location to which employees report each day for work. For situations in which employees do not report to any fixed location on a regular basis but are subject to common supervision, the facility may be defined as a central location where other OSHA records are maintained. (Note: Synonymous with establishment, as defined in OSHA recordkeeping requirements.)

Primary job activities: Job activities that make up a significant part of the work or are required for safety or contingency. Activities are not considered to be primary job activities if they make up a small percentage of the job (i.e., take up less than 10% of the worker's time), are not essential for safety or contingency, and can be readily accomplished in other ways (e.g., using equipment already available in the facility).

Externally paced activities: Work activities for which the worker does not have direct control of the rate of work. Externally paced work activities include activities for which (1) the worker must keep up with an assembly line or an independently-operating machine, (2) the worker must respond to a continuous queue (e.g., customers standing in line, phone calls at a switchboard), or (3) time standards are imposed on workers.

Tray 5–C. Workstation Checklist

"No" responses indicate potential problem areas which should receive further investigation.

1. Does the work space allow for full range of movement?	❑ yes	❑ no
2. Are mechanical aids and equipment available?	❑ yes	❑ no
3. Is the height of the work surface adjustable?	❑ yes	❑ no
4. Can the work surface be tilted or angled?	❑ yes	❑ no
5. Is the workstation designed to reduce or eliminate		
bending or twisting at the wrist?	❑ yes	❑ no
reaching above the shoulder?	❑ yes	❑ no
static muscle loading?	❑ yes	❑ no
full extension of the arms?	❑ yes	❑ no
raised elbows?	❑ yes	❑ no
6. Are the workers able to vary posture?	❑ yes	❑ no
7. Are the hands and arms free from sharp edges on work surfaces?	❑ yes	❑ no
8. Is an armrest provided where needed?	❑ yes	❑ no
9. Is a footrest provided where needed?	❑ yes	❑ no
10. Is the floor surface free of obstacles and flat?	❑ yes	❑ no
11. Are cushioned floor mats provided for employees required to stand for long periods?	❑ yes	❑ no
12. Are chairs or stools easily adjustable and suited to the task?	❑ yes	❑ no
13. Are all task elements visible from comfortable positions?	❑ yes	❑ no
14. Is there a preventive maintenance program for mechanical aids, tools, and other equipment?	❑ yes	❑ no

Tray 5–D. Task Analysis Checklist

"No" responses indicate potential problem areas which should receive further investigation.

1. Does the design of the primary task reduce or eliminate		
bending or twisting of the back or trunk?	❑ yes	❑ no
crouching?	❑ yes	❑ no
bending or twisting the wrist?	❑ yes	❑ no
extending the arms?	❑ yes	❑ no
raised elbows?	❑ yes	❑ no
static muscle loading?	❑ yes	❑ no
clothes wringing motions?	❑ yes	❑ no
finger pinch grip?	❑ yes	❑ no
2. Are mechanical devices used when necessary?	❑ yes	❑ no
3. Can the task be done with either hand?	❑ yes	❑ no
4. Can the task be done with two hands?	❑ yes	❑ no
5. Are pushing or pulling forces kept minimal?	❑ yes	❑ no
6. Are required forces judged acceptable by the workers?	❑ yes	❑ no
7. Are the materials		
able to be held without slipping?	❑ yes	❑ no
easy to grasp?	❑ yes	❑ no
free from sharp edges and corners?	❑ yes	❑ no
8. Do containers have good handholds?	❑ yes	❑ no
9. Are jigs, fixtures, and vises used where needed?	❑ yes	❑ no
10. As needed, do gloves fit properly and are they made of the proper fabric?	❑ yes	❑ no
11. Does the worker avoid contact with sharp edges when performing the task?	❑ yes	❑ no
12. When needed, are push buttons designed properly?	❑ yes	❑ no
13. Do the job tasks allow for ready use of personal equipment that may be required?	❑ yes	❑ no
14. Are high rates of repetitive motion avoided by		
job rotation?	❑ yes	❑ no
self-pacing?	❑ yes	❑ no
sufficient pauses?	❑ yes	❑ no
adjusting the job skill level of the worker?	❑ yes	❑ no
15. Is the employee trained in		
proper work practices?	❑ yes	❑ no
when and how to make adjustments?	❑ yes	❑ no
recognizing signs and symptoms of potential problems?	❑ yes	❑ no

Tray 5–E. Handtool Analysis Checklist

"No" responses indicate potential problem areas which should receive further investigation.

1.	Are tools selected to limit or minimize		
	exposure to excessive vibration?	❑ yes	❑ no
	use of excessive force?	❑ yes	❑ no
	bending or twisting the wrist?	❑ yes	❑ no
	finger pinch grip?	❑ yes	❑ no
	problems associated with trigger finger?	❑ yes	❑ no
2.	Are tools powered where necessary and feasible?	❑ yes	❑ no
3.	Are tools evenly balanced?	❑ yes	❑ no
4.	Are heavy tools suspended or counterbalanced in ways to facilitate use?	❑ yes	❑ no
5.	Does the tool allow adequate visibility of the work?	❑ yes	❑ no
6.	Does the tool grip/handle prevent slipping during use?	❑ yes	❑ no
7.	Are tools equipped with handles of textured, non-conductive material?	❑ yes	❑ no
8.	Are different handle sizes available to fit a wide range of hand sizes?	❑ yes	❑ no
9.	Is the tool handle designed not to dig into the palm of the hand?	❑ yes	❑ no
10.	Can the tool be used safely with gloves?	❑ yes	❑ no
11.	Can the tool be used by either hand?	❑ yes	❑ no
12.	Is there a preventive maintenance program to keep tools operating as designed?	❑ yes	❑ no
13.	Have employees been trained		
	in the proper use of tools?	❑ yes	❑ no
	when and how to report problems with tools?	❑ yes	❑ no
	in proper tool maintenance?	❑ yes	❑ no

Tray 5–F. Materials Handling Checklist

"No" responses indicate potential problem areas which should receive further investigation.

1.	Are the weights of loads to be lifted judged acceptable by the workforce?	❑ yes	❑ no
2.	Are materials moved over minimum distances?	❑ yes	❑ no
3.	Is the distance between the object load and the body minimized?	❑ yes	❑ no
4.	Are walking surfaces		
	level?	❑ yes	❑ no
	wide enough?	❑ yes	❑ no
	clean and dry?	❑ yes	❑ no
5.	Are objects		
	easy to grasp?	❑ yes	❑ no
	stable?	❑ yes	❑ no
	able to be held without slipping?	❑ yes	❑ no
6.	Are there handholds on these objects?	❑ yes	❑ no
7.	When required, do gloves fit properly?	❑ yes	❑ no
8.	Is the proper footwear worn?	❑ yes	❑ no
9.	Is there enough room to maneuver?	❑ yes	❑ no
10.	Are mechanical aids used whenever possible?	❑ yes	❑ no
11.	Are working surfaces adjustable to the best handling heights?	❑ yes	❑ no
12.	Does material handling avoid		
	movements below knuckle height and above shoulder height?	❑ yes	❑ no
	static muscle loading?	❑ yes	❑ no
	sudden movements during handling?	❑ yes	❑ no
	twisting at the waist?	❑ yes	❑ no
	extended reaching?	❑ yes	❑ no
13.	Is help available for heavy or awkward lifts?	❑ yes	❑ no
14.	Are high rates of repetition avoided by		
	job rotation?	❑ yes	❑ no
	self-pacing?	❑ yes	❑ no
	sufficient pauses?	❑ yes	❑ no
15.	Are pushing or pulling forces reduced or eliminated?	❑ yes	❑ no
16.	Does the employee have an unobstructed view of handling the task?	❑ yes	❑ no
17.	Is there a preventive maintenance program for equipment?	❑ yes	❑ no
18.	Are workers trained in correct handling and lifting procedures?	❑ yes	❑ no

Tray 5–G. Computer Workstation Checklist

"No" responses indicate potential problem areas which should receive further investigation.

1. Does the workstation ensure proper worker posture, such as		
horizontal thighs?	❑ yes	❑ no
vertical lower legs?	❑ yes	❑ no
feet flat on floor or footrest?	❑ yes	❑ no
neutral wrists?	❑ yes	❑ no
2. Does the chair		
adjust easily?	❑ yes	❑ no
have a padded seat with a rounded front?	❑ yes	❑ no
have an adjustable backrest?	❑ yes	❑ no
provide lumbar support?	❑ yes	❑ no
have casters?	❑ yes	❑ no
3. Are the height and tilt of the work surface on which the keyboard is located adjustable?	❑ yes	❑ no
4. Is the keyboard detachable?	❑ yes	❑ no
5. Do keying actions require minimal force?	❑ yes	❑ no
6. Is there an adjustable document holder?	❑ yes	❑ no
7. Are arm rests provided where needed?	❑ yes	❑ no
8. Are glare and reflections avoided?	❑ yes	❑ no
9. Does the monitor have brightness and contrast controls?	❑ yes	❑ no
10. Do the operators judge the distance between eyes and work to be satisfactory for their viewing needs?	❑ yes	❑ no
11. Is there sufficient space for knees and feet?	❑ yes	❑ no
12. Can the workstation be used for either right- or left-handed activity?	❑ yes	❑ no
13. Are adequate rest breaks provided for task demands?	❑ yes	❑ no
14. Are high stroke rates avoided by		
job rotation?	❑ yes	❑ no
self-pacing?	❑ yes	❑ no
adjusting the job to the skill of the worker?	❑ yes	❑ no
15. Are employees trained in		
proper postures?	❑ yes	❑ no
proper work methods?	❑ yes	❑ no
when and how to adjust their workstations?	❑ yes	❑ no
how to seek assistance for their concerns?	❑ yes	❑ no

Tray 5–H. Protocol for Videotaping Jobs for Risk Factors

The following is a guide to preparing a videotape and related task information for facilitating job analyses and assessments of risk factors for work-related musculoskeletal disorders.

Materials needed:

Video camera and blank tapes
Spare batteries (at least 2) and battery charger
Clipboard, pens, paper, blank checklists
Stopwatch, strain gauge (optional) for weighing objects

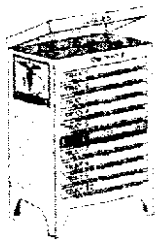
Videotaping Procedures:

1. To verify the accuracy of the video camera to record in real time, videotape a worker or job with a stopwatch running in the field of view for at least 1 min. The play-back of the tape should correspond to the lapsed time on the stopwatch.
2. Announce the name of the job on the voice channel of the video camera before the taping of any job. Restrict running time comments to the facts. Make no editorial comments.
3. Tape each job long enough to observe all aspects of the task. Tape 5 to 10 min for all jobs, including at least 10 complete cycles. Fewer cycles may be needed if all aspects of the job are recorded at least 3 to 4 times.
4. Hold the camera still, using a tripod if available. Don't walk unless absolutely necessary.
5. Begin taping each task with a whole-body shot of the worker. Include the seat/chair and the surface the worker is standing on. Hold this for 2 to 3 cycles, then zoom in on the hands/arms or other body parts which may be under stress due to the job task.
6. It is best to tape several workers to determine if workers of varying body size adopt different postures or are affected in other ways. If possible, try to tape the best and worst case situations in terms of worker "fit" to the job.
   The following suspected upper body problems suggest focusing on the parts indicated:

   — wrist problems/complaints . . . . . hands/wrists/forearms
   — elbow problems/complaints . . . . . arms/elbows
   — shoulder problems/complaints . . . . . arms/shoulders

   For back and lower limb problems, the focus would be on movements of the trunk of the body and leg, knee, and foot areas under stress due to task loads or other requirements.
7. Video from whatever angles are needed to capture the body part(s) under stress.
8. Briefly tape the jobs performed before and after the one under actual study to see how the targeted job fits into the total department process.
9. For each taped task, obtain the following information to the maximum extent possible:

   — if the task is continuous or sporadic
   — if the worker performs the work for the entire shift, or if there is rotation with other workers
   — measures of work surface heights and chair heights and whether adjustable
   — weight, size and shape of handles and textures for tools in use; indications of vibration in power tool usage
   — use of handwear
   — weight of objects lifted, pushed, pulled, or carried
   — nature of environment in which work is performed–(too cold or too hot?)



TRAY 6
EVALUATING JOB RISK FACTORS

EVALUATING JOB RISK FACTORS

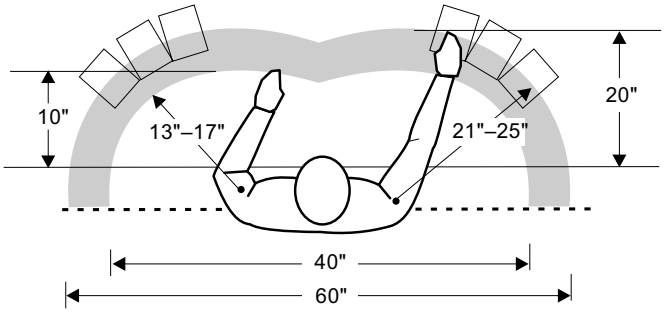
The current scientific literature contains many proposed reference levels or guidelines for gauging whether certain workplace conditions and job task demands may pose a risk of WMSDs. Although these recommendations are based on various assumptions and are subject to change with additional data, they offer a basis for making judgments about certain job risk factors. Exhibits of NIOSH investigations in the main text used several of these sources in making risk factor assessments. In these situations, special equipment and procedures were used to measure different characteristics of the job conditions and the exposure factors of consequence in rating the presence or absence of significant risk factors for WMSDs. The special equipment and procedures used for these purposes will not be described here since they go beyond the level of simple data gathering presented in this document. Instead, some general principles will be mentioned that govern the ratings of the different factors. Citations to articles describe the techniques and equipment for making actual job risk factor determinations.

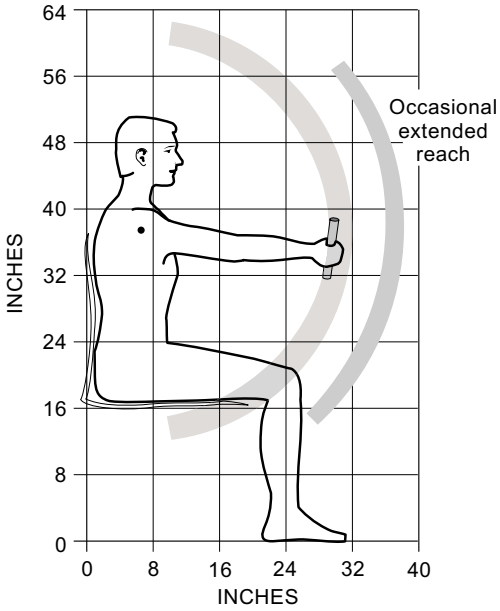
Applying reference levels or guidelines is often a controversial process. NIOSH has included these references or guidelines in this primer because they have been published in the scientific literature and have been used by NIOSH in some workplaces to evaluate specific work situations. However, most have not been extensively tested to determine their usefulness to identify hazardous situations accurately. Most scientists who proposed these guidelines realized that they were based on limited data, but they were developed to meet the needs of those who must evaluate workplaces on the basis of the current knowledge.

Work Space Features

Steps in making judgments about the adequacy of work spaces would consist of considering (1) the physical makeup of the worker population, (2) the specific body parts involved in particular tasks, and (3) whether the workstation features are fixed or adjustable. Finding workers who do similar work but differ widely in height, weight, and other body dimensions is not uncommon. The problem is whether workstation features such as bench or desk heights, access to tools, and space clearances can comfortably fit the range of body sizes. Indeed, a problem may exist if some workers are engaged in tasks in which they are constantly bending over a work surface or stretching to reach needed parts. Seated work with insufficient leg room under work tables is a problem because workers have to adopt awkward postures. Adjustable workstation features, if present, can ease these as well as other problems posed by the type of work. As an example, Tray 6–A displays work surface heights judged suitable for standing work involving precision, light assembly, and heavy duty tasks. The range of bench heights in this case

Tray 6–A. Recommended Workstation Measurements*





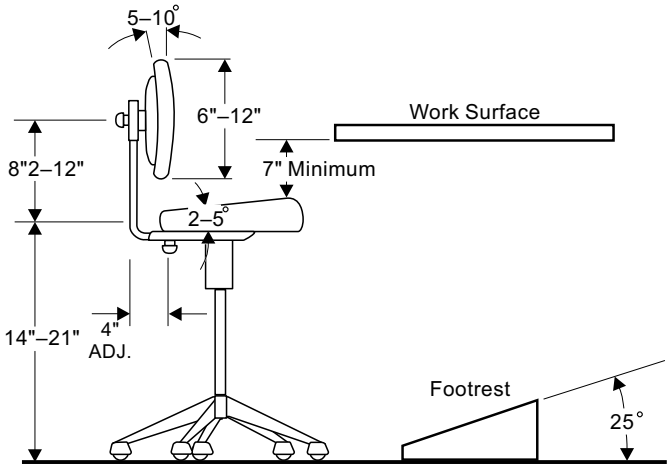
SEATED WORK:

Primary ☐ and secondary ▭ areas for table top work.

Optimal work surface height varies with the work performed:

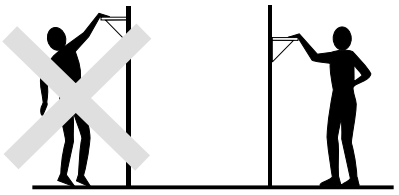
- Precision work = 31–37 in.
- Reading/writing = 28–31 in.
- Typing/light assembly = 21–28 in.

Seat and back rest heights should be adjustable as noted in chair requirements below.



SEATED WORK:

Boundaries for vertical reaches for grasping objects.

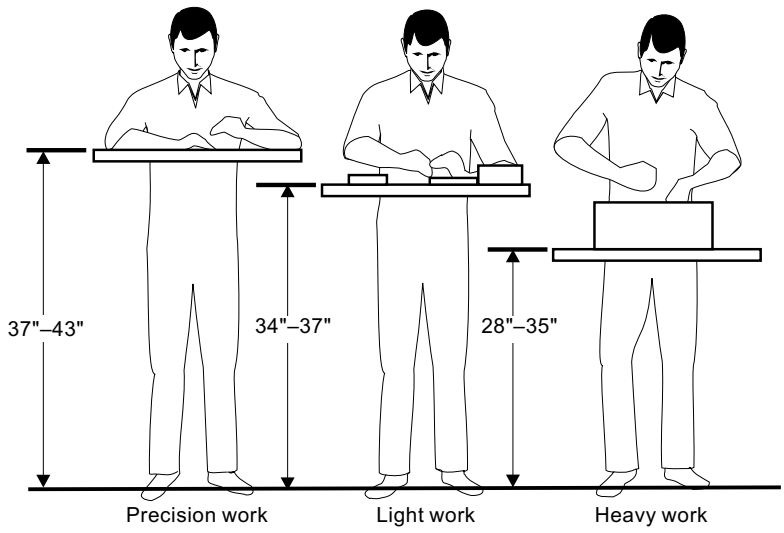


STANDING WORK:

Shelf heights to which a free-standing person can reach and place a hand flat on a shelf should not exceed 60 in.

STANDING WORK:

Workbench heights should be
- —above elbow height for *precision work*,
- —just below elbow height for *light work*, and
- —4–6 in. below elbow height for *heavy work*.



*Adapted in part from Grandjean E [1982] (*Fitting the Task to the Man: An Ergonomic Approach.* London: Taylor & Francis Ltd.) and UAW-GM [1990] (*UAW-GM Ergonomics Handbook.* Madison Heights, Michigan: Center for Health & Safety).

is intended to accommodate all but extremely tall or extremely short workers, regardless of gender. If a work surface height is not adjustable, a platform may be used to raise a short worker, or a pedestal can raise the height of the work surface for a taller worker.

Workstation layout can accommodate body size characteristics of the workforce. Some general guidelines are as follows:

- Avoid placing needed tools or other items above shoulder height.
- Position items for the shortest arm reach to avoid overstretching while reaching up or down.
- Keep frequently used tools or items close to and in front of the body.
- Position items for taller workers so that workers do not have to bend while reaching down.
- Ensure that items to be lifted are kept between hand and shoulder height.

Tray 6–A also describes an optimum layout for seated work. Boundaries take into account the range of functional reaches for most of the working population. For tabletop work, the space is divided into primary and secondary task areas. The primary area represents the space recommended for doing usual work activities; the secondary task area is for doing occasional work activities.

Data on body dimensions and reach distances when standing and sitting for men and women are cited in the literature for different percentages of the U.S. population as well as for populations in other countries and regions of the world. The following text includes these data and discusses their importance in the design of work spaces to fit the user population:

Eastman Kodak Company [1983]. Ergonomics design for people at work, Vol. 1. New York, NY: Van Nostrand Reinhold Company.

Other references suggesting recommended workplace layouts are as follows:

Kroemer K, Kroemer H, Kroemer-Elbert K [1994]. Ergonomics—how to design for ease and efficiency. Englewoods Cliffs, NJ: Prentice-Hall.

Grandjean E [1982]. Fitting the task to man. London, England: Taylor and Francis.

Woodson WE, Tillman B, Tillman P [1992]. Human factors design handbook. 2nd ed. New York, NY: McGraw Hill, Inc.

UAW-GM Center for Health and Safety [1990]. Ergonomics handbook, 29815 John R. Road, Madison Heights, MI.

Sanders MS, McCormick EJ [1987]. Human factors in engineering and design. 6th ed. New York, NY: McGraw Hill.

Manual Materials Handling—Lifting

In 1981, NIOSH developed an equation [NIOSH 1981] to rate lifting tasks in terms of whether the loads were excessive. A revised version of the equation was published in 1993 [Waters et al. 1993]. The latter formula takes into account six different factors in defining a recommended weight limit (RWL) for lifting and lowering of loads. The formula is designed to assess only certain lifting and lowering tasks (e.g., standing, two-handed, smooth lifting of stable objects in unrestricted spaces). The six factors, each of which requires actual measurements or numerical ratings on a scale, are as follows:

- Horizontal location of the load relative to the body
- Vertical location of the load relative to the floor
- Vertical distance the load is moved
- Frequency and duration of the lifting activity
- Asymmetry (lifts requiring twisting or rotation of the trunk or body)
- Quality of the worker's grip on the load

The RWL probably represents a load that nearly all (i.e., 90% of the adult population) can lift for up to 8 hours without substantially increasing the risk of musculoskeletal disorders to the lower back. Comparing the actual load weight for a task with the computed RWL estimates the risk presented by the task. For loads that exceed the RWL for a task, the factors contributing most to the excess risk can be identified. This information will suggest where control measures should have their greatest benefits.

Materials describing the NIOSH lifting formula, including its scientific justification, its limitations, and its user guidance (with sample applications and computations), are available in the following document:

> Waters TR, Putz-Anderson V, Garg A [1994]. Applications manual for the revised NIOSH lifting equation. DHHS (NIOSH) Publication No. 94–110, National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH. (The manual is available from NTIS. For ordering information, call the NTIS Sales Desk at 703–487–4560. The NTIS order number for this document is PB94–176930LJM.)

Other models for rating lifting tasks in terms of risk for low back disorders have been developed. The University of Michigan two-dimensional and more current three-dimensional approaches estimate the amount of compressive forces on spinal discs in the low back as well as the muscle strength needed for a person to perform the lifting task in question. Load weight, lift height, hand location, and hip and joint angles for the observed lifting act are measured and serve as input to these calculations. Risk estimates are based on the percentages of the U.S. male workforce who would have the strength capacity to withstand the compressive forces that may be generated. Disc compression forces of 770 lb and greater have been identified with increasing rates of reported low back pain and thus would pose a significant hazard. The following user friendly computer software can be used to make these calculations and estimate these risks:

3D Static Strength Prediction Program, Version 3.0 [1995]. University of Michigan Software:

Wolverine Tower, 3003 South State Street, Ann Arbor, MI 48109.

Other details of the three-dimensional model are found in the following:

Chaffin DB, Andersson GBJ [1991]. Occupational Biomechanics. 2nd ed. New York, NY: John Wiley & Sons Inc.

Another model offered by Marras et al., [1993; 1995] differs from both the NIOSH and Michigan formulations in requiring measurements of trunk motion in estimating lifting risks for low back disorders. A special lumbar motion monitor, worn as a back pack, is used for this purpose. For the same lifting rates, load weight and postural factors, higher peak, and average velocity measurements for trunk bending in certain directions and twisting movements will amplify the risk of low back problems. Further details about this model appear in the following two references:

Marras WS, Lavender SE, Leurgens SE, Rajulku SL, Allread WG, Fathallah FA et al. [1993]. The role of dynamic three-dimensional trunk motion in occupationally-related work-related low back disorders: the effect of workplace factors, trunk motion characteristics on risk of injury. Spine *18*(5):617–628.

Marras WS, Lavender SE, Leurgens SE, Fathallah FA, Ferguson SA, Allread WG, et al. [1995]. Biomedical risk factors for occupationally-related low back disorders. Ergonomics *28*(2):377–410.

Manual Materials Handling—Pushing, Pulling, and Carrying

Men and women performing pushing, pulling, and carrying tasks under laboratory conditions have been asked to judge the maximum loads or force levels that they believe are acceptable. Varying the frequency rate as well as the push, pull, or carry distances affects these judgments. The resulting data offer a reference for (1) evaluating whether these kinds of materials handling jobs are potentially problematic, and (2) setting future design or redesign requirements for similar tasks. The procedure for making this assessment includes a number of steps. The first is to identify the particular activity in question (i.e., pushing, pulling, or carrying). For pushing and pulling tasks, the initial and sustained forces involved in handling the load are then measured, usually by a strain gauge or "fish scale." For carrying tasks, the weight of the object being carried is measured, the frequency of the activity per min is determined, and measurements are taken of the vertical distance of the hands from the floor when the object is carried. These measurements are compared with tabled values corresponding to the task and considered acceptable for 75% and 90% of both male and female populations. For most protection, NIOSH recommends using the 90% table values. Finding the measured values to exceed these table values may suggest needs for controls to reduce task risk factors. Details of this procedure and the tables for rating the conditions are contained in the following document:

Snook SH, Ciriello VM [1991]. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. Ergonomics *34*:1197–1213.

Vibration—Whole-Body

Work conditions that involve sitting, standing, or lying on a vibrating surface produce whole-body vibration. Excessive levels and durations of exposure to whole-body vibrations may contribute to back pain and performance problems. The International Standards Organization (ISO) and American Conference of Governmental Industrial Hygienists (ACGIH) have proposed duration limits for vibration levels to reduce these problems. These limits take into account the fact that whole-body vibrations may be transmitted along three different axes corresponding to back-to-chest, right-to-left, and foot-to-head movements and that the body is more tolerant of certain vibration frequencies than others. Procedures for measuring and analyzing vibration are complex. They require use of special equipment, such as lightweight accelerometers. Accelerometers are positioned to take concurrent readings along the three axes. These readings are taken by frequency bands with the results compared with the vibration limits proposed for various exposure times. Added details about the measurement procedure appear in the following references:

ISO (International Organization for Standardization) [1985]. Evaluation of human exposure to whole-body vibration. Geneva, Switzerland: ISO Report No. ISO–2631.

ACGIH [1996]. Threshold limit values for chemical and physical agents and biological exposure indices: whole-body vibration. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, pp. 123–131.

Hand-Arm Vibration

Vibrating handtools or work pieces transmit vibrations to the holder and, depending on the vibration level and duration factors, may contribute to Raynaud's syndrome or vibration-induced white finger disorders. These disorders show a progression of symptoms beginning with occasional or intermittent numbness or blanching of the tips of a few fingers to more persistent attacks, affecting greater parts of most fingers and reducing tactile discrimination and manual dexterity. Measurements of hand-arm vibration, like whole-body vibration, are made along three axes. Accelerometers are used for these readings with the data collected and analyzed to take into account any changes in vibration hazard and frequency. Other details regarding the measurement procedures appear in the following references:

ANSI [1986]. American national standard—guide for measurement and evaluation of vibrations transmitted to the hand. New York, NY: American National Standards Institute, Inc., ANSI S3.34.

ACGIH [1996]. Threshold limit values for chemical and physical agents and biological exposure indices: hand-arm vibration. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, pp. 84–87.

These references propose limiting the values for exposure to the hand for the dominant frequency of vibration in any of the three directions. Measured vibration levels found to exceed the limits shown would dictate the need for actions to reduce the intensity or duration of the exposure.

NIOSH developed a recommended standard for hand-arm vibration that is not based on exposure limits, but focuses on engineering controls, work practices, and protective clothing to minimize vibration exposures. A cornerstone of this approach is medical monitoring for early identification of any signs of hand-arm vibration disorders among exposed workers. For details, see the following document:

NIOSH [1989]. NIOSH criteria for a recommended standard: occupational exposure to hand-arm vibration. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 89–106.

Repetition

A series of motions performed every few seconds with little variation may produce fatigue and muscle-tendon strain. If adequate recovery time is not allowed for these effects to diminish, or if the motions also involve awkward postures or forceful exertions, the risk of actual tissue damage and other musculoskeletal problems will probably increase. A task cycle time of less than 30 sec has been considered as "repetitive." Evidence that shows a link between highly repetitious actions and the development of WMSDs appears in the following reference:

Bernard BP, ed. [in press]. Musculoskeletal disorders and workplace factors: evidence for a causal relationship. 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.

Estimates vary as to repetition rates that may pose a hazard, because other factors, such as force and posture, also affect these determinations. One proposal for defining high risk repetition rates for different body parts is shown in the chart in Tray 6–B.

Tray 6–B. High Risk Repetition Rates by Different Body Parts

From Kilbom Å [1994]. Repetitive work of the upper extremity; Part II: The scientific basis for the guide. Int J Ind Erg *14*:59–86.

Body Part	Repetitions Per Minute
Shoulder	More than 2½
Upper Arm/Elbow	More than 10
Forearm/Wrist	More than 10
Finger	More than 200

The reader is cautioned not to judge the risk of WMSDs solely on the basis of repetition. As already noted, much depends on force and the postural factors that reflect the effort intensity of each action. Admittedly, this is more difficult to measure than repetition rate. In making risk

determinations, NIOSH typically supplements repetition measurements with ratings of the forces being exerted (using force gauges and subjective ratings of effort levels) and postural deviations of the body parts that may be involved (derived from time-motion analyses and other techniques). High repetitiveness when combined with high external forces and extreme postures probably represents the highest risk of WMSDs.

Physical Energy Demands

Muscular exertions to meet the physical demands of work need ample blood flow to carry oxygen to the tissues and carry away certain by-products from metabolic processes. Fatigue is experienced when the cardiovascular system cannot furnish sufficient oxygen to the muscles involved in coping with the imposed workload. Oxygen consumption measurements offer a direct means for determining the energy demands of a job. Heart rate is a less direct measurement, but heart rate reacts faster to an imposed work load. Portable direct reading instruments are available for capturing both kinds of data. Job energy demands may be determined by monitoring the oxygen consumption or heart rate of a few representative workers while they perform their usual tasks. Tables published in different sources use these measures to estimate the "heaviness" of work. The table values offer a basis for gauging whether job energy demands may be excessive and require rest or break periods to reduce fatigue, which is believed to increase a worker's risk of musculoskeletal injury.

Tables and procedures for collecting oxygen consumption and heart rate data appear in the following references:

Eastman Kodak Company [1986]. Ergonomic design for people at work. Vol. 2. New York, NY: Van Nostrand Reinhold.

Astrand P, Rodahl K [1986]. Textbook of work physiology: physiological basis of exercise. New York, NY: McGraw Hill Book Co.

NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86–113.

Another way for assessing the degree of physical effort is to have workers rate the perceived exertion in performing a work task. One scale especially designed for this purpose includes values with verbal reference points which range from"very, very light" to "very, very heavy" as aids to making these judgements. Ratings on such a scale have been found to correlate highly with physiological measures such as heart rate and offer an alternative to evaluating physical effort which is both convenient and inexpensive. Information about this type of scale and similar ones proposed for measuring the intensity of physical work appears in the following document:

Krawczyk S [1996]. Psychophysical methodology and the evaluation of manual materials handling and upper extremity intensive work. Chapter 6. In: Bhattacharya A, McGlothlin JD, eds. Occupational ergonomics. New York, NY: Marcel Dekker, Inc.

Thermal Stressors

Cold and hot working conditions can create added problems in assessing risk factors for WMSDs. Keeping hands warm may require gloves which, in turn, may cause workers to grip handtools more forcefully, resulting in added stress to the hands and wrists. More forceful gripping may also occur under hot conditions because sweating may increase the slipperiness of handtools. Workstation clearances should take into account workers wearing extra clothing for thermal protection in the cold. At the other extreme, hot work conditions may reduce a worker's capacity to do heavy physical work. In this situation, cardiac output needed to keep the body's temperature from rising too high limits the amount of blood that can deliver oxygen to the muscles. Fatigue buildup would be more readily experienced in these situations. NIOSH has published recommended exposure limits (RELs) for work under hot environmental conditions. These limits are provided for heat-acclimatized and nonacclimatized workers when performing tasks requiring different levels of energy expenditure. For details, see the following document:

NIOSH [1986]. NIOSH criteria for a recommended standard: occupational exposure to hot environments. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control, Public Health Service, National Institute for Occupational Safety and Health, DHHS [NIOSH] Publication No. 86–113.

TRAY 7
EVALUATING CONTROL EFFECTIVENESS

EVALUATING CONTROL EFFECTIVENESS

The ergonomics primers and manuals listed in Tray 10 of the Toolbox suggest ways to redesign work methods, tools, and workstations to control risk factors for musculoskeletal disorders. The reader is referred to these texts which contain numerous recommendations and illustrations of control strategies. To complement this presentation, this section lists published reports that show the effectiveness of various control measures that have been put into place. Shown in Tray 7–A are examples of engineering interventions. The work group at risk, the problem or risk factors of concern, the specific control measure introduced, and the results are described. Tray 7–B lists reports describing various forms of control measures including administrative approaches.

The main text stressed the need to evaluate the benefits of control actions. The measures noted in these reference lists reflect different ways for making such an assessment. Most are objective measurement procedures (e.g., differences in before and after readings of vibration levels, muscle activity using electromyography [EMG], and biomechanical force computations). Some show reductions in WMSD cases, lost time, or sick leave. Subjective techniques can also be used, such as the before and after use of the symptom survey described earlier in Tray 4–B. Admittedly, some of the listed intervention efforts may be more useful than others. For example, some solutions may be very task specific and have little generalizable value. Depending on the methods used in the data collection and evaluation, certain studies may yield stronger evidence of a positive intervention result. No attempt has been made to rate the studies for either generalizability or strengths of the efforts to evaluate the success of the interventions. The references for the various citations in Trays 7–A and 7–B are found at the end of this section.

Tray 7–A. Select Studies Demonstrating Effectiveness of Engineering Controls for Reducing Exposure to Ergonomic Risk Factors

Study	Target population	Problem and risk factor	Control measure	Effect
Miller et al. [1971]	Surgeons (use of bayonet forceps)	Muscle fatigue during forceps use, frequent errors in passing instruments	Redesigned forceps (increased surface area of handle).	Reduced muscle tension (determined by EMG) and number of passing errors.
Armstrong et al. [1982]	Poultry cutters (knives)	Excessive muscle force during poultry cutting tasks	Redesigned knife (reoriented blade, enlarged handle, provided strap for hand).	Reduced grip force during use, forearm muscle fatigue.
Knowlton and Gilbert [1983]	Carpenters (hammers)	Muscle fatigue, wrist deviation during hammering	Bent handle of hammer and its diameter.	Produced smaller decrement in strength and reduced ulnar wrist deviation.
Habes [1984]	Auto workers	Back fatigue during embossing tasks	Designed cut-out in die to reduce reach distance.	Reduced back muscle fatigue as determined by EMG.
Goel and Rim [1987]	Miners (pneumatic chippers)	Hand-arm vibration	Provided padded gloves.	Reduced vibration by 23.5% to 45.5%.
Wick [1987]	Machine operators in a sandal plant	Pinch grips, wrist deviation, high repetition rates, static loading of legs and back	Provided adjustable chairs and bench-mounted armrests; angled press; furnished parts bins.	Reduced wrist deviation and compressive force on lumbar-sacral discs from 85 to 13 lb.
Little [1987]	Film notchers	Wrist deviation, high repetition rates, pressure in the palm of the hand imposed by notching tool	Redesigned notching tool (extended, widened and bent handles, reduced squeezing force).	Reduced squeezing force from 15 to 10 lb; eliminated wrist deviation; increased productivity by 15%.
Johnson [1988]	Power handtool users	Muscle fatigue, excessive grip force	Added vinyl sleeve and brace to handle.	Reduced grip force as determined by EMG.
Fellows and Freivalds [1989]	Gardeners (rakes)	Blisters, muscle fatigue	Provided foam cover for handle.	Reduced muscle tension and fatigue buildup as determined by EMG.

Tray 7–A (Continued). Select Studies Demonstrating Effectiveness of Engineering Controls for Reducing Exposure to Ergonomic Risk Factors

Study	Target population	Problem and risk factor	Control measure	Effect
Andersson [1990]	Power handtool users	Hand-arm vibration	Provided vibration damping handle.	Reduced hand-transmitted vibration by 61% to 85%.
Radwin and Oh [1991]	Trigger-operated power hand tool users	Excessive hand exertion and muscle fatigue	Extended trigger.	Reduced finger and palmar force during tool operation by 7%.
Freudenthal et al. [1991]	Office workers	Static loading of back and shoulders during seated tasks	Provided desk with 10 degree incline and adjustable chair; provided adjustable tables.	Reduced moment of force on lower spinal column by 29% and by 21% on upper part.
Powers et al. [1992]	Office workers	Wrist deviation during typing tasks	Provided forearm supports and a negative slope keyboard support system.	Reduced wrist extension.
Erisman and Wick [1992]	Assembly workers	Pinch grips, wrist deviation	Provided new assembly fixtures.	Eliminated pinch grips; reduced wrist deviations by 65%; reduced cycle time by 50%.
Luttmann and Jager (1992)	Weavers	Forearm muscle fatigue	Redesigned workstation (numerous changes).	Reduced fatigue as measured by EMG and improved quality of product.
Fogleman et al. [1993]	Poultry workers (knives)	Excessive hand force, wrist deviation	Altered blade angle and handle diameter.	Wrist deviation reduced with altered blade angle.
Lindberg et al. [1993]	Seaming operators	Awkward, fixed (static) neck and shoulder postures, monotonous work movements, high work pace	Automated seaming task.	Provide freer head postures during automated seaming; reduced loads on neck and shoulder muscles as indicated by EMG; reduced perceived exertion.

Tray 7–A (Continued). Select Studies Demonstrating Effectiveness of Engineering Controls for Reducing Exposure to Ergonomic Risk Factors

Study	Target population	Problem and risk factor	Control measure	Effect
Nevala-Puranen et al. [1993]	Dairy farmers	Whole-body fatigue, bent and twisted back postures, static arm postures	Installed rail system for carrying milking equipment.	Heart rate decreased; bent and twisted back and trunk postures decreased by 64%; above-shoulder arm postures cut in half; mean milking time per cow decreased by 24%.
Degani et al. [1993]	Construction workers, landscapers (shovels)	Whole-body and local muscle fatigue	Modified shovel handle (mounted second shaft on handle).	EMG in the lower back muscles reduced; exertion showed less effort.
Gallimore and Brown [1993]	VDT operators	Visual fatigue and body discomfort due to operators adopting static postures	Fitted VDT screens with a device to move the image further away from the eye.	Glare reduced and awkward neck postures reduced for bifocal wearers.
Wick and Deweese [1993]	Shipping clerks	Wrist deviations; high pinch grip forces; awkward shoulder, neck, and back postures	Lowered and tilted the workstation; raised storage racks; provided a cutting device for wrapping materials.	Workstation changes reduced awkward wrist, shoulder, back, and neck postures; cutting tool reduced pinch grip problem; cycle time reduced by 12%.
Peng [1994]	Assemblers (percussive rivet tools)	Vibrations	Modified rivet hammer in numerous ways; introduced "recoilless" bucking bar.	Vibration at the bucking bar and rivet hammer handle reduced.

Tray 7–B. Select Studies of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study group	Intervention method	Summary of results	Additional comments
Itani et al. [1979]	Film manufacturing	124 film rollers in two groups	Reduced work time; increased number of rest breaks.	Reduced and shoulder disorders and low back complaints; improved worker health.	Productivity after the intervention was found to be 86% of the preintervention level.
Luopajarvi et al. [1982]	Food production	200 packers	Redesigned packing machine.	Decreased neck, elbow, and wrist pain.	Not all recommended job changes were implemented; workers still complained.
Drury and Wick [1984]	Shoe manufacturing	Workers at 6 factory sites	Redesign workstation.	Reduced postural stress; increased productivity.	Trunk and upper limbs were most affected by changes.
Westgaard and Aaras [1984, 1985]	Cable forms production	100 workers	Introduced adjustable workstations and fixtures and counter-balanced tools.	Turnover decreased; musculoskeletal sick leave reduced by 67% over 8-year period; productivity increased.	Reductions in shoulder, upper back muscle load verified by EMG.
McKenzie et al. [1985]	Telecommunication equipment manufacturing	6,600 employees	Redesigned handles on power screwdrivers and wire wrapping guns and instituted plant-wide ergonomics program.	Incidence rate of repetitive trauma disorders decreased from 2.2 to .53 cases/200,000 work hours; lost days reduced from 1001 to 129 in 3 years.	
Echard et al. [1987]	Automobile manufacturing	(Not indicated)	Redesigned tools, fixtures, and work organization in assembly operations.	Reduced long-term upper extremity and back disabilities; reduced carpal tunnel syndrome surgeries by 50%.	

Tray 7–B (Continued). Select Studies of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study group	Intervention method	Summary of results	Additional comments
Lutz and Hansford [1987]	Medical products manufacturing	More than 1,000 workers	Introduced adjustable workstations and fixtures and mechanical aids to reduce repetitive motions, and job rotation.	Medical visits reduced from 76 to 28 per month.	Employees also expressed enthusiasm for exercise program introduced with other interventions.
Jonsson [1988]	Telephone assembly, printed circuit card manufacturing, glass blowing, mining	25 workers	Introduced job rotation.	Job rotation in light-duty tasks were not as effective as in dynamic heavy-duty tasks.	Measured static load on shoulder upper back muscles with EMG.
Gears et al. [1988]	Rubber and plastic parts manufacturing	87 plants within one company	Ergonomics training and intervention program introduced; added material handling equipment and workstation modifications to eliminate postural stresses.	Lost time prevalence rates at two plants reduced from 4.9 and 9.7/200,000 hours to 0.9 and 2.6, respectively, within 1 year and maintained over a 4-year period.	Success attributed to increased training, awareness of hazards, and improved communication between management and workers.
Tadano [1990]	Office	500 VDT operators	Provided training, redesigned workstations, and incorporated additional breaks and exercises into the work schedule.	Cumulative trauma disorder cases reduced from 49 in the 6 months preceding the intervention to 24 in the 6 months following the intervention.	
Hopsu and Fouhevaara [1991]	Office	8 female cleaners	Provided training and greater flexibility in the work and eliminated strictly proportioned work areas and time schedules.	Average sick leave decreased from 20 days/year before the intervention to 10 days/year 2 years after intervention.	Mean maximum VO^2 rate increased, mean heart rate decreased after intervention.

Tray 7–B (Continued). Select Studies of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study group	Intervention method	Summary of results	Additional comments
LaBar [1992]	Household products manufac-turing	800 workers	Introduced adjustable workstations, improved the grips on handtools, improved parts organization, and work flow.	Reduced injuries (particularly back) by 50%.	Company also had a labor management safety committee to investigate ergonomics-related complaints.
Orgel et al. [1992]	Grocery store	23 employees	Redesigned checkout counter to reduce reach distances, installed a height-adjustable keyboard, and trained workers to adopt preferred work practices.	Decreased self-reported neck, upper back, and shoulder discomfort; no change in arm, forearm, and wrist discomfort.	The study lacked a reference group not subject to the same interventions for making suitable comparisons.
Rigdon [1992]	Bakery	630 employees	Formed union management committee to study cumulative trauma problems which led to workstation changes and tool modifications; improved work practices.	Cumulative trauma cases dropped from 34 to 13 in 4 years; lost days reduced from 731 to 8 during the same period.	Union advocated more equipment to reduce manual material handling.
Garg and Owen [1992]	Nursing home	57 nursing assistants	Implemented patient transferring devices.	IR of back injuries decreased from 83 to 43 per 200,000 work hours following the intervention; no lost or restricted work days during the 4 months following the intervention.	
Halpern and Davis [1993]	Office	90 office workers	Adjusted workstations according to the workers' anthropometric dimensions.	Body part discomfort decreased; perceived efficiency and usability of the equipment increased.	

Tray 7–B (Continued). Select Studies of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study group	Intervention method	Summary of results	Additional comments
Narayan and Rudolph [1993]	Medical device assembly plant	316 employees	Redesigned workstation to reduce reach distances, provided adjustable chairs and footrests, and provided fixtures and pneumatic gripper to eliminate pinch grips.	Plant-wide CTD incidence rate reduced from 13.7 to 11.3 per 200,000 worker hours after intervention, plant-wide severity rate reduced from 154.9 lost-time days to 67.8 lost time days per 200,000 worker hours	Not all jobs in plant affected by changes.
Parenmark et al. [1993]	Chain saw assembly plant	279 workers	Increased number of workers and tasks, provided training, reduced work pace, and adopted new wage system and flexible working hours.	Sick leave dropped from 17 to 13.7 days per worker per year; labor turnover dropped from 35% to 10%; assembly errors cut by 3%to 6%; total production cost reduced by 10%; productivity not affected.	Difficult to pinpoint which factor had biggest impact.
Shi [1993]	County government (various occupations represented)	205 workers	Introduced education, back safety training, and physical fitness activities and provided equipment and facility improvements (e.g., additional material handling equipment).	Back pain prevalence declined modestly; significant improvement in satisfaction, and a reduction in risky lifting behaviors were reported; a savings of $161,108 was realized, giving a 179% return in the investment.	
Reynolds et al. [1994]	Apparel manufac-turing	18 operators	Introduced height- and tilt-adjustable work stands, additional jigs, anti-fatigue mats, and automatic thread cutters.	Body part discomfort reduced in shoulders, arms, hands, and wrists; no injury costs incurred in 5 months following intervention.	Used worker participation approach; productivity significantly increased after intervention.

Tray 7–B (Continued). Select Studies of Various Control Strategies for Reducing Musculoskeletal Injuries and Discomfort

Study	Industry	Study group	Intervention method	Summary of results	Additional comments
Aaras [1994]	Telephone exchange manufac-turing, office	96 workers (divided into 4 groups)	Provided adjustable workstations and additional work space; tools were suspended and counterbalanced.	Significant reduction in intensity and duration of neck pain reported after intervention.	Reductions in static loading on the neck and shoulder muscles after intervention were confirmed via EMG.
Moore [1994]	Automotive engine and transmission manufac-turing	5 workers	Eliminated manual flywheel truing operation by implementing a mechanical press.	29% decrease in musculoskeletal disorders; 78% decrease in upper extremity CTDs; 82% reduction in restricted or lost work time.	Used participatory (team) approach to select intervention method.
NIOSH [1994]	Red meatpacking	3 beef and pork processing companies	Implemented a participatory (labor management) ergonomics program.	Results varied: only two teams able to introduce changes to address identified problems; some evidence that incidence and severity of injury was reduced following introduction of an ergonomics program.	Additional follow-up needed to evaluate intervention effectiveness.
NIOSH [1996]	Soft drink beverage delivery	9 driver-sales-workers	Installed pull-out steps, external handles and multi-shelving units to ease access to products, substituted plastic containers for glass to reduce weight, and redesigned carton for easier manual handling. In addition, 2-wheel hand trucks were modified to move easier over rough terrain.	Reductions in biomechanical stressors for the back and shoulders were observed when removing products from truck; heart rate decreased for 6 of 9 drivers despite increase in product volume. Reports of worker fatigue dropped; reductions in multiple handling of beverage cases and decreased awkward posture were also observed.	

Trays 7–A and 7–B. References

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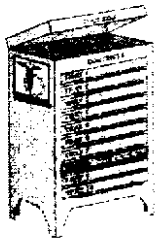

TRAY 8
HEALTH CARE MANAGEMENT

HEALTH CARE MANAGEMENT

Health care of WMSDs is still a developing field. Professionals providing health care services to companies must remain alert to any new developments. Recommended practices based on the latest and best information are described in reports listed in Tray 8–A. In taking steps to address WMSDs, employers should make efforts to select health care providers with training and interest in treating WMSDs.

Tray 8–A. Articles on Health Care Management Practices

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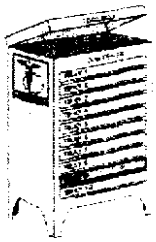


TRAY 9
PROACTIVE ERGONOMICS

PROACTIVE ERGONOMICS

Ergonomics focuses on the interactions between work demands and worker capabilities. The goal is to achieve those interactions between the work and the worker that will optimize productivity and, at the same time, preserve the safety and health of the workforce. This primer, and the manuals mentioned earlier in the main text and listed in Tray 10–A of the Toolbox, indicate various job and workplace recommendations that would assist in meeting this goal. According to this literature, certain sets of design principles govern workstation layout (Tray 9–A), task design (Tray 9–B), handtool selection (Tray 9–C), and manual materials handling (Trays 9–D, 9–E, 9–F). These principles can aid employers in reducing the risk of work-related musculoskeletal disorders. They offer ideas for correcting existing problems as well as preventing other problems when new production processes or job operations are planned. It is a matter of timing. Proactive ergonomics, by stressing these principles at the early design stages of developing work processes and job tasks, avoids the difficulty of finding retrofit solutions and any economic and human costs associated with an after-the-fact approach.

Tray 9–A. General Workstation Design Principles*

1. Make the workstation adjustable, enabling both large and small persons to fit comfortably and reach materials easily.

2. Locate all materials and tools in front of the worker to reduce twisting motions. Provide sufficient work space for the whole body to turn.

3. Avoid static loads, fixed work postures, and job requirements in which operators must frequently or for long periods

   — lean to the front or the side,
   — hold a limb in a bent or extended position,
   — tilt the head forward more than 15 degrees, or
   — support the body's weight with one leg.

4. Set the work surface above elbow height for tasks involving fine visual details and below elbow height for tasks requiring downward forces and heavy physical effort.

5. Provide adjustable, properly designed chairs with the following features

   — adjustable seat height,
   — adjustable up and down back rest, including a lumbar (lower-back) support,
   — padding that will not compress more than an inch under the weight of a seated individual, and a
   — chair that is stable to floor at all times (5-leg base).

6. Allow the workers, at their discretion, to alternate between sitting and standing. Provide floor mats or padded surfaces for prolonged standing.

7. Support the limbs: provide elbow, wrist, arm, foot, and back rests as needed and feasible.

8. Use gravity to move materials.

9. Design the workstation so that arm movements are continuous and curved. Avoid straight-line, jerking arm motions.

10. Design so arm movements pivot about the elbow rather than around the shoulder to avoid stress on shoulder, neck, and upper back.

11. Design the primary work area so that arm movements or extensions of more than 15 in. are minimized.

12. Provide dials and displays that are simple, logical, and easy to read, reach, and operate.

13. Eliminate or minimize the effects of undesirable environmental conditions such as excessive noise, heat, humidity, cold, and poor illumination.

*Adapted from design checklists developed by Dave Ridyard, CPE, CIH, CSP, Applied Ergonomics Technology, 270 Mather Road, Jenkintown, PA 19046–3129.

Tray 9–B. Design Principles for Repetitive Hand and Wrist Tasks*

1. Reduce the number of repetitions per shift. Where possible, substitute full or semi-automated systems.

2. Maintain neutral (handshake) wrist positions:

   - Design jobs and select tools to reduce extreme flexion or deviation of the wrist.
   - Avoid inward and outward rotation of the forearm when the wrist is bent to minimize elbow disorders (i.e., tennis elbow).

3. Reduce the force or pressure on the wrists and hands:

   - Wherever possible, reduce the weight and size of objects that must be handled repeatedly.
   - Avoid tools that create pressure on the base of the palm which can obstruct blood flow and nerve function.
   - Avoid repeated pounding with the base of the palm.
   - Avoid repetitive, forceful pressing with the finger tips.

4. Design tasks so that a power rather than a finger pinch grip can be used to grasp materials. Note that a pinch grip is five times more stressful than a power grip.

5. Avoid reaching more than 15 in. in front of the body for materials:

   - Avoid reaching above shoulder height, below waist level, or behind the body to minimize shoulder disorders.
   - Avoid repetitive work that requires full arm extension (i.e., the elbow held straight and the arm extended).

6. Provide support devices where awkward body postures (elevated hands or elbows and extended arms) must be maintained. Use fixtures to relieve stressful hand/arm positions.

7. Select power tools and equipment with features designed to control or limit vibration transmissions to the hands, or alternatively design work methods to reduce time or need to hold vibrating tools.

8. Provide for protection of the hands if working in a cold environment. Furnish a selection of glove sizes and sensitize users to problems of forceful overgripping when worn.

9. Select and use properly designed hand tools (e.g., grip size of tool handles should accommodate majority of workers).

*Adapted from design checklists developed by Dave Ridyard. CPE. CIH. CSP. Applied Ergonomics Technology, 270 Mather Road, Jenkintown, PA 19046–3129.

Tray 9–C. Handtool Use and Selection Principles*

1. Maintain straight wrists. Avoid bending or rotating the wrists. Remember, bend the tool, not the wrist. A variety of bent-handle tools are commercially available.

2. Avoid static muscle loading. Reduce both the weight and size of the tool. Do not raise or extend elbows when working with heavy tools. Provide counter-balanced support devices for larger, heaver tools.

3. Avoid stress on soft tissues. Stress concentrations result from poorly designed tools that exert pressure on the palms or fingers. Examples include short-handled pliers and tools with finger grooves that do not fit the worker's hand.

4. Reduce grip force requirements. The greater the effort to maintain control of a handtool, the higher the potential for injury. A compressible gripping surface rather than hard plastic may alleviate this problem.

5. Whenever possible, select tools that use a full-hand power grip rather than a precision finger grip.

6. Maintain optimal grip span. Optimum grip spans for pliers, scissors, or tongs, measured from the fingers to the base of the thumb, range from 6 to 9 cm. The recommended handle diameters for circular-handle tools such as screwdrivers are 3 to 5 cm when a power grip is required, and 0.75 to 1.5 cm when a precision finger grip is needed.

7. Avoid sharp edges and pinch points. Select tools that will not cut or pinch the hands even when gloves are not worn.

8. Avoid repetitive trigger-finger actions. Select tools with large switches that can be operated with all four fingers. Proximity switches are the most desirable triggering mechanism.

9. Isolate hands from heat, cold, and vibration. Heat and cold can cause loss of manual dexterity and increased grip strength requirements. Excessive vibration can cause reduced blood circulation in the hands causing a painful condition known as white-finger syndrome.

10. Wear gloves that fit. Gloves reduce both strength and dexterity. Tight-fitting gloves can put pressure on the hands, while loose-fitting gloves reduce grip strength and pose other safety hazards (e.g., snagging).

*Adapted from design checklists developed by Dave Ridyard, CPE. CIH. CSP. Applied Ergonomics Technology. 270 Mather Road, Jenkintown, PA 19046–3129.

Tray 9–D. Design Principles for Lifting and Lowering Tasks*

1. Optimize material flow through the workplace by

   — reducing manual lifting of materials to a minimum,
   — establishing adequate receiving, storage, and shipping facilities, and
   — maintaining adequate clearances in aisle and access areas.

2. Eliminate the need to lift or lower manually by

   — increasing the weight to a point where it must be mechanically handled,
   — palletizing handling of raw materials and products, and
   — using unit load concept (bulk handling in large bins or containers).

3. Reduce the weight of the object by

   — reducing the weight and capacity of the container,
   — reducing the load in the container, and
   — limiting the quantity per container to suppliers.

4. Reduce the hand distance from the body by

   — changing the shape of the object or container so that it can be held closer to the body, and
   — providing grips or handles for enabling the load to be held closer to the body.

5. Convert load lifting, carrying, and lowering movements to a push or pull by providing

   — conveyors,
   — ball caster tables,
   — hand trucks, and
   — four-wheel carts.

*Adapted from design checklists developed by Dave Ridyard, CPE, CIH, CSP. Applied Ergonomics Technology, 270 Mather Road, Jenkintown, PA 19046–3129.

Tray 9–E. Design Principles for Pushing and Pulling Tasks*

1. Eliminate the need to push or pull by using the following mechanical aids, when applicable:

   - Conveyors (powered and non-powered)
   - Powered trucks
   - Lift tables
   - Slides or chutes

2. Reduce the force required to push or pull by

   — reducing side and/or weight of load;
   — using four-wheel trucks or dollies;
   — using non-powered conveyors;
   — requiring that wheels and casters on hand-trucks or dollies have (1) periodic lubrication of bearings, (2) adequate maintenance, and (3) proper sizing (provide larger diameter wheels and casters);
   — maintaining the floors to eliminate holes and bumps; and
   — requiring surface treatment of floors to reduce friction.

3. Reduce the distance of the push or pull by

   — moving receiving, storage, production, or shipping areas closer to work production areas, and
   — improving the production process to eliminate unnecessary materials handling steps.

4. Optimize the technique of the push or pull by

   — providing variable-height handles so that both short and tall employees can maintain an elbow bend of 80 to 100 degrees,
   — replacing a pull with a push whenever possible, and
   — using ramps with a slope of less than 10%.

*Adapted from design checklists developed by Dave Ridyard. CPE, CIH. CSP. Applied Ergonomics Technology, 270 Mather Road, Jenkintown, PA 19046–3129.

Tray 9–F. Design Principles for Carrying Tasks*

1. Eliminate the need to carry by rearranging the workplace to eliminate unnecessary materials movement and using the following mechanical handling aids, when applicable:

    - Conveyors (all kinds)
    - Lift trucks and hand trucks
    - Tables or slides between workstations
    - Four-wheel carts or dollies
    - Air or gravity press ejection systems

2. Reduce the weight that is carried by

    — reducing the weight of the object,
    — reducing the weight of the container,
    — reducing the load in the container, and
    — reducing the quantity per container to suppliers.

3. Reduce the bulk of the materials that are carried by

    — reducing the size or shape of the object or container,
    — providing handles or hand-grips that allow materials to be held close to the body, and
    — assigning the job to two or more persons.

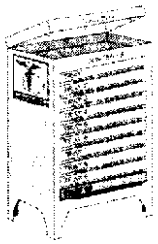
4. Reduce the carrying distance by

    — moving receiving, storage, or shipping areas closer to production areas, and
    — using powered and nonpowered conveyors.

5. Convert carry to push or pull by

    — using nonpowered conveyors, and
    — using hand trucks and push carts.

*Adapted from design checklists developed by Dave Ridyard, CPE, CIH, CSP. Applied Ergonomics Technology, 270 Mather Road, Jenkintown, PA 19046–3129.



TRAY 10
OTHER PRIMERS AND MANUALS

OTHER PRIMERS AND MANUALS

The Introduction to the main text mentioned several ergonomics primers and manuals. Some of these documents and selected ergonomics texts are listed in Tray 10–A. These documents, along with other reports already cited in the toolbox and located in the reference list at the end of the main text, can serve as added sources of information in addressing various ergonomics topics.

NIOSH staff can be helpful in identifying materials appropriate to your needs. Requests can be made by calling 1–800–35–NIOSH (1–800–356–4674). In addition, computer on-line services are available to access assorted ergonomic information. The Internet sites are:

ERGOWEB at htt://ergoweb.com/

NIOSH at http://www.cdc.gov/niosh/homepage.html

Tray 10–A. Other Selected Ergonomics Primers, Manuals, and Texts

General Ergonomics Manuals

Making the Job Easier—An Ergonomics Idea Book. [1988]; National Safety Council, 1121 Spring Lake Drive, Itasca, IL 60143–3201.

Ergonomics—A Basic Guide. [1988]; Canadian Center for Occupational Health and Safety, Hamilton, Ontario, Canada: L8N 1H6

Cumulative Trauma Disorders—A Manual for Musculoskeletal Diseases of the Upper Limbs. [1988]; Putz-Anderson V, ed.: Taylor and Francis Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007.

Lessons For Lifting and Moving Materials. [1996]: Department of Labor and Industries, Division of Consultation and Compliance, P.O. Box 44610, Olympia, WA 98504–4610.

Creating the Ergonomically Sound Workplace. [1993]; Ostrom LT; Jossey-Bass Publishers, 350 Sansomee Street, San Francisco, CA 94104.

The Ergonomics of Workspaces and Machines—A Design Manual. [1995]; Corlett EN, Clark TS; Taylor & Francis, Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007.

Industrial Ergonomics—A Practitioner's Guide. [1985]; Alexander DC, Pulat BM, eds.; Institute of Industrial Engineers, 25 Technology Park/Atlanta, Norcross, GA 30092.

Industry or Operation Specific Manuals

Ergonomics Program Management Guidelines for Meatpacking Plants. [1993]; Occupational Safety and Health Administration, U.S. Department of Labor, Washington, DC, OSHA Report No. 3123.

Stand, Lift, Carry—Back Care and Manual Materials Handling in Construction. [1993]; Construction Safety Association of Ontario, 74 Victoria Street, Toronto, Ontario, Canada M5C 2A5.

Ergonomics Awareness Manual. UAW Health and Safety Department, 8000 East Jefferson Avenue, Detroit, MI 48214.

Management Strategies for Preventing Strains and Sprains: A Guide to Practical Ergonomics. [1988]; American Meat Institute, P.O. Box 3556, Washington, DC 20007.

UAW—GM Ergonomics Handbook. [May 1990]; UAW-GM Center for Health and Safety, 29815 John R. Road, Madison Heights, MI 48071.

Tray 10–A (Continued). Other Selected Ergonomics Primers, Manuals, and Texts

Ergonomics Texts

Work-Related Musculoskeletal Disorders (WMSDs): A Reference Book for Prevention. [1995]; Kuorinka I, Forcier L, eds.; Taylor & Francis Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007.

Occupational Ergonomics—Theory and Applications. [1996]; Bhattachrya A, McGlothlin JD, eds.; Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016.

Ergonomic Design for People at Work. Vol 1. [1983]; Eastman Kodak Co., Van Nostrand Reinhold Company, 115 Fifth Avenue, New York, NY 10003

Ergonomic Design for People at Work. Vol 2. [1986]; Eastman Kodak Co., Van Nostrand Reinhold Company, 115 Fifth Avenue, New York, NY 10003

Fitting the Task to Man. [1982]; Grandjean E; Taylor and Francis Ltd, London, England.

Ergonomics—How to Design for Ease and Efficiency. [1994]; Kroemer K, Kroemer H, Kroemer-Elbert K; Prentice-Hall, Englewood Cliffs, NJ.

Ergonomic Interventions to Prevent Musculoskeletal Injuries in Industry. [1987]; American Conference of Governmental Industrial Hygienists, Lewis Publishers Inc.,121 S. Main St., Chelsa, MI 48118

Cumulative Trauma Disorders—Prevention, Evaluation, Treatment. [1997]; Erdil M, Dickerson OB, eds.; Van Nostrand Reinhold, 115 Fifth Avenue, New York, NY 10003.

Evaluation of Human Work. [1990]; Wilson JR, Corlett EN, eds.; Taylor & Francis Inc., 1900 Frost Road, Suite 101, Bristol, PA 19007.

*U.S. Government Printing Office: 1997 — 550-920