Ergonomics in Action

Tech Guide 220

USACHPPM

Readiness thru Health

Chapter 3: Hazard Prevention and Control

HAZARD PREVENTION AND CONTROL OVERVIEW

Ideally, the principles of ergonomics should be applied before workers start working on a new job. However, ergonomics is still a relatively new field and many jobs, workstations, tools, and equipment were in place before ergonomic designs were employed. Consequently, existing problems in the workplace need to be addressed by implementing the correct solutions.

Initiate Hazard Prevention and Control

The action team initiates the hazard prevention and control process once the hazards have been defined and prioritized under worksite analysis. See algorithm 2-1 in chapter 2.

Identify Solution

- To identify a solution to any ergonomics problem, the ergonomics subcommittee must first define the management criteria for selecting an intervention method. These management criteria may include:
  - –Solution effectiveness (e.g., is the risk factor eliminated by the intervention, or to what degree is the risk factor eliminated?).
  - –Timeliness (e.g., how much time will it take to implement the intervention?).
  - –Employee acceptance (this often determines the effectiveness and success of the intervention).
  - –The cost of intervention (e.g., what is the cost of the modifications under one intervention compared to the cost of another intervention?).

- In every instance, the ergonomics subcommittee must consider all criteria and ask:
  - –How does the criteria affect the worker and the workplace?
  - –What is the cost of the intervention versus the cost of the work-related musculo-skeletal disorder (WMSD) over time?

- There are often several possible interventions available to prevent or control exposure to WMSDs. The ergonomics subcommittee must identify viable interventions on a case-by-case basis, and should consider all possible—
  - –Engineering controls.
  - –Administrative controls.
  - –Personal protective equipment.

- If the action team determines that the ergonomics problem is area-wide, they should notify the health care provider of a possible health risk to other workers.

- If the action team determines that the problem is related to a single WMSD case, which would require individual accommodations and a return-to-work plan, they should coordinate and consult with the health care provider to determine—
  - –The severity of the WMSD.
  - –The type of treatment to be prescribed.
  - –How that treatment affects the ergonomics intervention(s). See chapter 4 for detailed information.

- In all instances, the ergonomics subcommittee's decision process must be clear, documented, supported by the organization, and justifiable.

- Part III of this chapter lists and details the intervention methods in order of priority.

Select Solution

Based on the established management criteria, the action team selects, prioritizes, plans, and recommends an intervention method to management and employees.

Prototype and Implement Solution

The implementation of an intervention may involve a test or prototype before full implementation. Sample workstations or limited changes in work methods can provide information about potential problems and modifications that may be needed.

The ergonomics subcommittee evaluates the prototype once it has been in effect for a short time, and determines if the intervention is an acceptable one (e.g., is the intervention feasible, effective, and acceptable?).

- If yes, management and employees implement the intervention based on the action team's recommendations. The ergonomics subcommittee should also initiate education and training, including job-specific training and an overview of the interventions begin implemented. See algorithm 4-5 in chapter 4.
- If no, the action team selects and prototypes another intervention until one is acceptable.

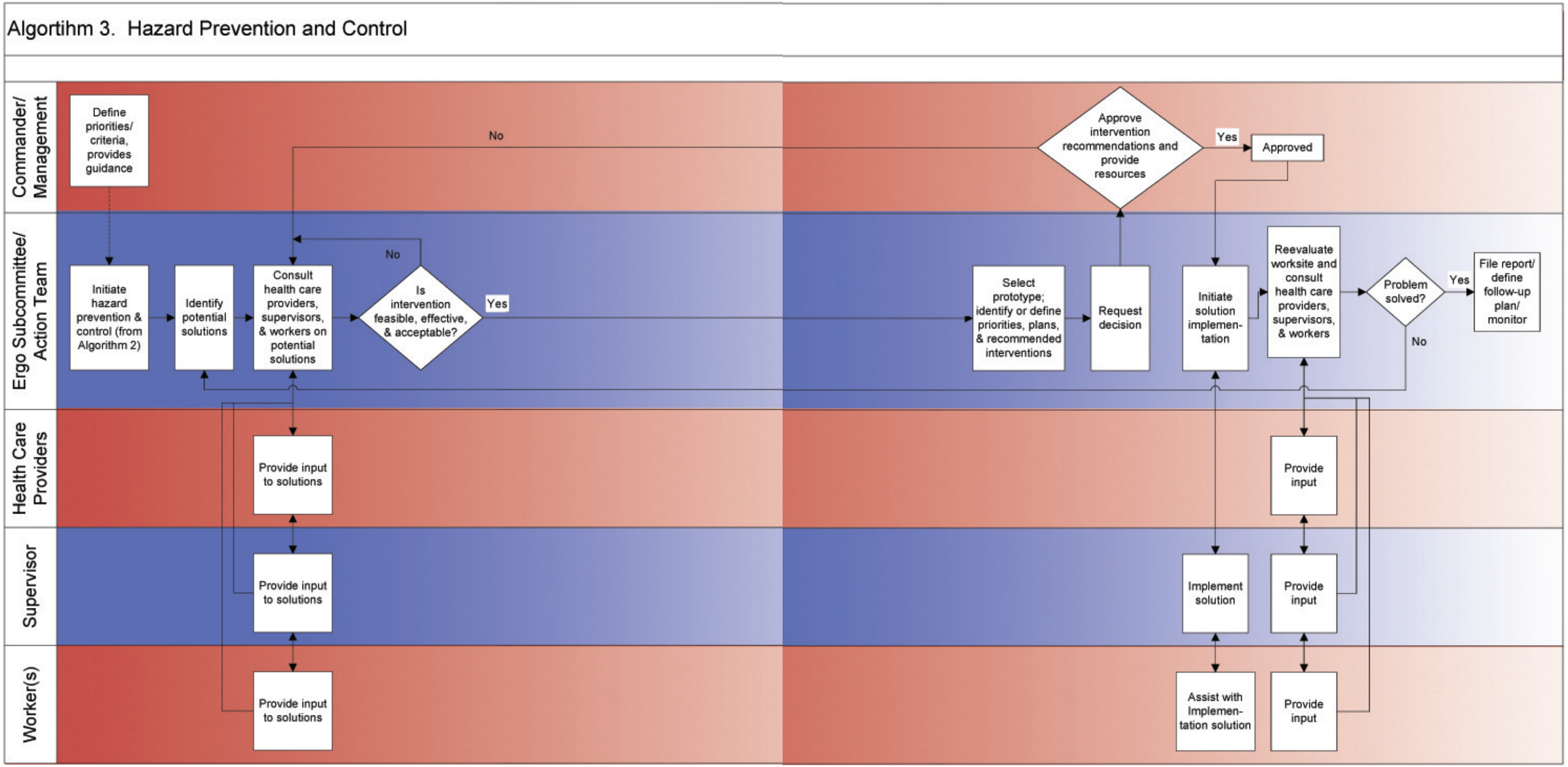
Evaluate Solution

Once an appropriate intervention is in place, and over time, the action team, under the direction of the ergonomics subcommittee, reassesses the worksite to see if the problem is solved.

- If yes, appropriate reports are filed, with copies furnished to management and employees.
- If no, the action team selects another intervention.

In their recommendation, the action team should clarify what problem they are solving, as well as the timeframe they will allow for a successful solution to the problem. The action team's recommendation to management must clearly outline the criteria they will use to determine if the solution was successful. As an example, the action team could measure, among other things:

- Reduced WMSD risk factors.
- Reduced compensation costs.
- Reduced absenteeism.
- Reduced physical discomfort.
- Increased productivity.
- Increased workplace comfort.


Algortihm 3. Hazard Prevention and Control
Commander/ Management
Ergo Subcommittee/ Action Team
Health Care Providers
Supervisor
Worker(s)
Define priorities/ criteria, provides guidance
Initiate hazard prevention & control (from Algorithm 2)
Identify potential solutions
Consult health care providers, supervisors, & workers on potential solutions
Is intervention feasible, effective, & acceptable?
No
Yes
Provide input to solutions
Provide input to solutions
Provide input to solutions
Approve intervention recommendations and provide resources
Yes
Approved
Select prototype; identify or define priorities, plans, & recommended interventions
Request decision
Initiate solution implemen-tation
Reevaluate worksite and consult health care providers, supervisors, & workers
Problem solved?
Yes
No
File report/ define follow-up plan/ monitor
Provide input
Implement solution
Provide input
Assist with Implemen-tation solution
Provide input

DESIGNING ERGONOMICWORK ENVIRONMENTS

The principles of ergonomics should be applied before workers start working on a new job or operation. This section discusses how designers apply knowledge about the physical dimensions of people to the design of workstations, reach distances, clearances, tools, and equipment. It also outlines the different approaches and principles used in designing an ergonomic work environment.

Anthropometry

Designers use anthropometry to tailor their design of workstations, reach distances, clearances, tools, and equipment to fit the people who will actually be working at the workstations. The initial part of this process involves two steps:

- Defining the Actual Working Population. There are numerous anthropometric data sources providing information on the physical dimensions of workers by gender, age, and ethnic origin. Designers use the source that best matches the working population.
- Identification of the Body Parts and Dimensions of Interest. The types of tasks involved in a job determines which body parts will be used to perform those tasks and what dimensions need to be considered in design specifications. For example, the task may involve reaching, seated or standing operations, or use of controls, tools, and containers. The designer first identifies the percentile(s) and gender of interest (e.g., the 5th percentile woman and the 95th percentile man), and then extracts the data from the anthropometric sources and applies the information. This design approach is called "design for the range" and is discussed on the next page.

Workstations are designed so that the majority of all people can safely and effectively perform the required tasks. The best design is one that allows an employee to work within their work space envelope. The work space envelope is the threedimensional area within which a person can perform some type of manual activity safely, comfortably, and efficiently. Objects most frequently used in performing tasks are located within the work space. The reasonable limits of a work space are determined by functional arm reach, which is influenced by multiple variables, such as:

- Direction of arm reach.
- The nature of the manual activity.
- The use of restraint apparel worn.
- The angle of the backrest.
- Personal variables such as age, sex, ethnic group, and handicaps.

Whenever possible, the work space envelope is designed with consideration for the personal characteristics of the population using the facility.
Designers often design the space for the 5th percentile of the using population (usually the smallest woman), thus making it suitable for 95 percent of the population.

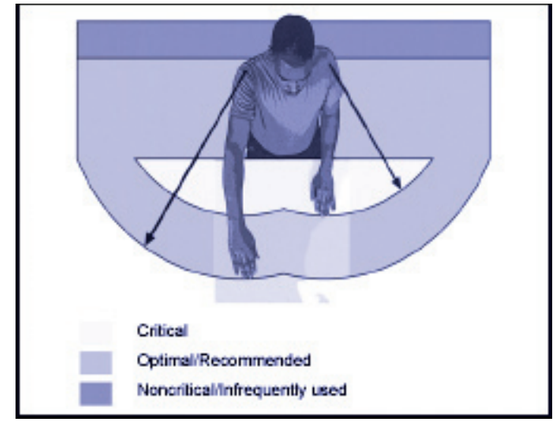


Figure 1a.
Sample Work- Reach Envelope

Design Approaches

There are three main design approaches to applying anthropometric data: design for the range, design for the extreme, and design for the average. However, the selection of a design approach is situation specific, and no one approach is appropriate in all circumstances.

Design for the Range. The preferred approach is design for the range, which usually involves some adjustability and "fits" the majority of workers. Workstations and equipment designed using the design for the range approach usually fits the majority of workers, from the 95th percentile man to the 5th percentile woman, thus accommodating approximately 90 percent of the working population.

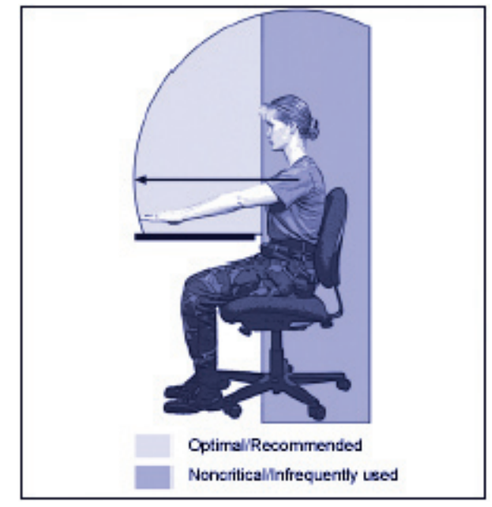
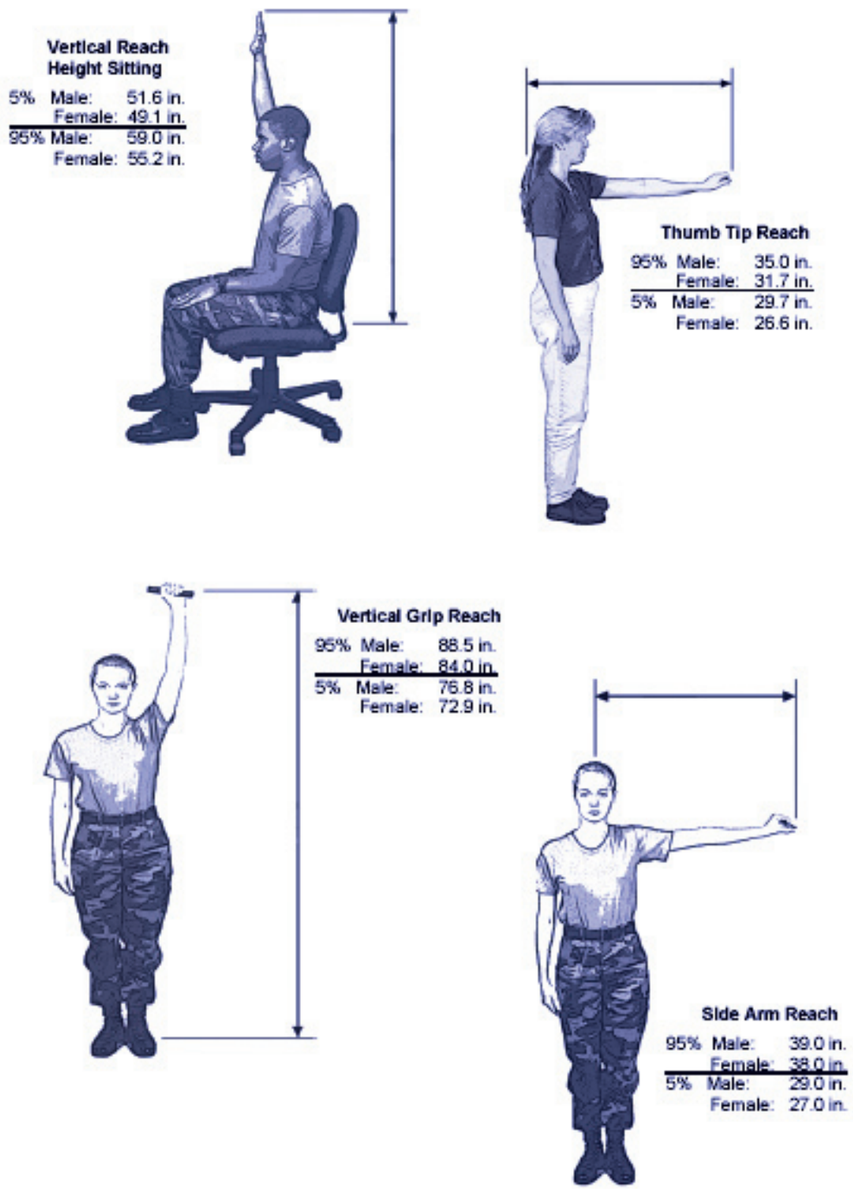


Figure 1b.
Sample Work-Reach Envelope

Figures 3-1a and 3-1b illustrate two work space envelope scnarios.
Figure 3-2 illustrates four reach dimensions.

Figure 2. Sample Reach Dimensions



Design for the Extreme.

The second best approach, design for the extreme, involves designing for either the smallest woman or the largest man in the population. The smallest workers (5th percentile) determine reach dimension (e.g., fire extinguisher placement) and visual clearances. The largest workers (95th percentile) determine clearances (e.g., doorways, walkways).

Design for the Average.

The last approach is design for the average, which uses anthropometric data on the average-sized worker for designing workplaces and equipment. Although this approach is more economical, the equipment or workplace will not accommodate the majority of the workforce.

Worksite Design Principles

The worksite is the physical area in which a worker performs job activities. Each component in a worksite should be in its optimum location, that is, where it will best benefit the safe and efficient performance of the activities carried out in the space. There are four basic worksite design principles that can be applied to improve workstation arrangement and workflow while reducing risk factors:

- Importance Principle. The important components of a job should be placed in convenient locations. Importance refers to critical safety features, and determines to what degree each component is important in achieving the objectives of the job. For example, in an auto dashboard, the speedometer is most important; therefore, it is placed in the middle. This allows for the driver to refer to the speedometer (at his or her center of vision) without taking his or her eyes off the road.
- Frequency-of-Use Principle. Frequently used tools, equipment, and other workstation components such as switches or buttons should be located in convenient locations. For example, the copy machine should be near the department secretary. In an assembly operation, certain tools may be used for all assemblies and should therefore always be within the safe reach of the worker; whereas, other tools that are used only occasionally can be stored on a nearby shelf or in a drawer.
- Function Principle. Workstation components should be grouped and arranged according to their function, such as the groupings of displays, controls, or machines that are functionally related to the operation of the system. For example, direction indicators and direction controls should be located together.
- Sequence-of-Use Principle. In some operations, sequences or patterns of relationship frequently occur in performing a task. Components should be arranged to take advantage of the sequences or patterns of the task. This principle should be followed wherever and whenever possible as it has the greatest positive effect on performance, productivity, and errors. For example, in a small package weighing and sorting operation, the location of the scale and conveyors should allow the worker to follow the proper sequence of the work process.

ERGONOMIC PROBLEM SOLVING PROCESS

As mentioned earlier, applying ergonomic designs to the work environment before starting a new operation is the best way to avoid ergonomic hazards. However, ergonomics is still a relatively new field and many jobs, workstations, tools, and equipment were in place before ergonomic designs were employed. Consequently, existing problems in the workplace need to be addressed by implementing the correct solutions.

The action team first needs to look for potential hazards embedded in poor designs which could later cause work-related musculoskeletal disorders (WMSDs). Once the action team conducts passive or active surveillance, and determines that a potential problem or WMSD exists, they—

- Assess area-wide or individual case hazards.
- Prioritize the problem(s).
- Initiate the hazard prevention and control process.

> The worksite analysis process is outlined in chapter 2.

Identifying a Solution

There are often several possible solutions to ergonomic problems. The ergonomics subcommittee must clearly define the criteria for solution selection. One approach bases solution selection on the following four criteria:

Solution Effectiveness, which measures the effectiveness of a solution based on a four-point scale, where—
4 = risk factors completely eliminated.
3 = risk factors mostly eliminated.
2 = some risk factors eliminated.
1 = few or no risk factors eliminated.

Timeliness, which represents the time required to fully implement the solution and reduce or eliminate the risk factors. If a solution will require a significant amount of time to implement, the action team should implement an interim solution.

Employee Acceptance, which ultimately determines the effectiveness and success of the solution. Employees must be actively involved in the solution identification and selection process.

Cost of the solution and the cost/benefit analysis. Management will use cost as a primary factor to determine if they should implement a proposed intervention. When identifying solutions, the ergonomics subcommittee should consider—

- The cost of one solution over another.
- The cost of the solution versus the cost of the WMSD over time, which may include medical costs, worker compensation liabilities, and additional hidden costs, such as pain and discomfort, increased sick leave, increased error rates, wasted materials, and overtime paid to other employees. When trying to estimate the true cost of WMSDs, the ergonomics subcommittee should use a multiplier of 4 (e.g., the calculated cost of the WMSD times 4) to ensure that all hidden costs are included in the "bottom line" figure.

If the problem is related to one individual case, the ergonomics subcommittee must also consult with health care providers to determine—

- The severity of the WMSD.
- The type of treatment to be prescribed.
- How that treatment affects the ergonomics solution(s).

Other decision schemes can be developed based on the organization's management philosophies, values, and criteria. Regardless of the method used, the decision process must be clear, documented, supported by the organization, and justifiable.

> Algorithms 4-1 and 4-2 in chapter 4 outline the strategies for health care management and medical treatment of WMSDs.

Selecting a Solution

Based on the established management criteria, the action team selects, prioritizes, plans, and recommends an intervention to management and employees.
In their recommendation, the action team should clarify what problem they are solving, as well as the timeframe they will allow for a successful solution to the problem. The action team's recommendation to management must clearly outline the criteria they will use to determine if the solution was successful. As an example, the action team could measure, among other things:

- Reduced WMSD risk factors.
- Reduced physical discomfort.
- Reduced compensation costs.
- Increased productivity.
- Reduced absenteeism.
- Increased workplace comfort.

Prototyping and Implementing a Solution

Implementation may involve a test or prototype before full implementation. Mockups, sample workstations, or limited changes in work methods, can provide information about potential problems and modifications that may be needed.
Once the intervention is in effect for a short time, the action team should evaluate the prototype to determine if the intervention is an appropriate one. The ergonomics subcommittee—

- Should establish clear and relevant criteria for the action team to follow when assessing the effectiveness of the intervention.
- Must ensure appropriate documentation of walk-through and worksite evaluations. This documentation should include the date, areas visited, risk factors recognized, actions initiated, follow-up time frame, and results of the follow-up. Problems, delays, and subsequent actions should also be documented. A tracking log must be used to record activities.

Remember to keep employees actively involved in the design, testing, and implementation of all interventions. If they don't believe they "own" the process, they are less likely to implement change.

Evaluating the Solution

Once an appropriate intervention is in place for a period of time, the action team, under the direction of the ergonomics subcommittee, reassesses the worksite to see if the problem is solved. Unless the process and outcomes are measured accurately against appropriate criteria, it will be impossible to distinguish ergonomic-related effects from other effects. Therefore, in their reassessment, the action team should refer to the criteria they established in their initial recommendation to management.

USING ERGONOMIC INTERVENTIONS FOR

Effective design (or redesign) of a worksite or job is the primary method of preventing or controlling exposure to WMSD hazards. Intervention methods are defined below and listed in order of priority.

Engineering Controls

Researchers have identified specific workplace risk factors for WMSDs. Exposure to these risk factors can result in decreased blood flow to muscles, nerves, and joints; nerve compression; tendonitis; muscle strain; and joint damage. Prolonged exposure to the risk factors can lead to damage and debilitating conditions. Engineering controls (which include worksite design, area layout, equipment design, and tool, handle, and container design) are the most effective method of reducing or eliminating identified risk factors.

Process Elimination. Is the process necessary? Is there a better or easier way to complete the process? For example, the use of an automatic bar code scanner by logistics personnel does not entail the repetitive motion necessary when using a hand-held bar code scanner. In all instances, try to eliminate the most demanding processes first. Also keep in mind that it is important to get the employees' input when identifying the most demanding processes.

Redesign of the Worksite. Worksite modifications and equipment and hand tool redesign are based on the physical characteristics, or anthropometry, and capabilities of the current working population. Refer to Part I of this booklet for more information on how the redesign of the worksite benefits all workers.

Substitution. By substituting a new work process or tool (without WMSD hazards) for a work process or tool with identified WMSD hazards, the hazard can be eliminated. Some hand tools, for instance, require awkward wrist positions. Others are available that allow for neutral, or natural, wrist posture.

See chapter 1 for more information on workplace risk factors.

Administrative Controls

Administrative controls limit the duration, frequency, and severity of exposure to WMSD hazards. Examples of administrative controls include, but are not limited to—

- Reducing the number of repetitions by decreasing production rate requirements and limiting overtime work.
- Reducing the number and speed of repetitions by reducing line or production speed. Production speeds should be based on the worker, not the machine.
- Providing rest breaks to relieve fatigued muscle-tendon groups. Taking a break does not necessarily mean a stop in work—just a break from using identical muscles. Breaks are most effective if taken before the point of fatigue.
- Increasing the number of personnel assigned to a task, or exchanging subtasks among the personnel.
- Rotating personnel through various tasks.
- Modifying work practices. The following work practices can decrease or eliminate exposure to WMSD hazards:
  - Proper work techniques. These techniques should encourage correct posture, use of proper body mechanics, appropriate use and maintenance of hand and power tools, and correct use of equipment and workstations.
  - Personnel conditioning. This refers to a conditioning or break-in period for new or returning personnel. A gradual integration into a full workload may be necessary depending on the job or the person.
  - Routine monitoring of operations. Routine monitoring is essential to ensure that proper work practices are in place, and to confirm that these work practices do not contribute to WMSD hazards.
- Rotating personnel to nonstress jobs as a preventive measure, with the goal of alleviating physical fatigue and stress to a particular set of muscles and in the rotation schedule rather than prevent problems. However, job rotation is not the proper response to symptoms of WMSDs in all cases. For some, such as those performing high-risk tasks, job rotation can contribute to symptom development in all personnel involved in the rotation schedule rather than prevent problems.
- Providing modified- or restricted-duty assignments to allow injured muscletendon groups time to rest and properly heal. Every effort should be made to provide modified- or restricted-duty assignments when physical limitations (as identified by a health care provider) allow the worker to return to work performing less than his or her normal work requirements. In addition, trained ergonomics personnel should assess the modified- or restricted-duty assignment to ensure that the worker is not exposed to other hazardous conditions that can interfere with the healing process or lead to another WMSD.
- Maintaining tools and equipment.
- Maintaining effective housekeeping to eliminate "slip and trip" conditions.

Figure 3-3 discusses microbreaksand exercise and their effectiveness in reducing WMSDs.

Figures 3-4a, 3-4b, and 3-4c illustrateexercises to perform in the office.

Personal Protective Equipment

Proper PPE should accommodate the physical requirements of the worker on the job, and should act as a barrier between the worker and the potential hazard. However, PPE may not be the proper recommendation for controlling WMSD hazards. Incorrect or ill-fitting equipment may actually make stressors worse. Some PPE can also increase the worker's reaction to heat stress, physical demands of the task, and fatigue. In these cases, the work-rest schedule may need to be adjusted to accommodate the increased physiological stress caused by PPE use.

Workers should consult trained ergonomics personnel regarding the necessity and effectiveness of PPE in preventing WMSD hazards in their respective workplaces. PPE for ergonomic hazards are limited as most of the hazards involve workstation and task features that force a response from the worker. Vibration is the only ergonomic hazard that requires a barrier, such as gloves or vibration dampening wrap.

Medical appliances such as wrist rests, back belts, and back braces are not considered PPE. In fact, the DoD does not support the use of these types of devices in the prevention of wrist or back injuries. Appliances such as those listed above can be prescribed by a credentialed health care provider. The health care provider then agrees to assume responsibility for the medical clearance of the device; the proper fit of the device; and treatment and monitoring as the worker wears the device.

Figure 3-3. Microbreaks and Exercise

Experts have found that short, frequent breaks at the worker's discretion are effective in reducing the risk of cumulative trauma disorders and do not reduce the productivity of the worker. Exercise breaks are intended to compliment proper ergonomic job design, not substitute for it.

Breaks are more effective if they are taken before the worker reaches the point of fatigue. Breaks should vary with the intensity of work. More intense work requires longer or more frequent breaks.

The breaks are most effective if light execise and stretching are done during the break. Companies report that exercise programs have been effective in reducing workplace injuries, improving morale, and generally making the employees feel better.

Exercise breaks allow physiologic recovery, improve circulation, increase flexibility, and increase strength. Exercise training improves both physical fitness and the ability to perform physical work without fatigue. Exercise can increase maximum aerobic power, reduce heart rate, reduce blood pressure, and increase muscle strength and endurance.

A physical therapist or physician should be consulted when selecting an exercise program. The exercises chosen should not be conspicuous or disruptive. The worker should be able to perform the exercises at his/her workstation in a short period of time. The exercises must be safe for the worker; they must not exacerbate existing conditions or pose health risks. Workers with preexisting medical conditions should be screened before starting an exercise program. The exercise program has four essential components:

- Stretch chronically shortened and tensed muscles.
- Mobilize the spine, decreasing lower back muscle stress and the compressive force on intervertebral discs.
- Strengthen and contract chronically stretched and fatigued muscles.
- Improve blood flow from the lower extremity.

The exercise program should include the eyes, neck, shoulders, elbows and lower arms, lower back and hips, and the knees and lower legs.

Figure 3-4a. Exercises to Do in the Office

Many office workers have jobs where they sit or stand for long periods. Working in one position can lead to muscle pain and strain. The following exercises, which can be done at the workstation, can help.

Warm Up. Before you start to exercise, relax and warm up your body by breathing deeply in through your nose and out through your mouth. Take a couple of long relaxed breaths. Next, slowly lower your head to your chest. Then start breathing in through your nose as you slowly and carefully roll your head up to your left shoulder. If you reach a point where you become stiff and experience pain, stop at that point for now. After your head is up, slowly exhale through your mouth as you lower your head back down to your chest. Repeat this exercise by rolling your head up to your right shoulder, making sure you breathe in through your nose when going up, and exhale through your mouth when going down.

For Eye Relief

1. Hide and Seek

- Lean your elbows on your desk.
- Cup your hands and place them lightly over your closed eyes.
- Hold for a minute while breathing deeply in through your nose and out through your mouth.
- Slowly uncover your eyes.

2. Do the Groucho

- Close your eyes and slowly roll your eyeballs clockwise all the way around like Groucho Marx. Repeat 3 times.
- Slowly roll your eyes all the way around counter-clockwise. Repeat 3 times.

3. Daydreaming Baby

- Every half-hour, look away from the computer screen.
- Focus on an object at least 20 feet away.
- Look back at the screen, then look away again and focus your eyes back on the object.
- Repeat 3 times.

For Stretching Your Neck and Head

4. Topsy Turvy

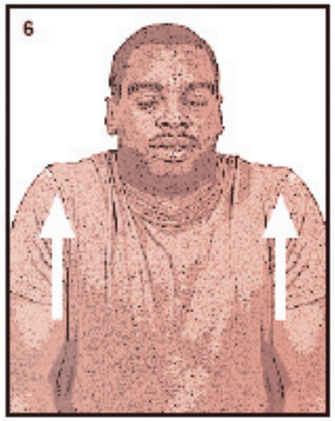
- Sit up straight and tuck in your chin.
- Gently tip your head to the left. Return to center, then tip your head to the right. Repeat 3 times on each side.

5. The Exorcist

- Sit up straight. Turn your head to the left and look over your left shoulder. Hold for a few seconds.
- Return your head to the ceter and look over your right shoulder. Repeat 3 times on each side.

Figure 3-4b: Exercises to Do in the Office

For Stretching Your Shoulders



6. I Don't Know!
- Slowly shrug your shoulders towards your ears. Hold for a few seconds.
- Slowly bring your shoulders down and relax. Repeat 3 times on each side.

7. Hands Up!
- Put your hands up, with forearms raised.
- Push your arms backward, squeezing your shoulder blades. Hold for a few seconds.
- Slowly bring your shoulders down and relax.

For Stretching and Toning the Muscles in Your Arms 8/9. For Your Arms Only

- Hold your arms straight out in front of you.

- First rotate your arms so the backs of your hands face each other. Hold for a few seconds.

- Now rotate your arms so the palms of your hands face upward. Hold for a few seconds.

For Stretching and Toning the Muscles in Your Wrists, Hands, and Fingers

10/11/12. Gimme 10!
- Hold your arms in front of you and make gentle fists.
- Point your knuckles toward the floor a nd hold for a few seconds.
- Straighten your fingers and point them down.
- Slowly point your fingers up toward the ceiling and hold for a few seconds. Relax and repeat each step 3 times.

Figure 3-4c. Exercises to Do in The Office For Stretching and Toning the Muscles in Your Wrists, Hands, and Fingers

For Stretching and Toning the Musclesin Your Wrists, Hands, and Fingers

13. Shake, Rattle, and Roll
- While standing or sitting, lower your arms to your sides.
- Gently shake out your arms and roll them around for a few seconds.
- Relax. Repeat 3 times.

For Stretching and Toning the Musclesin Your Back

14. Cable Guy
- Sit up straight and imagine you have a cable attached to the top of your head.
- Feel the cable pull you up higher and higher. Hold for a few seconds.
- Relax. Repeat 3 times.

For Stretching and Toning the Muscles in Your Feet and Legs

15. The Hokey Pokey
- While sitting, turn your right foot in. Then turn your right foot out.

Do the "hokey pokey" and shake it all about.
- Be sure to rotate your foot slowly.
- Do this exercise 3 times clockwise, then 3 times counterclockwise.
- Rotate the other foot 3 times in each direction.
- Relax. Repeat 3 times with each foot.

NOTE: Some exercises can actually aggravate existing medical conditions. Consult a physical therapist or physician prior to selecting an exercise program

Ergonomically designed workstations can allow workers to work safely for extended periods of time; however, the worker must maintain the proper posture and move correctly during his or her tasks to take full advantage of the design features. A worker who is overly tense or who lacks sufficient muscle strength and endurance for the job is at greater risk for developing work-related health problems. Common complaints include tired eyes, tight shoulders, stiff neck, and aching back. Specific exercises, like those recommended in figures 3-4a, 3-4b, and 3-4c, can help workers build muscle strength and endurance, provide relief from symptoms, and ultimately help prevent WMSDs.

While each workplace has its own unique set of work-related hazards, there are some common problems found at most facilities. This section will help you identify those common problems and find the solution that best fits your problem.

Workstation Height

Working height must provide for the optimum visual distance for fine or precise manipulation.

- Delicate work (e.g., drawing) is best performed when the elbow is supported to help reduce static loads in the muscles of the back. A good working height is about 2 to 4 inches above the elbow.
- The best working height for lighter work while standing is 2 to 4 inches below the elbow.
- When performing manual work, the worker often needs space for various tools, materials, and containers. A suitable height for these items is 4 to 6 inches below the elbow.
- Heavier work, involving much ef fort and use of the weight of the upper part of the body (e.g., woodworking or heavy assembly work), should be done at a lower working surface: 6 to 16 inches below the elbow depending on the required force.
- The maximum speed of operation for manual jobs carried out in front of the body is achieved by keeping the elbows down at the sides and the arms bent at a right angle.

If the organization cannot provide adjustable workstations, working heights should be set for the tallest worker and should accommodate smaller workers by allowing them to stand on something.

Figure 3-5 illustrates various props for use in a standing workplace, and shows accommodations for a worker who stands at a fixed-height work surface. Figure 3-6 shows six work space scenarios and gives the dimensions of each.

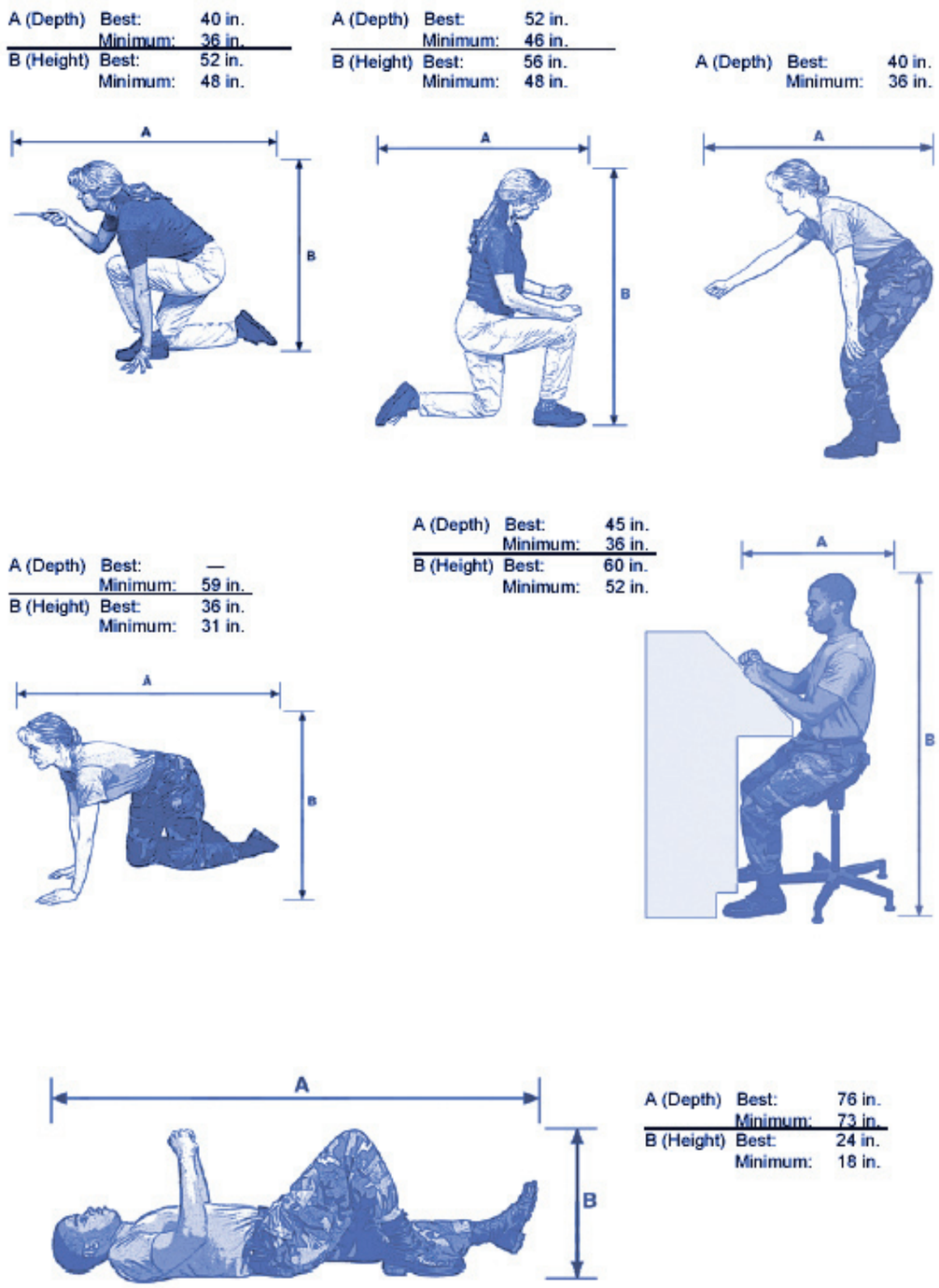
Figure 3-5: Standing Work Surface Props to Accommodate the Standing Worker

Prop Stool

Set the height of the work surface for the tallest worker. Accommodate smaller workers by allowing them to stand on something.

Jump Seat

Figure 3-6: Sample Work Space Dimensions

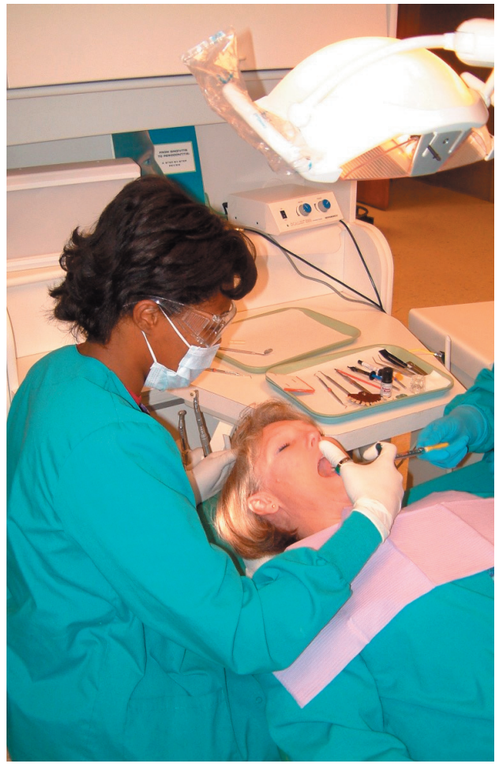


Lighting and Glare

Eye strain is the most common complaint among office workers. Inadequate lighting causes many of the vision-related problems seen in the office. The lighting in the work area depends on the task being performed.

Workers should consider both natural and electric lighting and the objects in the space that reflect their light since almost all objects in a work area are reflective, including the floor, ceiling, walls, partitions, equipment, furniture, and furnishings. Their finishes, such as paint, lacquer, glass, fabric, or carpeting, determine the amount and nature of their reflections. Even the clothing a worker wears may produce unwanted reflections. Because there are so many factors that affect the lighting in the work area, it's important that the workstation lighting is both adjustable and under the worker's control. Possible solutions to common lighting problems include:

- Positioning the monitor screen so that it is perpendicular to the light source (i.e., windows, overhead light, task lighting).
- Using diffused, indirect lighting rather than direct lighting.
- Arranging task lighting so it does not create new glare sources. Direct a task light at the work, but do not focus it on a small area. Do not diffuse the task light. Task lights should not be in the worker's direct line of sight.
- Checking the luminance ratio for computer work to make certain it meets the recommended 1:3 ratio between the monitor screen and the immediate surrounding lighter areas and 1:10 for remote lighter areas.
- Avoiding high luminance sources in the peripheral field of view.
- Moving or tilting the monitor screen so reflections are not in the field of view.



Glare is a difficult lighting problem to eliminate. Direct glare is caused by light sources in the field of view, whereas indirect, or reflective, glare is caused by light being reflected by a surface in the field of view. Even a low level of glare can cause enough eye strain to impair a worker's performance. To control glare:

- Turn off some lights, especially if viewing a monitor screen, or adjust the brightness and contrast on the display screen or cover the screen with glare filters.
- Make sure the workstation has matte or nonglare surfaces.
- Reduce the source of glare by covering windows and baffling ceiling light fixtures, allowing light to be evenly dispersed.

Table 3-7 presents recommended illumination levels for various types of work areas, tasks, and recreational and household activities. The Federal Energy Conservation levels are based on Title 41, CFR, Section 101-20.107, Energy Conservation. The task summary is a composite of several references on illumination.

Higher illumination than levels prescribed by 41 CFR 101-20.107 may be used if the prescribed level presents a safety hazard. However, permission of the facilities engineer must be obtained prior to an illumination upgrade. filters.

Table 3-7. Recommended Illumination Levels

Illumination Level (foot candles)	Tasks: Federal Energy Conservation	Tasks: Illumination Specialist Summary
1-5	Corridors, stairwells, walking surfaces, elevator-boarding areas	
6-10	Storage areas, nonwork areas	Auto parking areas, aisles, hallways
11-20		Auditoriums, storage areas, stairways, swimming pools
21-30	Work areas (30" above floor)	Gymnasiums, assembly (average), loading dock, shipping preparation
31-50	Workstation surfaces (30" above floor)	Document preparation, average reading
51-100		Food preparation, assembly and manufacturing (medium), workstation tabletop
101-200		Fine inspection, detailed work, assembly (fine), fine detail drafting/drawing
201-500		Machine work (fine detail), circuit assembly, very fine inspection

Materials Handling

Solutions to material handling problems involve changes to the workstation, job, or containers and tools. The design approaches listed below can reduce or eliminate many of the risk factors seen in materials handling tasks.

Workstation. The workstation design should optimize the horizontal and vertical position of the load, considering the individual anthropometric dimensions of the worker(s) (e.g., height and reach envelope). Suggestions for reducing or eliminating workstation design problems follow:

- Change the work area layout so that all material is provided at work level, rather than from the floor or overhead. This can involve a change in height of either the work surface or the worker level.
- Provide anti-fatigue matting if the worker stands in one place for prolonged periods of time. The DOD recommends using a firm, compressible material that is 2-inch thick for the matting.
- Provide ways to adjust the height of materials to be handled so that less lifting and more sliding can be done (e.g., provide a spring-loaded table or scissors table to adjust the height of the load).
- Minimize the horizontal distance between the starting and ending points of a lift (i.e., minimize carrying and travel distance).
- Limit stacking heights to the shoulder height of operators.
- Keep heavy objects at knuckle height of the operators.
- Locate objects to be handled within the arm reach envelope of the operator.
- Avoid the use of deep shelves that require the operator to bend and reach to obtain objects toward the rear of the shelves.
- Design work areas to provide sufficient space for the entire body to turn.
- In production line operations, adequately space the in-process inventory so time constraints do not over stress the worker.
- Use gravity to move material wherever practical (e.g., gravity feed conveyors and lowering instead of lifting).
- Choose carts with casters and wheels best suited to the type of floor in the work area (e.g., uneven, concrete, carpeted). Maintain a manageable weight on the cart so it moves easily and minimizes the effect of movement (e.g., pushing or pulling) on the worker. pulling.

Job.

Reducing static work is very important in reducing the worker's physiological stress and risk of injury on the job. Most tasks involve both static and dynamic work, but, in many cases the static component is the limiting performance factor. Static work, such as holding or carrying an object, frequently results in local muscle fatigue even for short-duration activities. Acceptable limits for dynamic work durations range from minutes to hours depending on the task. However, acceptable limits for static work durations are measured in seconds and minutes for any task.

Figure 3-8 provides additional information on static work.

In the design of jobs, reducing the static component of any task can prevent local muscle fatigue from limiting productivity. Follow these guidelines:

- Decrease the weight of the object being handled.
- Assign the handling to two or more persons.
- Change the type of materials handling activity (e.g., lifting, lowering, pushing, pulling, carrying, and holding). It is preferable for a job to require lowering rather than lifting, pulling rather than carrying, and pushing rather than pulling.
- Maximize the time available to perform the job by reducing the frequency of lift, and/or by incorporating work/rest schedules or job rotation programs.
- Provide increased rest periods if recommended energy levels are exceeded. The recommended energy expenditure limits are based on the daily workload. This workload should not exceed about 35 percent of a person's maximum aerobic power over an 8-hour day. Though this represents approximately 5 kilocalories (kcal)/min for men and 3.35 kcal/min for women, the worker's age, weight, and conditioning variables, such as their target heart rate, also need to be considered when determining their maximum aerobic power and creating or changing their work-rest schedule. On average, a worker's heart rate should not exceed 120- 140 beats/min for aerobic exercise; 112 beats/min for leg work; and 99 beats/min for arm work.
- Rotate people to a lighter job after 1 to 2 hours in a constant handling task.
- Automate production handling and storage functions when possible.

The most common standardized approach to materials handling lifting and lowering assessment is the NIOSH Lift Equation, discussed in chapter 2, appendix 2-C.

Chapter 2 offers an expanded discussion of energy expenditure.

Figure 3-8. Static Work

Skeletal muscles are unique in that the muscle fibers can shorten to one-half of their normal length.

Movement results when enough tension is created within the muscle to overcome other forces exerted on the skeletal system. Isotonic (dynamic) contraction occurs when muscle fibers shorten and perform work.

- Isometric (static) contraction occurs when the muscle remains the same length (doing no work), but the tension within the muscle increases.

During dynamic work, the muscle acts as a pump, increasing the blood supply to the muscle by 10 to 20 times the amount present when the muscle is at rest. A muscle performing dynamic work is thereby maintained with energy and oxygen, while waste products are simultaneously removed.

In contrast, muscles maintaining a static contraction must depend on reserves of sugar and oxygen already contained in the muscle. Waste products are not removed as efficiently, and the accumulation of waste products eventually results in a burning sensation, pain, and fatigue.

Most tasks involve both static and dynamic work, but, in many cases, the static component is the limiting performance factor. Static work frequently results in local muscle fatigue even for short-duration activities. Acceptable limits for dynamic work durations range from minutes to hours depending on the task. However, acceptable limits for static work durations are measured in seconds and minutes for any task. In the design of jobs, reducing the static component of any task can prevent local muscle fatigue from limiting productivity.

General guidelines to reduce the amount of static work are:

- Provide seating or leaning supports, anti-fatigue mats, or cushioned insoles for shoes for workers who are required to work on their feet much of the day.
- Provide carrying aids such as boxes or carts for carrying tasks that involve objects weighing more than 15 pounds, or objects that have to be lifted or carried for more than one minute or more than a few feet.
- Use jigs and fixtures to reduce the requirement for holding tools.

Chapter 2 offers an expanded discussion of energy expenditure. A detailed hand tool assessment checklist is presented in chapter 2, appendix 2-B.

Containers and Tools.

Use the following guidelines for safe handling of containers and tools.

- Reduce the size of the container.
- Reduce the container weight (e.g., use plastic drums rather than metal drums).
- Distribute the load into two or more containers.
- Change the shape of the object (by using a different container) or the location of handholds to allow the object to be handled close to the body.
- Provide good handholds on containers or objects to be handled.
- Use mechanical aids (e.g., hoists, lift trucks, lift tables, cranes, elevating conveyors, and chutes).
- Use devices such as handles and grips to provide better control of the handled object.
- Balance contents within containers.
- Provide rigid containers for increased operator control of the object.
- Avoid lifting excessively wide objects from the floor level.
- Provide carts, carrier bags, handles, or handholds to support the weight of objects that have to be lifted or carried for more than one minute or more than a few feet.
- Provide tools to help in applying forces with the hand.
- Use jigs and fixtures to reduce the requirement for holding in assembly tasks.

Hand Tools.

Hand tools, in one form or another, are used in all occupations. Poorly designed tools can lead to injuries, accidents, and WMSDs. Common problems seen with hand tools include awkward positions, mechanical compression, vibration, and forceful exertions. Shortcomings in hand tool design are generally easy to identify. However, the majority of these problems can be resolved by applying some basic principles, such as those outlined below.

- Use special purpose tools.
- Use lightweight, well-balanced, or counter-balanced tools.
- Use a tool balancer, holder, or jig if prolonged use or holding is required.
- Use tools designed for use by both hands.
- Use power hand tools whenever possible.
- Use the best grip for the task (e.g., a power grip when high force is required).
- Use only tools that have the appropriate handle thickness, shape, and length for the job.
- If a tool is used with gloves, choose a handle thickness, shape, and material to allow safe and comfortable use with the gloves.
- Use tools with compressible and nonconductive handles, and without sharp edges.
- Apply the adage, "Bend the tool handle (when appropriate), not the worker."
- Select tools that minimize stress on muscles and tendons.
- Allow for adequate finger clearance if trigger use is required, or increase the size of the trigger so more than one finger can be used.
- Allow for the hose connection of pneumatic tools to have a two-directional wivel.
- Cover power tool handles with vibration dampening material, such as Sorbothane®.
- Properly calibrate and maintain all tools.

Use chater 4 as your guide for monitoring the success of the intervention methods presented here, and for evaluating the overall ergnomics program.

CHOOSING ERGONOMICS SOLUTIONS

The Air Force has developed a comprehensive guide—known as the *Level 1 Ergonomics Methodology Guide*—that is designed to help:

- Identify workplace risk factors.
- Prioritize ergonomics problems to select realistic controls.
- Modify the workplace.
- Maintain readiness by improving employee performance and well-being.

The Level 1 Guide is the focal point for identifying the causes of workplace risk factors and selecting the appropriate interventions. In addition, the Level I Guide provides strategies or options to use to control ergonomics hazards. In appendix 4 of the Level I Guide, medium to high-risk tasks are matched to case study problemsolving matrices. These matrices are organized so that users simply look for the affected body region(s) and risk factor(s), and match the cause with correction actions, risk factor by risk factor. The lists below are a snapshot of the case studies in the Level I Guide. In the guide, each case study is matched with a page number for easy reference. The first list represents those case studies of highest interest to ergonomics subcommittee and action team members.

A copy of the Level I Guide is available on-line by contacting Brooks Air Force Base at http://sg-www.satx.disa.mil/~hscoemo/index.htm.

Case Studies of Highest Interest

1. Using a Computer/General Word Processing
2. Writing/Illustrating
3. Stapling
4. Monitoring Visual Displays (Vigilance)
5. Calling (Telephone Use)
6. Copying/Sorting
7. CAD System Use (Drafting)
8. Filing/General Administrative
9. Use of Calculator/Numeric Key Pad
10. Lifting/Pushing/Pulling
11. Microscope Work

General Case Studies

1. Abrading
2. Assembly/Disassembly—
3. Assembly/Repair—Bench Work
4. Bolting/Screwing
5. Chipping
6. Cleaning by Hand
7. Cleaning with High Pressure
8. Coating/Immersing
9. Computer Work
10. Crimping
11. Cutting/Shearing
12. Drilling
13. Driving (Vehicles)
14. Excavating/Shoveling
15. Flame Cutting
16. Folding/Fitting
17. Forming
18. Gluing/Laminating (Dopping)
19. Grinding
20. Hammering
21. Hose Handing
22. Lifting
23. Machining
24. Masking
25. Masoning
26. Media Blasting—Blast Cabinet
27. Media Blasting—
28. Melting
29. Monitoring (of Displays)
30. Nailing
31. Opening/Closing Heavy Doors
32. Ordnance Disposal
33. Packing
34. Painting/Spraying
35. Paving
36. Prying
37. Pumping
38. Riveting/Bucking
39. Sanding
40. Sawing
41. Sewing
42. Soldering
43. Stripping/Depainting by Hand
44. Stripping/ Depainting by
45. Turning Valves
46. Tying/Twisting/Wrapping
47. Visual Inspection
48. Welding
49. Wiring
50. Wrenching/Ratcheting

Each of these topics provides a general task description (or category), and sends the user to appropriate case studies within the Level I Guide. The case studies for each category provide numerous potential risk factors, causes, and corrective actions by body part, which can be matched to the particular risk factors observed in any worksite on any installation. Decision-making information on the level of changes, cost, and impact on quality and productivity are provided for each potential corrective action. An example of how the matrices apply to this technical guide is presented below.

Example: Level I Guide Decision-Making Matrix

Job Factor	Potential Causes	Corrective Action	Level of Changes		Cost	Impact On	
			Minor Modification	Major Change		Quality	Productivity
Hand Forces	Person tends to hit keys hard	Train proper keying style: encourage person to practice using as light a touch as possible on keys			Low	Low	Low

EVALUATING THE SOLUTION

Once an appropriate intervention is in place for a period of time, the action team, under the direction of the ergonomics subcommittee, reassesses the worksite to see if the problem is solved.

- If yes, appropriate reports are filed, with copies furnished to management and employees.
- If no, the action team selects another solution.

The action team may use the Ergonomics Concern Tracking Log on the next page as a tool for documenting the follow-up evaluation.

ERGONOMIC CONCERN TRACKING LOG	
Date Opened	
Problem	
Location	
RAC(s)	
Supervisor/ POC/Action Officer	
Plan and Target Date	
Follow-up Date	
Results of Follow-up	
Action	