Preventing Work-Related Musculoskeletal Disorders

A DoD Information Guide for Supervisors

August 1999

This publication was produced by the Department of Defense (DOD) Ergonomics Working Group, in coordination with the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). For questions on ergonomics issues, please visit your local occupational health or safety office or contact the appropriate service office listed on page 2 of this guide.

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Ergonomics—An Overview

Ergonomics is essentially fitting the workplace to the worker.* It involves applying our knowledge about human capacities and limitations to the design of workplaces, jobs, tasks, tools, equipment, and the environment.** An organized ergonomics program is essential in avoiding musculoskeletal injuries and illnesses, and thereby preventing WMSDs, at your facility.

An effective ergonomics program follows a team approach, led by top installation management. However, it also requires a commitment by all levels of management and worker involvement. This guide is meant to provide supervisors with the information they need to be active participants in the ergonomics program. Much of this information can also be shared with workers to educate them on their role in maintaining a safe and healthy workplace.

Program Authority.

On 4 February 1997, the Deputy Under Secretary of Defense (Environmental Security) issued a memorandum establishing interim requirements and procedures for the control of work-related musculoskeletal injury and illness within the Department of Defense (DOD). Based on the standards set forth in this memorandum, the May 1998 revision of DOD Instruction 6055.1, which regulates the DOD Occupational Safety and Health Program, also includes ergonomics requirements.

For information on service-specific ergonomics guidance or local ergonomics programs and their resources, contact your installation occupational safety and health (OSH) professionals, or the appropriate office from the following list:

- **Army**
  U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM); Ergonomics Program; DSN 584-3928 or commercial 410-436-3928.

- **Air Force**
  Institute for Environment, Safety, and Occupational Health Risk Analysis, Risk Analysis Directorate, Health and Safety Division, Ergonomics and Hearing Conservation Branch; DSN 240-6116 or commercial 210-536-6116.

- **Navy**
  Chief of Naval Operations (N45); DSN 332-2575 or commercial 703-602-2575.

- **Marine Corps**
  HQ Marine Corps; Safety Division; DSN 224-1077 or commercial 703-614-1077.

**For purposes of this guide, the term "worker" includes both civilian and service members of the DOD. The term "management" includes both civilian and command-level service members of the DOD, and the term "supervisor" applies to both civilian personnel and NCOs.*

***Although the science of ergonomics applies to all aspects of human performance (e.g., cognitive, physical, and psychological), this document focuses specifically on musculoskeletal disorders.*

Program Goals.

The goal of an ergonomics program is to eliminate or reduce exposure to ergonomic risk factors, and—

- Improve the health and well being of the worker.
- Improve productivity and quality.
- Prevent work-related musculoskeletal disorders (WMSDs) and related injuries and illnesses.

Program Elements.

Five critical program elements must be accomplished to successfully implement an ergonomics program at any installation:

- Worksite Analysis.
- Hazard Prevention and Control.
- Health Care Management.
- Education and Training.
- Program Evaluation.

Management Commitment.

All managers, supervisors, and workers should be informed of their role in various elements of the ergonomics program. Basically, the supervisor's responsibilities include:

- Coordinating with trained ergonomics, safety, and health personnel to reduce risks and support the overall ergonomics program.
- Holding personnel accountable for failure to follow safe work practices.
- Recognizing initiatives in improving operating conditions and procedures.
- Ensuring personnel are aware of their benefits and responsibilities.
- Reviewing work areas, tasks, and tools and equipment on a routine basis for potential workplace risk factors. This also means maintaining effective schedules for facility, equipment, and tool maintenance, adjustments, and modifications.
- Ensuring personnel are trained, and that they can recognize and report hazardous work practices.

- Encouraging personnel to report all injuries and illnesses as soon as they occur or when signs or symptoms of WMSDs appear.

- Showing personal concern for worker safety and making the elimination of ergonomic hazards a priority.

- Considering safety and health to be as important as production. Safety and health protection should be built into daily production activities.

If given the authority and resources to meet their responsibilities, supervisors can work together to promote good ergonomic design in the workplace, thereby improving production, product quality, and morale while decreasing the costs associated with absenteeism, turnover, training, and replacement.

Worker Involvement.

Supervisors should encourage workers to participate in the ergonomics program and in decisions that affect their safety and health by—

- Providing a procedure for complaints or suggestions.

- Allowing workers to bring their concerns to management without fear of reprisal.

- Providing a procedure for workers to report signs and symptoms of WMSDs so they may be evaluated and treated.

- Allowing safety and health committees to make recommendations for corrective action when they receive and analyze information on ergonomic problem areas.

- Encouraging worker groups to identify and analyze jobs for ergonomic stress and recommend solutions.

Workplace risk factors do more than cause WMSDs; they also create fatigue and poor work performance. This cuts into productivity and quality. Therefore, WMSDs are more than an injury issue; they are also a productivity issue. It is human performance that determines productivity and quality of the output in a work area, which is the ultimate measure of a supervisor's success.

Introduction to Work-related Musculoskeletal Disorders

Work-related musculoskeletal disorders—

- Arise from repeated stress to the body encountered in the workplace.
- Can result in a variety of injuries or illnesses of the muscles, tendons, ligaments, nerves (outside the brain and spine), joints, cartilage, bones, and supporting blood vessels in either the upper or lower extremities, or back.
- Can cause, over a period of time, permanent damage to muscles, tendons, and tendon sheaths, and related bones, muscles, and nerves.
- Can result in permanent disability.
- Result from the cumulative effect of repeated traumas associated with specific workplace risk factors.

Synonymous Terms
Other terms and acronyms used synonymously for WMSDs include cumulative trauma disorders (CTDs), repetitive strain injuries, repetitive strain disorders, and occupational overuse syndrome.

Workplace Risk Factors
- Task-related, workplace risk factors that contribute to WMSDs include **posture**, **repetition**, **force**, **mechanical compression or contact stress**, **vibration**, and **temperature**.
- Terms used synonymously for workplace risk factors include environmental, generic, biomechanical, and basic risk factors.

In recent years, the number of WMSDs due to ergonomic hazards has substantially increased. In fact, WMSDs account for nearly half of the occupational illnesses reported in the annual Bureau of Labor Statistics (BLS) survey and an increasingly large percentage of annual workers' compensation claims.

WMSDs are also a significant problem for the Department of Defense (DOD) because they result in duty or work limitations, decreased readiness, and increased workers' compensation costs. Therefore, preventing WMSDs not only protects the workforce, but it also makes good business sense. The production-related costs of an injured worker are at least 8 to 10 times more than their medical costs. Injured service members or employees force units to deal with decreased output, replacement costs, retraining, increased errors, and an increased demand on the rest of the work force.

DOD facilities that have implemented successful ergonomics programs have seen measurable results in terms of protecting the work force, increasing productivity and quality, decreasing workers' compensation expenditures, increasing readiness, and reducing absenteeism and employee turnover.

Figure 1. Common Work-related Musculoskeletal Disorders

*Keep in mind, WMSDs are not diagnoses**;** they are work-related disorders with similar characteristics. Common WMSDs include:*

- **Tendonitis (also Tendinitis)**. This condition is an irritation (inflammation) of a tendon resulting from repeated force or stress on that muscle/tendon group.

- **Lateral epicondylitis (tennis elbow).** This condition is an irritation (inflammation) of the tendons attached on the outside of the elbow caused by activities that have jerky throwing motions or impact (e.g., turning a screwdriver).

- **Medial epicondylitis (golfer's elbow).** This condition is an irritation (inflammation) of the tendon attachments on the inside of the elbow resulting from activities that require repeated or forceful rotation of the forearm and bending of the wrist at the same time.

- **Tenosynovitis.** Tenosynovitis is an irritation (inflammation) of the tendon and the lining of the smooth sheath surrounding the tendon, resulting from repeated movement of the tendon in the sheath.

- **Synovitis**. Synovitis is an irritation (inflammation) of the inner lining of the membrane surrounding a joint or tendon.

- **Stenosing tenosynovitis of the finger (trigger finger).** This condition results from a tendon surface becoming irritated and rough. If the tendon sheath also becomes inflamed and presses on the tendon, a progressive constriction of the tendon can occur, resulting in a loss of free movement in that joint area. This disorder is commonly caused, for example, by repeated use of a staple gun or pair of pliers.

- **de Quervain's disease**. This "disease" is a stenosing tenosynovitis affecting the tendons on the radial side (e.g., thumb side) of the wrist. Constriction of these tendons pulls the thumb back away from the hand, causing severe pain and limited thumb movement or use.

- **Raynaud's phenomenon (white finger or vibration syndrome)**. This "phenomenon" is caused by the reflexive constriction of the small arteries, which causes the fingers to become white (pale) and feel cold, numb, and tingly. This disorder is caused, in part, by prolonged hand-arm vibration from powered handtools.

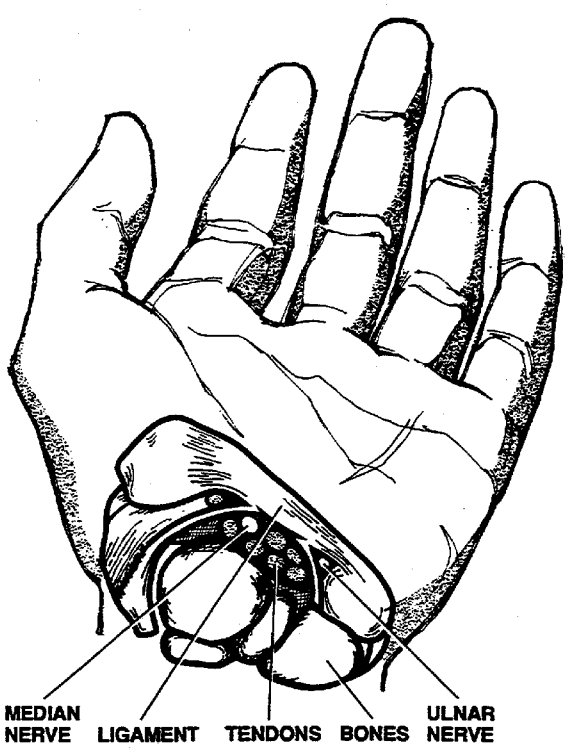
- **Thoracic Outlet Syndrome**. This syndrome involves compression of the nerves and blood vessels between the neck and shoulder. Symptoms include numbness of the fingers and hand. Compression is due to various postures or activities, such as working with the arms above shoulder height and pulling the shoulders back and down.

Carpal Tunnel Syndrome

Carpal Tunnel Syndrome (CTS) is the most common upper extremity WMSD. It can lead to permanent disability if not detected early and treated properly.

Anatomy and Physiology of the Carpal Tunnel.

To understand how this disorder develops, you need to know something about the structures within the forearm, wrist, and fingers. When you perform a task using the hand, the wrist and fingers are flexed by muscles located in the forearm. Those muscles are connected to the wrist and fingers by tendons (bands of tough, nonstretchable, flexible fibers that connect the muscles to the bone). These tendons enter your wrist through a U-shaped cluster of eight bones, the carpal bones, which form the "back" and "sides" of the wrist. Across the "top" of the wrist is a tough, strong ligament (similar to a tendon, but linking two bones together at a joint). This ligament forms the arch of the carpal bones, or the "roof" of the carpal tunnel. The median (middle) nerve of the forearm also runs through this tunnel to your palm and some of your fingers. The median nerve is compressed when your wrist is forced into an unnatural posture (such as typing on a straight keyboard) or by direct pressure on the median nerve from hard, sharp edges of work surfaces or tools. Surrounding the median nerve are the tendon sheaths (tubular sacs lined with a thin layer of tissue and a layer of oily lubricating fluid). Continued pressure and tendon activity on the tunnel can cause inflammation, which puts pressure on the nerve, and eventually results in nerve damage or CTS.



Early recognition of the signs and symptoms of CTS, and the recognition and control of any workplace risk factors contributing to the problem should reduce the number and severity of cases of CTS. The following is presented as guidance, and should not be substituted for a professional medical examination and proper treatment of persons with possible CTS.

Symptoms of CTS.

When the median nerve is compressed, the following CTS symptoms typically appear:

- Burning pain.
- Numbness.
- Tingling in the thumb and first two or three fingers.

These symptoms may radiate to the forearm. Sufferers frequently feel these symptoms at night, and many find performing simple tasks, such as tying their shoelaces, difficult because of weakness or numbness.

Workplace Risk Factors Associated With CTS.

Workplace risk factors associated with CTS include—

- Hands held in fixed positions over prolonged periods (e.g., installing overhead electrical wiring).
- Repeated wrist and finger flexion (e.g., operating a hand tool).
- Light, highly repetitive wrist and finger movements (e.g., typing or data entry).
- Repeated flexion or hyperextension (wrist and hand bent back) of the wrist (e.g., painting).
- Prolonged strenuous use of the hands (e.g., molding materials).
- Repeated pinching or grasping (e.g., inspecting materials).
- Vibration, particularly that associated with power tools.
- Bending the wrist toward the little finger (e.g., typing).
- Acceleration and velocity of dynamic motions (e.g., scanning items in a checkout line).

Prevention of CTS.

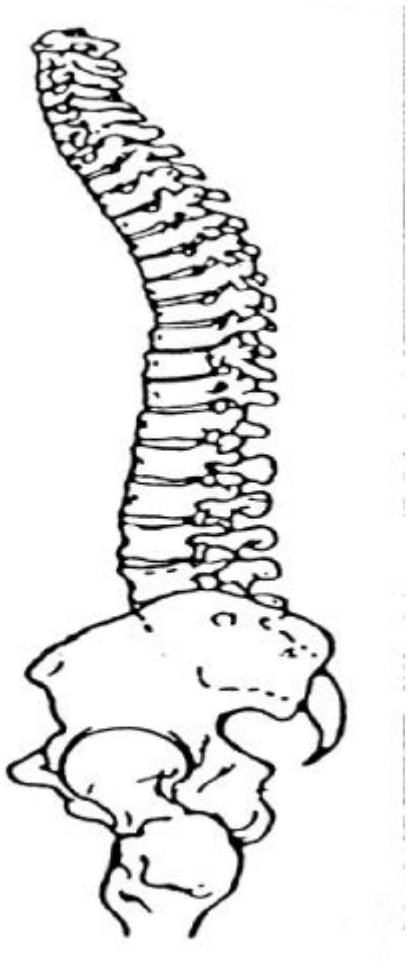
Focus prevention on—

- Reducing exposure to suspected causes.
- Conditioning or training the muscles to have a better tolerance for repeated motions.

Low Back Pain

The key to managing low back pain is to understand it and know when to seek treatment.

What Causes Low Back Pain?
Low back pain (LBP) can be caused by a variety of workplace risk factors. Those that seem to contribute most directly to LBP include:



- **Repetitive or Awkward Motions.** Workers who perform repeated (unsupported) lifting, turning, or moving motions within a work cycle have an increased susceptibility to LBP and other WMSDs. Repetitive motions increase fatigue and muscle-tendon strain. They often prevent adequate tissue recovery from one cycle to the next.

- **Awkward Postures.** Studies have shown that exposure to awkward postures for extended periods may lead to a variety of potentially disabling injuries and disorders of the musculoskeletal tissues or peripheral nerves, or both. Awkward postures that can contribute to LBP are caused by poor workstation layout and/or equipment design. Poor chair design with inadequate lower back support can also contribute to LBP, especially when performing tasks that require prolonged sitting.

- **Force.** Forceful exertions increase physiologic stress on the muscles, tendons, and joints, and can increase mechanical stress on the spine. Muscles fatigue faster as the force exerted increases. Therefore, particularly when performing bending, twisting, or lifting tasks, the following factors can contribute to LBP:
    - Object weight.
    - Load distribution (e.g., shifting or bulky loads require more force exertion).
    - Object friction (e.g., slippery objects require more force).

Self-Care Guidelines To Follow If Experiencing Low Back Pain.

Most back pain resulting from minor strains can be resolved with over-the-counter medicines and simple home treatment. Over-the-counter (OTC) medicines are available without a prescription. They are very effective for reducing inflammation, swelling, and pain. OTC pain relievers include acetaminophen (e.g., Tylenol®) and nonsteroidal anti-inflammatory drugs such as aspirin, ibuprofen (e.g., Advil® or Motrin® IB), and naproxen sodium (e.g., Aleve®). Keep in mind that OTCs are medicines and you should take them with caution. If you are taking other medicines, talk with your doctor or pharmacist to be sure an OTC medicine will not negatively interact with any of the prescription drugs you are taking. Do not take aspirin with ibuprofen or naproxen sodium.

There are many safe and effective ways to relieve your low back pain without using medication. Sometimes these techniques are used in combination with drug treatments. Many of these pain relief methods can be used at home; others require the help of a doctor. Remember to talk with your doctor about any pain relief techniques you are planning to use.

- **Use Ice First.** For a day or two, apply ice or a cold pack for about 20 minutes at a time, three or four times a day. Always wrap ice or cold pack in a thin protective layer, such as a towel or face cloth. This will protect your skin.

- **Try Heat Next.** If ice has not relieved the pain after 2 or 3 days, apply moist heat. Wrap a hot water bottle in a towel or take a warm shower. Apply moist heat about 15 to 20 minutes, two or three times a day. Do not use heat if you injured your back in a fall, or if the heat increases your symptoms.

- **Avoid Bed Rest.** Staying in bed more than a few days can cause supporting back muscles to become weaker; some movement is necessary to heal properly.

If the pain is a result of a serious injury or the pain increases within a few day of the injury, seek professional medical treatment.

Preventing Low Back Pain.

Focus prevention on—

- Reducing exposure to known risk factors such as repetition, awkward postures, or stress on muscles, tendons, joints, or the lower spine.

- Conditioning or training the muscles to have a greater tolerance for physiological stress.

- Losing weight. Extra pounds, especially around the middle, increase stress on the lower back.

- Smoking cessation. Smoking can interfere with blood circulation to the lower back, and a constant cough can bring on a back spasm.

- Exercising daily. Choose a sport that is easy on your back such as walking, swimming, or bicycling in an upright position.

Computer Workstations

Over 30 million computers are in use throughout the United States, and the number is growing rapidly. Growing as rapidly as the numbers of computers are the health problems associated with prolonged computer use. Those workers who use computers irregularly and intermittently throughout the workday are generally not affected by computer use. However, those workers who use computers continuously, from 6 to 8 hours during the workday, can experience computer-related ailments and discomforts.

Health Problems Associated With Computer Use.

The symptom most frequently associated with computer use is fatigue. Fatigue may be muscular, mental or emotional, visual, or a combination.

- Muscular fatigue is characterized by—
  - Pain.
  - Stiffness.
  - Physical discomfort.

- Mental or emotional fatigue is characterized by—
  - Weariness.
  - Loss of concentration.
  - Irritability.
  - Dizziness.

- Visual fatigue is characterized by—
  - Eye discomfort due to prolonged, fixed focus.
  - Eye irritation.
  - Headache.
  - Abnormal after-image.
  - Blurred and/or double vision.

Lighting Solutions

Inadequate lighting or direct or indirect glare can force the worker to assume awkward and fixed postures. (Direct glare is caused by light sources in the field of view whereas indirect glare is caused by light being reflected by a surface in the field of view.) Inadequate lighting also often leads to eye strain. The amount of light needed for maximum visual efficiency varies with the worker's age (e.g., older workers require more light) and the type of task being performed (e.g., continuous or intermittent computer use).

Simple solutions to common lighting problems include:

- Positioning the monitor screen so that it is perpendicular to the light source (i.e., windows, overhead lights, task lighting).
- Reducing the source of glare by covering windows and baffling ceiling light fixtures, allowing light to be evenly dispersed.
- Using diffused, indirect lighting rather than direct lighting.

Federal Energy Conservation levels are based on Title 41, Code of Federal Regulation (CFR), Section 101-20.107, *Energy Conservation*. 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.

Whether computer workers are experiencing one or a combination of these problems, the results are the same — a loss in proficiency and productivity, and the occurrence of WMSDs, particularly as a result of muscular fatigue. (See figure 3.)

Assessing the Components of a Computer Workstation.

The components of a computer workstation are not separate units but should be considered as an interactive system. The frequent complaints about discomfort from the use of computers typically arise from the way in which these components are integrated in the workstation. The interdependent nature of different components makes intervention a challenge. When you act to achieve a healthier computer workstation, you often discover that a change in one component affects others.

Design Assistance
When designing or redesigning computer workstations, be sure that the furniture is as flexible as possible. You may also want to consider the office ergonomic features of furniture, lighting, acoustics, and temperature in order to optimize worker comfort.

Refer to page 30 of this guide for a list of manufacturers and vendors of ergonomic devices.

The Workstation. More often than not, computers are placed on existing work surfaces that are neither adjustable nor comfortable for the majority of the workers. The person is fitted to the task, rather than the task being fitted to the person. Proper workstation design provides a computer operator with comfortable postures at an appropriate distance from the keyboard, source document, and screen, while also giving the operator enough space to perform a number of tasks efficiently. Optimal workstation design, however, is complicated by differences in anatomy and work habits among operators and the wide variation in tasks performed at a computer. Workstation "adjustability" is the key to minimizing or eliminating the amount of discomfort caused by prolonged computer use. Figure 2 illustrates proper computer workstation accommodations. Figure 3 is a quick reference to potential causes of operator discomfort and ways to eliminate or reduce the discomfort.

The Chair. The benefits of a well-designed workstation will be partially or totally offset if coupled with a poorly designed and uncomfortable chair. Therefore, the chair should not only adjust to the size and comfort of each worker, but should also adapt to each person's specific duties — whether in a conference room, at a computer workstation, or at a drafting stand. Computer workstation chairs should, however, meet the following basic requirements:

- Adjustable seat height.
- Five-point base with casters, as appropriate, depending on the floor surface.
- Can pivot 360°, allowing for easy access to various surfaces within the work area.
- Adjustable back rest that includes a lumbar (lower back) support.
- Designed for a forward and reclining posture.
- Rounded, waterfall-type front edge of the seat surface.
- Adjustable armrests.

Figure 2. Proper Computer Workstation Components

Figure 3. Causes and Quick Solutions to Operator Musculoskeletal Discomfort

Condition	Probable Cause	Correction
Neck, upper back, and shoulder tightness, tension, or discomfort	a. Head is too far forward during reading, writing, or viewing the monitor.	a. Elevate the work surface, reading materials, and monitor to keep the head and trunk relationship more vertical.
	b. Hands and arms are not supported while typing, inputting data, writing, or using hands in manipulating or holding work.	b. Use armrest, palm rest, or work surface to counterbalance and support the weight of the hands and arms. For typing tasks, allow the upper arms to hang naturally at the side and use palm rests or wrist rests.
	c. Head is too far back during reading, writing, or viewing the monitor.	c. Tilt the seat and backrest forward so as to keep the head and trunk relationship more vertical.
	d. Leaning forward on the work surface and supporting the weight of the head and trunk.	d. Use chair and backrest as support instead of the arms. Lower the work surface to support the arms.
	e. Head and neck are tilted in a lateral direction holding the telephone between the shoulder and ear.	e. Use a headset.
Hand, wrist, and lower arm discomfort	a. The wrist is deviated in an unnatural position.	a. Arrange the keyboard (or other input device) to produce a neutral wrist position. *NOTE: A "neutral" position is the one the body naturally assumes. It is the least stressful, strongest, and most efficient position for the body.*
	b. Excessive application of force during typing/keying.	b. Reduce excessive force through training and practice.
Lower back pain and discomfort	a. Lumbar curvature is not being maintained and supported.	a. Bring backrest in further horizontally through an in-and-out adjustment or by tilting forward and/or changing the lumbar curvature via air bag adjustment (if properly equipped). The backrest should be placed just slightly above the pelvis and should provide support in the lumbar region (lower back).
	b. Major thigh muscle is pulling on the spine because the feet are dangling or unsupported.	b. Lower chair and/or use a footrest so that feet are supporting the weight of the feet and lower legs only. Backrest should be placed just slightly above the pelvis and should provide support in the lumbar (lower back) region.
	c. Increased disc pressure because of vertebrae not having equidistant spacing. This results in stretching the muscle, tendon, and ligament system.	c. Open up trunk/thigh angle towards the neutral posture position.
Buttocks discomfort	a. Sitting too far forward in the seat pan and not using the backrest.	a. Sit deeper in the chair. It may be necessary to adjust the backrest by tilting the angle.
	b. Pressure is too much on the buttocks/ischial tuberosities (the bony parts of the pelvis where we sit).	b. Raise the chair height and increase the pressure naturally for the thigh. The back of the thigh should be touching the seat pan.

Hand Tools and WMSDs

Hand tools, in one form or another, are used in all occupations, and are designed to extend the range, strength, mobility, and effectiveness of a person's upper limbs. However, poorly designed tools, or risk factors, such as awkward positions, mechanical compression, vibration, and forceful exertions, can lead to injuries, accidents, and WMSDs. The duration of exposure to these risk factors may also affect the worker by increasing local and generalized fatigue and tissue stress.

Shortcomings in hand tool design are generally easy to identify, and can often be resolved by applying some basic principles outlined below.

- Use special purpose tools.
- Use lightweight, well-balanced, or counter-balanced tools.
- Use a tool balance, holder, or jig if prolonged use or holding is required.
- Use powered 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. In addition, the tool handle should—
  - Distribute the hand-force concentration over a greater surface area.
  - Be comfortable to hold and well rounded.
  - Reduce compressive forces on the hand surface.
  - Be long enough to distribute forces over the large, fleshy areas at the base of the thumb and little finger.
- 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.

Basic Anatomy of the Hand

To understand how hand tools can cause WMSDs, it is necessary to understand the basic anatomy and functioning of the hand.

The human hand is a complex structure consisting of bones, nerves, blood vessels, ligaments, and tendons. Finger flexion is caused by forearm muscles that are connected to the fingers by means of tendons that run through a channel in the wrist called the carpal tunnel. Also running through this tunnel is the median nerve and radial artery.

The bones of the wrist connect to the two long bones of the forearm — the radius, connecting to the thumb side of the wrist, and the ulna, connecting to the little finger side of the wrist. This configuration permits wrist movement in essentially two planes, each approximately 90 degrees to the other:

- The first plane permits *palmar flexion*, or bending of the hand toward the wrist. The opposite is called dorsiflexion, or bending of the hand back of the wrist.
- The second plane of motion of the wrist is bending the wrist toward the *ulnar or radial deviation*.

In addition to tendon disorders, poorly designed hand tool handles can affect nerves in the fingers. For example, the *digital nerves*, which run along the sides of the fingers, are compressed when using scissors and can result in numbness and tingling in the ends of the fingers.

- Select tools that minimize stress on muscles and tendons. You should be able to keep the wrist in a neutral or relaxed position during tool use.

- 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 swivel.

- Cover power tool handles with vibration dampening material, such as Sorbothane®.

- Properly calibrate and maintain all tools.

The use of ergonomically designed hand tools significantly reduces the risk of WMSDs. Moreover, tools that fit in the hand comfortably will ultimately result in increased productivity. Refer to page 27 of this guide for a list of manufacturers and vendors of ergonomic hand tools and devices.

Powered Hand Tools

Powered hand tools allow heavier work to be performed with greater speed and efficiency. However, as with regular hand tools, the improper design and use of powered hand tools can contribute to WMSDs.

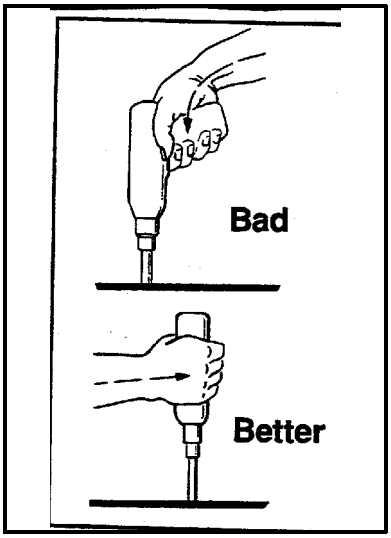
Workplace Risk Factors Affecting the Health of Powered Hand Tool Users.

Whether the tools are powered by electricity, gas, compressed air, or explosive charges, a number of factors affect the performance and health of tool users.

Static muscle loading, particularly of the forearm, will cause fatigue and reduced productivity with possible muscle soreness. A tool that weighs 10 to 15 pounds, such as a power grinder or sander, cannot be held in a horizontal position for more than a few minutes without extreme forearm discomfort, fatigue, possible muscle soreness, and reduced productivity.

Awkward postures, such as those where the wrist is hyperflexed or extended, stretch the underlying tendons and blood vessels over the rigid carpal bones or wrist ligament.

Figure 4



Pressure exerted on the palm and fingers may be greater for powered tools than for hand tools because—

- Powered tools are usually heavier than hand tools, requiring a more forceful grip to maintain control of the tool.
- Powered tools tend to vibrate during operation, causing the user to grip more forcefully to maintain control of the tool.
- Powered tool triggers are normally located in the handle and operated by the index finger. If poorly designed, a condition known stenosing tenosynovitis, or "trigger finger," can result. This occurs when a tool is so large that the last segment of the index finger must be used to depress the trigger, while the middle segment remains straight.

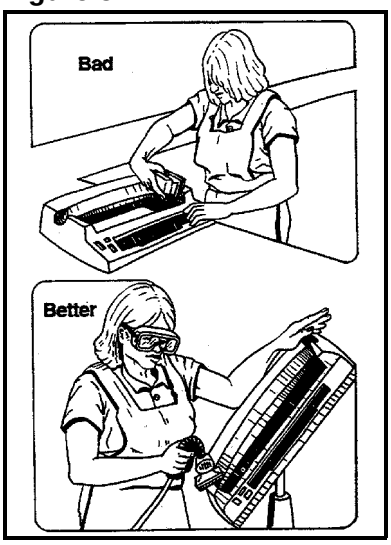
Vibration of powered hand tools, such as chain saws, pneumatic drills, grinding tools, and chipping hammers, can cause vascular spasm—or a constriction of blood vessels in the fingers, which then appear white or pale. Vascular constriction may lead to numbness and swelling of hand tissue, with a loss of grip strength. Vibration-induced white finger, also known as VWF or "Raynaud's phenomenon," afflicts its victims with tingling, numbness, or pain that can be brought on or intensified by exposure to cold.

Eliminating or Controlling Workplace Risk Factors.

For each risk factor that affects the health of a powered hand tool user, there is a solution to eliminate or control the risk involved.

- Static muscle loading can be avoided by—
  - Making sure that frequently used or continuously held tools are as light as possible, preferably under 2 pounds.
  - Suspending heavier tools overhead using a counter balance (e.g., retractor linkage).
  - Aligning the tool's center of gravity with the center of the grasping hand to allow the user to align the tool with minimal effort.

Figure 5



- Awkward postures can cause a mismatch between the job and the tool, increasing the risk of WMSDs. Therefore—
  - Rotate the workpiece 90 degrees to the horizontal, allowing the operator to maintain a straight wrist.
  - Substitute a tool with an in-line handle for a tool with a pistol grip, allowing the operator to maintain the wrist in a neutral position. See figure 4.
  - Place the tool on an adjustable jig, allowing the tool to be positioned so that the user can maintain the wrist in a near-neutral position. See figure 5.

- Pressure exerted on the palm and fingers can be lessened by using tools with the proper handle shape and size.
  - Hand grips should be cylindrical in shape with no sharp edges.
  - Handles should be at least 4 inches long. If used with gloves, the handles should be 0.4 inches longer.
  - In order to avoid the condition known as "trigger finger," powered hand tools should be designed with triggering mechanisms that are large enough for activation by two or three fingers.

- Refer to the American National Standards Institute (ANSI) S3.34-1986 for hand-arm vibration and ANSI 3.18-1979 for whole-body vibration. The American Conference of Governmental Industial Hygienists (ACGIH) also publishes threshold limit values (TLVs®) for both hand-arm and whole body vibration. For practical purposes, reduce the impact of vibration of the tool on the user by —
  - Reducing the number of hours or days vibrating tools are used.
  - Arranging tasks to alternate use of vibrating and nonvibrating tools.
  - Scheduling tool maintenance so tools remain sharp, lubricated, and properly tuned.
  - Selecting tools that perform satisfactorily with the least vibration. Ask tool manufacturers to furnish vibration and frequency data on their tools.
  - Reducing handle grip force.
  - Using gloves with vibration-damping materials in the palms and fingers.
  - Using tools with vibration-damping handles.
  - Using antivibration isolators or damping techniques on tools.
  - Using antivibration equipment, clothing, and handgear that are ergonomically appropriate.

Materials Handling Tasks

A poorly designed materials-handling task is one where the strength requirements to complete the task exceed the strength capabilities of most workers. Simply put, most workers would not be able to perform the task without overexertion.

Poorly designed tasks generally require workers to lift, lower, push, pull, or carry heavy loads. These tasks may also include excessive bending, reaching, or twisting of the body.

A task is potentially hazardous if it includes one or, more significantly, a number of the following activities:

- Lifting or lowering an item with one hand and/or rough, jerking motions rather than with a two-handed, smooth motion.
- Lifting, lowering, or carrying bulky objects that cannot be held close to the body.
- Handling or lifting materials more than 3 or 4 times per minute during an 8-hour work shift.
- Lifting or lowering between the floor and mid-thigh.
- Lifting or lowering above shoulder height.
- Lifting or lowering objects in cramped work areas that may result in twisting the torso (e.g., lifting and twisting in one motion).
- Exerting forces in awkward positions—to the side, overhead, or at extended reaches.
- Handling difficult-to-grasp items (e.g., with no handles).
- Handling items that place high pressure on the hands from thin edges, such as pail handles or sheet-metal edges.
- Pushing or pulling items, such as carts or boxes, that require large breakaway forces to get started.
- Lifting and carrying items on walkways that are obstructed, poorly illuminated, slippery, too narrow, or congested with vehicle and/or pedestrian traffic.

Figures 6, 7, and 8 provide suggestions on how to properly lift and lower, push and pull, and carry various objects.

Figure 6. Proper Design of Lifting and Lowering Tasks

To do this:	Follow these suggestions:
Increase material flow through the workplace	■ Establish adequate receiving, storage, and shipping facilities. ■ Maintain adequate aisle and access areas.
Eliminate the need to lift or lower manually	Use— ■ Lift tables and platforms. ■ Lift trucks. ■ Cranes and hoists. ■ Drum and barrel dumpers. ■ Elevating conveyors. ■ Elevated pallets. ■ Gravity dump and/or chute systems. ■ Vacuum systems. ■ Automatic feed systems.
Increase weight to a point where it must be mechanically handled	■ Use pallets to handle raw materials and products in bulk quantities. ■ Use the unit load concept (e.g., bulk handling of large bins or containers).
Reduce the weight of the object(s) or the force required to lift or lower the object(s)	■ Reduce the weight and capacity of the container(s). ■ Improve the handhold or grip on the object. ■ Reduce the load in the container. ■ Specify the quantity per container to suppliers. ■ Assign the job to two or more persons.
Reduce the hand distance from the body	■ Change the shape of the object or container. ■ Provide grips or handles. ■ Provide better access to objects.
Convert lift/carry or lower/carry combinations to a push or pull task	Use— ■ Conveyors. ■ Hand trucks. ■ Ball-caster tables. ■ Four-wheel carts.

Figure 7. Proper Design of Pushing and Pulling Tasks

To do this:	Follow these suggestions:
Eliminate the need to push or pull	Use— ■ Conveyors (powered and nonpowered). ■ Powered trucks. ■ Lift tables. ■ Slides or chutes.
Reduce the force required to push or pull	■ Improve the handhold or grip on the handle. ■ Reduce the size and/or weight of the load. ■ Use four-wheel trucks or dollies. ■ Use nonpowered conveyors. ■ Require that wheels or casters on hand trucks and dollies have periodic lubrication of bearings, adequate maintenance, and proper sizing (e.g., provide larger diameter wheels and casters). ■ Maintain floors to eliminate holes and bumps. ■ Improve the sole of the shoe to increase the shoe's grip on the floor surface.
Reduce the distance of the push or pull	■ Relocate receiving, storage, production, or shipping areas. ■ Improve production process to eliminate unnecessary material handling steps.
Optimize the technique of the push or pull	■ Eliminate one-handed pushing or pulling tasks. ■ Provide variable-height handles so that both short and tall persons can maintain an elbow bend of 80 to 100 degrees. ■ Make sure wrists are not fully pronated when pulling. ■ Replace a pull with a push whenever possible. ■ Use ramps with a slope of less than 10 percent. ■ Keep exertion within shoulder to mid-thigh (standing) vertical range.

Figure 8. Proper Design of Carrying Tasks

To do this:	Follow these suggestions:
Eliminate the need to carry heavy objects	■ Rearrange the workplace to eliminate unnecessary movement of material. ■ Use mechanical handling aids, such as— • Conveyors. • Lift trucks. • Hand trucks. • Tables or slides between workstations. • Four-wheel carts or dollies. • Air or gravity press ejection systems. • Overhead cranes.
Reduce the weight carried	■ Reduce the weight of the object. ■ Reduce the weight of the container. ■ Reduce the load in the container. ■ Specify quantity per container to suppliers. ■ Eliminate one-handed carries. ■ Improve the handhold or grip on the container.
Reduce the bulk of materials carried	■ Reduce the size or shape of the object or container. ■ Provide handles or hand grips that allow materials to be held close to the body. ■ Assign the job to two or more persons.
Reduce the carry distance	■ Relocate receiving, storage, production, or shipping areas. ■ Use powered and nonpowered conveyors.
Convert the carry to a push or pull task	■ Use nonpowered conveyors. ■ Use hand trucks and pushcarts.

References

The following list is for your reference when seeking additional information on ergonomics in your workplace.

Policy

Memorandum, Office of the Deputy Under Secretary of Defense (Environmental Security), 4 February 1997, subject: Ergonomics Program Requirements.

Memorandum, Office of the Assistant Secretary for Installations, Logistics, and Environment, 18 May 1998, subject: Policy Memorandum — Army Ergonomics Program.

Related Standards

American National Standards Institute/Human Factors Society (ANSI/HFS). (1988). American national standard for human factors engineering of visual display terminal workstations (ANSI/HFS 100-1988). Santa Monica, CA: Human Factors and Ergonomics Society.

U.S. Department of Defense. (1996). Military Standard (MIL-STD)-1472E. Human engineering design criteria for military systems, equipment and facilities. Philadelphia, PA: Defense Printing Service.

Guidance

American National Standards Institute (ANSI) S3.18-1979, (R1993), Guide for the Evaluation of Human Exposure to Whole-Body Vibration.

American National Standards Institute (ANSI) S3.34-1986, (R1997), Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand.

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National Institute for Occupational Safety and Health (NIOSH). 1993. U.S. Department of Health and Human Services. Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks. Cincinnati: National Institute for Occupational Safety and Health.

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General Reading

American Conference of Governmental Industrial Hygienists. 1987. Ergonomic Interventions to Prevent Musculoskeletal Injuries in Industry. Chelsea, MI: Lewis Publishers.

Apts, D.W. 1992. Back Injury Prevention Handbook. Chelsea, MI: Lewis Publishers.

Armstrong, T.J. and Lackey, E.A., CSP. 1994. Cumulative Trauma Disorders of the Hand and Wrist: An Ergonomics Guide. Fairfax, VA: American Industrial Hygiene Association.

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Websites

The following list is for information purposes only and is not intended as an endorsement by the DOD.

Government Sites

DOD Ergonomics Working Group: ***http://chppm-www.apgea.army.mil/ergowg/index.htm***

U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Ergonomics Program: ***http://chppm-www.apgea.army.mil/ergopgm/ergohome.htm***

U.S. Air Force Ergonomics Function: ***http://sg-www.satx.disa.mil/~hscoemo/index.htm***

U.S. Marine Corps Safety Division: ***http://www.hqmc.usmc.mil/safety.nsf*** (Use "Search" feature for keywords like ergonomics.)

Navy Facilities Safety and Health: ***http://www.navfac-safety.navy.mil/ergonmcs.htm***

U.S. Navy Environmental Health Center: ***http://www-nehc.med.navy.mil/occmed/occlinks.htm#ergonomiclinks***

U.S. Army Safety Program: ***http://safety.army.mil/home.html***

Defense Threat Reduction Agency: ***www.dtra.mil***

Army Industrial Hygiene: ***http://chppm-www.apgea.army.mil/Armyih***

GSA: ***http://www.fss.gsa.gov***

OSHA: ***http://www.osha-slc.gov/SLTC/ergonomics***

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

National Library of Medicine MedLinePlus: ***http://www.nlm.nih.gov/medlineplus***

ErgoEASER Software Download: ***http://tis-hq.eh.doe.gov/others/ergoeaser/download.html***

Professional Societies

Human Factors and Ergonomics Society: ***http://hfes.org***

Board of Certification in Professional Ergonomics: ***http://www.bcpe.org***

American Industrial Hygiene Association (AIHA): ***http://www.aiha.org***

Ergonomic Resource Sites

CTDNEWS: ***http://ctdnews.com***

- Information and links to research and journals

ERGOWEB: ***http://www.ergoweb.com***

- Evaluation tools
- Links to vendors

ERGOWORLD: ***http://www.interface-analysis.com/ergoworld***

Work-Related Musculoskeletal Disorder Sites

BioMedNet: ***http://biomednet.com/db/medline***

R.S.I. Page: ***http://engr-www.unl.edu/ee/eeshop/rsi.html***

- A good beginning reference for wrist problems with links to finding medical help and links to supporting articles

Carpal Tunnel Syndrome Home Page: ***http://www.netaxs.com/~iris/cts/welcome.html***

Typing Injury "Frequently Asked Questions" (FAQ) Home Page (RSIs):
http://www.cs.princeton.edu/~dwallach/tifaq

Biomechanics World Wide: ***http://www.per.ualberta.ca/biomechanics***

Design Guidelines

ERGOWORLD: ***http://www.interface-analysis.com/ergoworld***

Bad Human Factors Designs: ***http://www.baddesigns.com***

- Examples of poor designs and discussion of ergonomics principles

University Sites

Cornell University Ergonomics Web: ***http://ergo.human.cornell.edu***

Human Factors Engineering Center (HFEC) and Department of Industrial and Systems Engineering (ISE) at Virginia Tech: ***http://hci.ise.vt.edu/hfec***

UCSF/UCB Ergonomics Program: ***http://www.me.berkeley.edu/ergo***

U of Michigan Center for Ergonomics: ***http://www.engin.umich.edu/dept/ioe/C4E***

- Primarily info about projects and papers from U of Michigan

UVA/EHS Ergonomics: ***http://www.virginia.edu/~enhealth/ERGONOMICS/toc.html***

- Basic office ergo information (Links found here are also in this index)

U of Texas at Austin Ergonomics Task Force: ***http://www.lib.utexas.edu/Pubs/etf/index.html***

- Links to ergonomics programs at other universities and sites regarding Computers and Eyestrain; Pointing Devices; Taking Care of Your Back; Disability Software

Musculoskeletal Injuries in Construction: ***http://info.pmeh.uiowa.edu/construc/cons10.htm***

- Bibliography (searchable) for construction work and musculoskeletal injuries from biomedical, industrial hygiene, and ergonomic literature

How to Evaluate a Product

It is a vendor's job to sell. Although there is a detailed vendor list presented in this guide, the information is not intended as an endorsement by the DOD. Therefore, it will be *your* job to cut through the sales pitch to determine if what is being offered truly meets your needs. Before choosing any product, you should know how WMSDs occur and how to best prevent them from occurring by using ergonomic equipment and tools in your workplace. Some suggestions for evaluating a product are presented below. For additional guidance, contact your local occupational health or safety office or contact the appropriate service office noted on page 2 of this guide.

- **Perform "real life testing."** The best way to evaluate equipment is to use the equipment under a variety of conditions with different users. Work with local logistics personnel and contact the vendors. Some may provide a demonstration of or allow you to test their equipment prior to purchase.

- **Evaluate the product literature.** Look for adjustability to accommodate a wide range of users. If the equipment is not adjustable, look at the working dimensions and assess the usability for your working population.

- **Evaluate the manufacturer's "track record."** Does the manufacturer usually provide a good ergonomic design based on your (or someone else's) experience with the manufacturer?

- **Evaluate the vendor's reputation.** Vendors with a reputation for quality design work tend to consider the human usability of their designs.

- **Develop clear specifications for the equipment.** This is the best way to evaluate the equipment without hands-on use *prior* to purchase.

Dimensional specifications, such as seat height, table width, and bag weight, will tell you more about the equipment; however, this information should be interpreted in order to understand its impact on the user population.

Anthropometry ...
... Is the study of the physical dimensions of people, including size; breadth; girth; distance between anatomical points; and joint range of motion.

Functional specifications are the best way to evaluate equipment. Some examples of functional specifications include:

- "Usable by 95 percent of the population" for general tasks. That is, 95 percent of the population can exert the grip force required to activate the tool.

- "Reachable by the 5th percentile female" for anthropometric concerns. For example, machine controls are placed within the forward reach of the smallest workers (e.g., the 5th percentile female), which means that the rest of the workers should also be able to reach the controls.

- "Supports the weight of 95 percent of the population" for chair specifications. That is, if the hydraulic cylinder in the chair can support 95 percent of the workers, there should be few, if any, problems with using the chair in the workplace.

- "Table height adjustment range accommodates the working height for the 5th percentile female to the 95th percentile male." That is, the table height can be adjusted to meet the elbow rest height of the smallest worker (e.g., the 5th percentile female) to the largest worker (e.g., the 95th percentile male) in the work area.

Keep in mind, specifications like "ergonomically designed" and "user friendly" are very general and vague. Assume products with these descriptions are not any better than any other product on the market.

Vendors

The following list is for information purposes only and is not intended as an endorsement by the DOD. Use of trademarked names does not imply endorsement by the DOD, but is intended only to assist in identification of a specific product.

Hand Tools

Ames
P.O. Box 1774
Parkersburg, WV 26101

AMP, Inc.
Advanced Mfg Tech Division
3901 Fulling Mill Road
Middletown, PA 17057
(Hand tools and automated systems for electromechanical connections)

Atlas Copco
Industrial Tools, Inc.
24404 Indoplex Circle
Farmington Hills, MI 48018
313-478-5330

American Tool and Supply Co.
P.O. Box 1233
Galesburg, IL 61402
1-800-343-1417

BAHCO Tools, Inc.
570 Lexington Avenue
New York, NY 10022
212-750-3823

Bettcher Industries
P.O. Box 336
Vermillion, OH 44089
800-321-8763

Bodyguard Seating Systems
7 North Pinckney Street
Suite 305
Madison, WI 53703
608-256-0344

Cooper Industries
P.O. Box 728
Apex, NC 27502
919-362-7510
(Scissors)

Danaher Tool Group
5414-E Backlick Rd.
Springfield, VA 22151
703-256-1500

Dresser Industries, Inc.
Industrial Tool Division
7007 Pienmont
Houston, TX 77040
713-462-4521

Dynamics Operational, Inc.
600 Fondulac Drive
East Peoria, IL 61611
309-699-6046
(Handles)

Fiskars
P.O. Box 1727
Wausau, WI 54401

Honsa Ergonomic
Technologies, Inc.
550 34th Street
Moline, IL 61265
309-736-0200

Ingersoll-Rand Company
1627 K Street, N.W., Suite 900
Washington, DC 20006
202-955-1463

ITD Automation
1765 Thunderbird
Troy, MI 48084
313-244-9250
(Articulating arms)

Kipper Tool Company
870 Grove Street
Gainesville, GA 30501
770-532-3232

Klein Tools, Inc.
7200 McCormick Blvd.
Chicago, IL 60645
312-677-9500

SCANDEX, Inc.
87 Crescent Road
Needham, MA 02194
617-449-1550

Seymour Smith & Son, Inc.
Snap-Cut
Oakville, CT 06779
203-274-2558

Snap On Tools
2801 80th Street
Kenosha, WI 53141
414-656-5849

Sorbothane, Inc.
P.O. Box 178
Kent, OH 44240
216-678-9444
(Vibration dampening materials)

Stanley Air Tools
700 Beta Drive
Cleveland, OH 44143
216-461-5500

Stanley Tools
1804 Champion Circle
Carrollton, TX 75006
972-919-7911

Steere Enterprises
285 Commerce Street
Tallmadge, OH 44278
216-633-4926
(Custom dip/blow-molding, plastics)

Hand Tools *(continued)*

Stirex Innovation
c/o Intercodev, Inc.
4 Royal Oak Court
Holbrook, NY 11741
516-472-6384
(Scissors, aids for the disabled)

Sullair Corp.
3700 E. Michigan Blvd.
Michigan City, MI 46360
800-348-2722
(Air hammers)

Sunnex Equipment, AB
Box 242
686 00 Sunne, SWEDEN
(Handgrips, powered tools)

All Office Vendors

Kare Pillows, Inc./Ergo Kare[1]
P.O. Box 2295
Boulder, CO 80306
1-800-927-5273
www.kareproducts.com

Equipment Direct[1]
2861 Saturn #D
Brea, CA 92621
1-800-424-4410
FAX 1-800-842-2412
www.equipdirect.com

Smith & Nephew Rolyan Inc.
N93 W14475 Whittaker Way
P.O. Box 555
Menomonee Falls, WI 53052-0555
1-800-558-8633
FAX 1-800-545-7758
www.easy-living.com

Sunway[1]
1857 Buerkle Road
White Bear Lake, MN 55110
1-800-969-9708
(612) 773-5320
FAX (612) 773-5324
www.sunwayinc.com

Mead-Hatcher, Inc.[1]
P.O. Box 861
Buffalo, NY 14240-0861
(716) 877-1185
FAX (716) 877-7381
www.meadhatcher.com

AliMed
297 High Street
Dedham, MA 02026-9135
1-800-225-2610
FAX 1-800-437-2966
www.alimed.com

3M
P.O. Box 33275
St. Paul, MN 55133-3275
1-800-332-7483
www.mmm.com/ergonomics

Fox Bay Industries, Inc.
4150 B. Place NW #101
Auburn, WA 98001
(206) 941-9155
www.foxbay.com

Accu-Back, Inc.
1475 East Sel Amo Blvd
Carson, CA 90746
1-800-272-8888
(310) 639-7992
FAX (310) 639-1080
www.jobri.com

Ergodyne[1]
1410 Energy Park Drive, Suite 1
St. Paul, MN 55108
1-800-225-8238
FAX (612) 642-1882
www.ergodyne.com

Ergonomic Chairs

Neutral Posture Ergonomics, Inc.
3904 North Texas Avenue
Bryan, TX 77803
(409) 778-0502
FAX (409) 778-0408
www.neutralposture.com

Dauphin
300 Myrtle Avenue
Boonton, NJ 07005
1-800-995-6500
FAX (973) 263-3551
www.dauphin.com

Bodybilt
One Bodybilt Place
Navasota, TX 77868
(409) 825-1700
FAX: (409) 825-1725
www.bodybilt.com

Biofit Engineered Seating[1]
P.O. Box 109
Waterville, OH 43566
1-800-597-0246
FAX (419) 823-1342
www.engseat.com

Gibo/Kodama Chairs
5555 McFadden Avenue
Huntington Beach, CA 92649
1-800-888-3746
FAX (714) 897-7201
www.gibokodamachairs.com

Grahl Industries, Inc.
One Grahl Drive
Coldwater, MI 49036
1-888-289-4724
FAX (800) 472-4507
www.grahl.com

Interfaces by Cramer
5657 Memorial Avenue North
Stillwater, MN 55082
1-888-881-7592
FAX (651) 439-1689
www.ergointerfaces.com

Herman Miller
Mail Stop 0443
855 East Main
Zeeland, MI 49464
1-888-520-7646
www.hmstore.com

Amotek
1730 State Street
Bridgeport, CT 06605
1-800-242-4777
FAX (203) 334-4684
www.amotek.com

Alternative Design QWERTY Keyboards

Kinesis Corporation
22121 17th Avenue SE
Suite 112
Bothell, WA 98021-7404
1-800-454-6374
FAX (206) 402-8181
www.kinesis-ergo.com

KeyTronic[1]
P.O. Box 14687
Spokane, WA 99214-0687
1-800-262-6006
(509) 928-8000
www.keytronic.com

Ergonomic Design, Inc.
10650 Irma Drive, Number 33
Northglenn, CO 80233
(303) 452-8006
www.ergodesign.com

Safe Computing
2059 Camden Avenue, Suite 285
San Jose, CA 95124
(408) 269-5430
www.safecomputing.com

Keyboard Alternative and Vision Solutions, Inc.
537 College Avenue
Santa Rosa, CA 95404
1-800-953-9262
FAX (707) 522-1343
www.keyalt.com

Anti-Vibration Gloves

Chase Ergonomics
P.O. Box 92497
Albuquerque, NM 87199
1-800-621-5436
FAX (503) 344-1426
www.chaseergo.com

Viscolas, Inc.[1]
8801 Consolidate Drive
Soddy Daisy, TN 37379
1-800-548-2694
FAX (423) 332-0800

ErgoSource
P.O. Box 695
Wayzata, MN 55391
1-800-969-4374
FAX (612) 404-1058
www.ergosource.com

Ergodyne[1]
1410 Energy Park Drive, Suite 1
St. Paul, MN 55108
1-800-225-8238
FAX (612) 642-1882
www.ergodyne.com

Rehab Plus Therapeutic Products
6104 45th St., Space D
Lubbock, TX 79407
1-800-288-8059
(806) 791-2288
FAX (806) 791-2290
www.rehabplus.com

North Coast Medical, Inc.
18305 Sutter Blvd.
Mortan Hill, CA 95037
1-800-821-9319
FAX (977) 213-9300
www.ncmedical.com

Equipment Direct[1]
2861 Saturn #D
Brea, CA 92621
1-800-424-4410
FAX 1-800-842-2412
www.equipdirect.com

LHR
7815 Hansen Road
Houston, TX 77061
(713) 943-2324
www.lhrservices.com

Lift Products

Air Technical Industries
7501 Clover Avenue
Mentor, OH 44060
(216) 951-5191
1-800-321-9680
www.airtechnical.com

Southworth Products Corporation
P.O. Box 1380
Portland, Maine 04104-5001
(207) 772-0130
1-800-341-0122
www.southworthproducts.com

Lee Engineering Company, Inc
505 Narragansett Park Drive
Pawtucket, RI 02861
1-800-343-9322
www.lee-presto.com

Tiffin Systems
450 Wall Street
Tiffin, OH 44883
1-800-221-1994
FAX (419) 447-8512
www.tiffinsystems.com

Vestil Manufacturing Company
ska T&S Equipment Company
2999 N. Wayne St.
P.O. Box 507
Angola, IN 46703
1-800-348-0868
www.vestil.com

Lift Products, Inc.
1300 West Bluemound Road
P.O. Box 349
Elm Grove, WI 53122-0349
(414) 860-13895
FAX (414) 860-1894
www.liftproducts.com

Lift Products *(continued)*

AutoQuip Corp.
P.O. Box 1058
Guthrie, OK 73044
1-888-811-9876
FAX (405) 282-8105
www.autoquip.com

Aero Material Handling, Inc.
103 Pleasant Street
P.O. Box 337
Anoka, MN 55303-1644
1-800-822-0020
FAX (612) 427-0919
www.aero-material.com

Knight Industries
1160 Centre Road
Auburn Hills, MI 48326
(248) 377-4950
FAX (248) 377-2135
www.knight-ind.com

Anti-Fatigue Mats

Ergomat USA
871 Canterbury Road
Westlake, OH 44145
(216) 899-1700
1-800-357-2111
www.ergomat.com

Standers' Choice Health Mats
1855-65 Columbia Avenue
P.O. Box 1746
Lancaster, PA 17608-1746
1-800-537-3731

ErgoSource
P.O. Box 695
Wayzata, MN 55391
1-800-969-4374
www.ergosource.com

Tennessee Mat Company
1414 Fourth Avenue South
Nashville, TN 37210
1-800-264-3030
www.wearwell.com

Illumination

Aero-Motive Company
P.O. Box 2678
Kalamazoo, MI 49003-2678
1-800-999-8559
www.aeromotive.com

Environmental Lighting Concepts, Inc.[1]
3923 Coconut Palm Drive, Suite 101
Tampa, FL 33619
1-800-842-8848
FAX (813) 626-8790
www.ott-line.com

Sit/Stand Chairs

Biofit Engineered Seating
P.O. Box 109
Waterville, OH 43566
1-800-597-0246
www.biofit@bright.net

Frank Eastern Co
599 Broadway
New York, NY 10012-3258
1-800-221-4914
www.belowcost.com

Aero-Motive Company
P.O. Box 2678
Kalamazoo, MI 49003-2678
1-800-999-8559
www.aeromotive.com

AliMed, Inc
297 High street
Dedham, MA 02026-9135
1-800-225-2610
1-800-437-2966
www.alimed.com

ErgoSource
P.O. Box 695
Wayzata, MN 55391
1-800-969-4374
www.ergosource.com