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An Ergonomics Guide

to Computer Workstations

3rd edition

Addresses the cluster of ergonomic conditions associated with computers that are distinct from other workplace concerns.

Edited by
Sheree L. Gibson, PE, CPE
Mary O'Reilly, PhD, CIH, CPE
Marjorie K. Werrell, PT, CPEE, CIE
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1 Introduction

The American Industrial Hygiene Association (AIHA®) defines ergonomics as a multidisciplinary science that applies design principles, based on the physical and psychological capabilities of people, to the design of jobs, equipment, products, and workplaces. The original guide was published in 1994 and summarized the basic peer-reviewed research prior to the early nineties. Since that time, the knowledge base provided by peer-reviewed data has continued to grow. In addition, the work environment has continued to evolve with significant changes in the equipment used and the time spent on the computer. This guide updates the information established in the second edition, published in 2012, and furnishes industrial hygienists and occupational health and safety professionals with that information.

Computers are used in a variety of settings including offices, hospitals, laboratories, factories, retail stores, manufacturing, construction, home, classrooms, and vehicles (see Figure 1.1). The primary focus should be where extended periods of time are spent on the computer.

Ergonomic considerations associated specifically with computer workstations include:

- Static postures from prolonged sitting or standing, neck cradling to hold a phone, or holding input devices.
- Awkward postures due to monitor placement.
- Continuous neck movements to view multiple monitors.
- Repetitive reaching to activate touch screen monitors when they are positioned at appropriate viewing distances.
- Movements of the hand and wrist when operating input devices.
- Keyboard and mouse placement.
- Eye health and optics, particularly for individuals with specific visual needs that require bifocals or trifocals.
- Workstation design when multiple users are assigned to one computer workstation.
- Accommodations for users with disabilities.
- Work organization and psychosocial factors.

This guide will address the risk factors and available controls for upper extremity discomfort, back pain, and vision complaints. Keep in mind that ergonomics programs should be coupled with ongoing workplace evaluation, employee education, and good medical management.

Figure 1.1 – Although computers, laptops, and tablets may be used in different scenarios, it is important to apply proper ergonomic principles for safe use. Additional effort should be made where an extended period of time is spent on this technology.

Musculoskeletal Disorders and Computer Work

2

The term musculoskeletal disorder usually refers to problems of the muscles, tendons, blood vessels or nerves that are caused, precipitated, or aggravated by repeated movements or exertions of the body.[1] For the purposes of this guide, a methodology has been described to anticipate, recognize, evaluate and control musculoskeletal disorders that are associated with computer use.

Musculoskeletal Risk Factors

The office-related risk factors implicated in the development of musculoskeletal disorders include:

- **Repetition** – repetitive work without adequate recovery time.
- **Forceful exertions** – use of excessive strength during any activity.
- **Static and/or awkward postures** – prolonged holding of a single posture or performing work in non-neutral postures for extended periods of time.
- **Localized contact stress** – compression on the soft tissues caused by pressure from external surfaces.
- **Psychosocial stress** – includes the contribution of stress to musculoskeletal problems as well as how working at a computer for most of the day contributes to stress.

Repetition

The most obvious examples of repetition for computer users, of course, are keying and mousing. The fingers of a typist working at 70 words per minute are each experiencing about 2100 exertions per hour. This exceeds the 1500–2000 repetitions per hour suggested limit for human tendons.[2]

The amount of repetition also depends on the length of time spent using the computer. Although not all agree[3], musculoskeletal symptoms typically increase with increased continuous time at a computer workstation.[4,5]

Repetition Controls

Perhaps the best way to reduce repetition in computer workstation jobs is to alternate tasks, introduce frequent breaks, or a combination of the two. Broadening jobs or intermixing other activities such as scanning documents or sorting mail have long been used to reduce repetition. The job should be designed for variability and breaks from repetition.

Rest breaks are important, too. Studies have shown that rest breaks reduce muscle fatigue and/or discomfort[6-9] and/or increase performance.[10] However, some studies do not support this.[11] Research suggests that frequent microbreaks of 1 minute or less several times an hour are more beneficial than longer, less frequent breaks.[12,13] Even two second breaks reportedly decrease fatigue and increase endurance, if taken recurrently.[13] Breaks that include active exercise may be more beneficial than passive breaks, massage, or resisted exercise.[6,9,13] Software that prompts the worker to pause or exercise can also be useful.[14]

Using shortcut keys can minimize the amount of typing required throughout the day. These keyboard shortcuts are found in the Help menu. There are also many mouse settings available to reduce the number of clicks required during the work day. Adjusting settings can allow the user to single click rather than double click, and to enhance pointer precision to reduce wrist movement. Using the control panel allows for customized mouse settings.

Voice recognition is a process where spoken words are converted into text in a software application. In some cases, voice recognition software may be the most effective means of eliminating musculoskeletal discomfort from repetitive typing and mousing activities.

Forceful Exertions

Forceful exertions have been associated with an increased risk of musculoskeletal injuries among factory workers.[15-17] Forceful exertions can occur in the office setting while performing tasks such as stapling, hole punching, filing, binding, or processing/handling of bulk material.

Different keyboards require varying levels of force to activate the keys. People typically use more force than necessary to activate the keys. This extra force is transmitted back to the fingers and may be significant when coupled with the number of repetitions during keying.[18-21] Determining an acceptable level of force for the digits is difficult.[17]

Stress due to deadlines or performance monitoring may also cause workers to use excessive keyboard force during keying.[21]

Forceful Exertion Controls

Forceful exertions can be addressed through worker awareness and training programs. Showing workers videos of themselves while pounding keys, for example, can be constructive because most people do not realize how little force is required for key activation and how much excess force they are using.[18,19,22] The extra force is transmitted back to the fingers of the user. Although the force for each key is small, the total force can be significant when the keying rate is high. Joint torque can be reduced, even when force remains constant, when fingers are flexed[23,24] and/or when the direction of key travel is away from the user.[25]

Special equipment, such as electric staplers that don't require manual operation, may eliminate some forceful exertions.

Static Postures

Muscles can act to produce motion or to sustain posture. Holding a position continuously for a period of time, or static, can result in decreased blood flow to the muscles, leading to oxygen deprivation and buildup of waste products. In this situation, muscles fatigue in a matter of minutes.

The human body is made for movement and any position held for more than 20 minutes produces increasing physiological stress (See Figure 2.1).

Examples of sustained static exertions for computer users include prolonged:

- Gripping of the mouse, phone, or tablet;
- Sitting or standing;
- Holding the hands poised above the keyboard while keying or between strokes;
- Holding of a phone handset against the ear (either with a hand or a shoulder);
- Hunching or elevating the shoulders while keying;
- Reaching with the arms while keying or mousing (See Figure 2.3); and
- Rotating or forward bending of neck to view monitor, hand held device or documents.

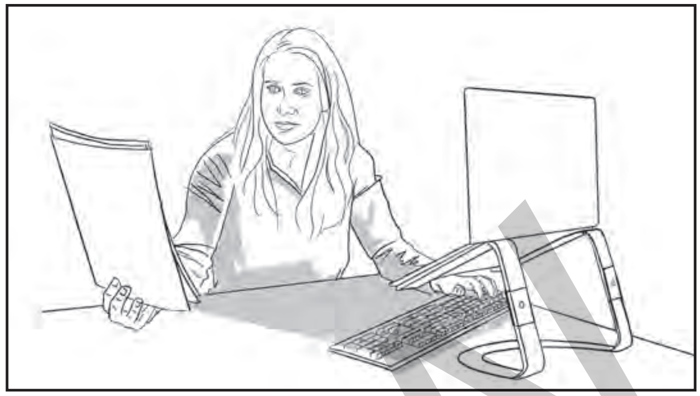

Figure 2.1 – Sustained wrist and elbow extension occurs when work is positioned too low

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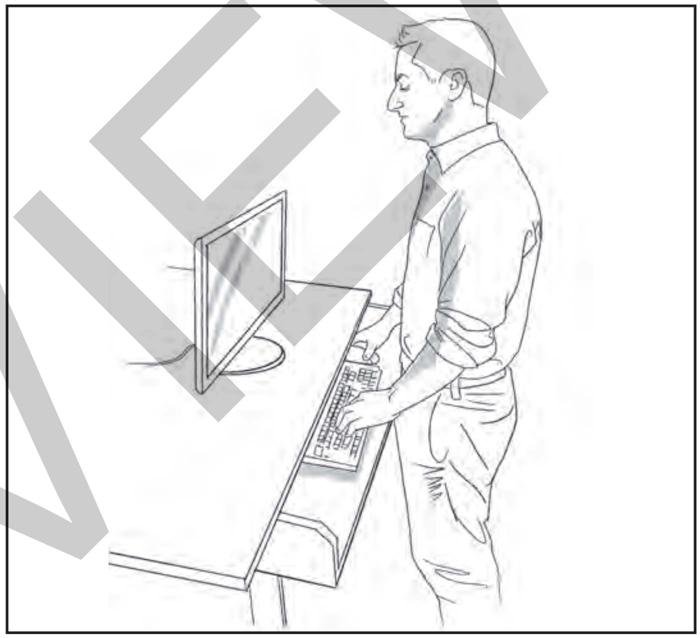

Figure 2.2 – Sustained wrist and elbow extension occurs when work is positioned too low.

Figure 2.3 – An extended arm and dropped wrist are frequent problems for keyboard users.

Static Posture Controls

Some jobs require sustained static exertion. Sometimes the task and work environment contribute to this, while other times the static posture is maintained by a worker's unintentional postural habit. Examples include:

- Maintaining shrugged shoulders;
- Holding fingers poised over keys; and
- Gripping the mouse while in thought.

Whatever the cause, the worker can reduce the exertion by varying postures, relaxing the tensed muscles, and/or performing periodic exercises. Some evidence supports the use of exercise and rest breaks in reducing musculoskeletal discomfort in computer tasks. Other research suggests rest breaks alone yield benefits.[26] Furthermore, some studies have also demonstrated increased productivity with short breaks.[27] A timer, computer program, phone application, or sensor technology may be used as a reminder for position change to ensure that they are incorporated into the work tasks.

Sustained postures of the upper arm can be reduced by moving the mouse or input device to the midline of the user. This reduces the reach necessary to operate the mouse.[28] Moving the input device closer to the keyboard is recommended to maintain a relaxed shoulder and wrist posture. This can be accomplished through a variety of means:

- Using a shorter length keyboard;
- Positioning the mouse to the left of keyboard;
- Using mouse bridges to position the input device over the numeric keyboard; and
- Operating keyboards with embedded rollers, touchpads or trackballs.

There are also ways to reduce sustained postures of the hand and wrist. The hand and wrist extensor muscles, located in the forearm, are used to position the hands and the fingers over the keyboard. When the fingers are moved downward to depress the keys, the extensor muscles are lengthened under tension, which can result in muscle pain.

Maintaining a neutral wrist position will minimize the force exerted by the extensor muscles and reduce their risk of injury while keying.[29] Sloping the keyboard away from the user can also reduce wrist extension while keying.[30,31] Several input device designs, including the touchpad and roller mouse, allow the user to control the input device with simple finger manipulations and allow the user to easily switch hands. These devices reduce or eliminate the static tension associated with gripping a traditional mouse for extended periods of time. Another innovation is the vertical mouse, which takes the design of a traditional mouse and orients it vertically so that the user's hand and wrist are in a neutral position. Care should be taken, however, not to compress the ulnar nerve by weight-bearing on the pinky side of the wrist while mousing.

Sustained postures of the head, neck, and shoulders may also be managed with design. Computer workstation users who spend a lot of time holding a phone often benefit from using a headset. Elevated shoulders are another problem that can be corrected by lowering the keyboard and other input devices.

Changing posture from sitting to standing reduces static positioning. For example, standing to take a phone call or to read allows the spine to assume its natural curve (lordosis) and reduces compression on the discs. In addition, sit-stand workstations and tabletop devices allow for a change in positions while working on the computer. More information about Sit to Stand Workstations is offered in the Special Applications section.

Awkward Posture

Awkward posture can be understood in terms of deviating from the preferred neutral position of a given joint (See Figures 2.2, 2.3, and 2.4). Awkward postures are problematic in the workplace when the workstation is configured in such a way that the person using the workstation must utilize unnatural body positions to perform his/her job. A two inch (5 cm) increase in work surface height during a typing task has been associated with a statistically significant increase in muscle activity, primarily due to an increased length of motor unit contraction.[32] Sustained awkward postures can have adverse effects on muscles, tendons, joints and nerves.[33-35] They have been associated with both muscle-tendon disorders and nerve compression disorders, the two main types of occupational musculoskeletal issues.[36] Muscle-tendon disorders often involve inflammation of the muscle tissue, the tendon itself, or the synovial membranes surrounding specialized tendons in the hand. Nerve compression disorders are caused by direct pressure on a nerve and may be associated with inflammatory swelling.

Figure 2.4 – Multiple risk factors such as sustained awkward arm positions with local wrist and elbow pressure are common occurrences.

Examples of awkward postures during computer use include:

- Bending wrists upward or downward while keying;
- Bending wrists sideways toward the thumb or the pinky while keying, manipulating the input device, or gripping a hand-held device such as a phone or tablet;

Appendix A: Quick Checklist

A

This checklist presents a few of the more common potential ergonomic problems that might be observed in computer workers. The provided lists are guidelines and are not a substitute for a thorough understanding of ergonomic issues. Many possible conditions and interventions are not shown. Also, be aware that some interventions can cause other problems.

List 1: Things to Look for and Possible Interventions

Arrange either anatomically, by workstation equipment, or by risk factor.

Things to look for:	Possible interventions:
Visual fatigue or eyestrain	1. Adjust lighting for comfort 2. Reduce glare: closing blinds, moving monitor position, shade screen 3. Consult with vision specialist re: proper prescription 4. Position monitor for comfortable viewing distance (20–32") 5. Reduce over-illumination to 200–500 lux 6. Adjust brightness, contrast, font size and refresh rate to comfort 7. Utilize task light for difficulty viewing hard copy 8. Perform frequent eye exercises 9. Clean screen
Prolonged elevated shoulder to ear posture while using phone	1. Telephone headset 2. Utilize speaker phone
Sustained neck rotation to view screen or documents off to the side	1. Center monitor for neutral neck position 2. Bring viewed items to center
Neck bent too far forward to read screen	1. Elevate monitor 2. Habit training
Neck tipped backwards to view screen	1. Lower monitor 2. Review screen distance and prescription with vision specialist
Repetitive neck motion to view screen and documents	1. Position documents close to screen 2. Position documents on document holder

Appendix C: Workstation Adjustment

C

One of the key concepts of computer workstation design is incorporation of adjustability in the chair, keyboard, and work surface height. This workstation adjustment guide is simplified for a typical case and should be modified based on job and personal factors.

Before beginning to adjust the workstation, a decision must be made: Will the user utilize the top of the desk as the primary worksurface? Or will they use a keyboard/mouse tray?

For taller individuals (above 5′–10″), the desktop will probably be preferred since a keyboard/mouse tray will often be an obstacle for their knees and the desktop will be near or below elbow height. For some others (such as engineers or graphic designers with large drawing pads), their activities or equipment will dictate the use of the desktop as the primary work location. If a keyboard/mouse tray is to be used,

1. Adjust the chair height so that the:
   a. feet rest solidly on the floor
   b. thighs are approximately parallel with the floor
   c. the angle of the knee joints is 90 degrees or slightly more
2. Adjust the chair tilt tension so the user can recline mostly by a weight shift rather than pushing off with the feet. If the heels rise significantly off the floor when reclining, the user is pushing with the feet too much and the tension should be decreased. If the user prefers not to recline, the tension can be kept tight.
3. Place the keyboard and mouse on the tray(s). Adjust the tray height and angle so the user is comfortable and the wrists are in a neutral position.
4. Place the mouse at the same height as the keyboard, as close to the mid-line of the user as possible. If the mouse is placed to the right side of the keyboard, consider using a keyboard without a number pad. Also consider alternative pointer devices.
5. Begin with the monitor at arm's length from the user. Adjust distance to accommodate vision and/or corrective lenses.
6. Adjust monitor height so that entire viewing area is at or below eye level. One way to ensure neutral neck position is to have the user tuck his or her chin. If the chin is jutting out the neck is bending backwards (extending).
7. Adjust the monitor angle to face the user's face. The bottom of the screen will be closer to the user than the top of the screen. The angle can be checked with a small mirror in the middle of the screen; the user should be able to see his or her eyes.
8. Check for glare and correct it by changing or shielding the light source, or by rearranging the workstation. Do not attempt to reduce glare by compromising the monitor's height, angle or location.
9. Place documents (if used during computer work) on a document holder at about the same viewing distance from the eyes as the monitor.
10. Adjust the document and monitor position to minimize eye and head movement between them.
11. If possible, adjust the work surface height so that the shoulders are not abducted significantly when writing or reading. The keyboard should be moved out of the way and the chair height readjusted, if necessary, when significant time is spent reading or writing. Be sure to readjust the work surface to an appropriate height for the monitor when computer workstation use is resumed.
12. If present, adjust the chair arms so that they support the forearms without raising or abducting the shoulders. Chair arms that force the user to assume a non-neutral position while keying and/or mousing are not recommended.

Sometimes the desktop is to be used as the primary worksurface. This may be due to user preference, equipment limitations, or a taller individual user. In such situations the following steps are recommended:

1. Adjust the chair height so that the user's elbows are approximately the same height as the keyboard.
2. If the feet are not firmly on the floor, a footrest can be used to provide support for the feet and prevent contact stress at the back of the thighs. Footrests should be height adjustable and have an adequate surface area. If the surface area is too small, the footrest may restrict foot placement and increase muscle tension.[44]
3. Follow the pertinent steps described above for adjusting the workstations.

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G

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