T he growth in computer use has been accompanied by muscu-
loskeletal injuries associated with poor seated work postures and poor ergonomic design of many office workstations. For a majority of office workers, discomfort in the neck, shoul-
ders, back, arms, wrists, and hands seems an inevitable consequence of computer use. Collectively, these muscu-
loskeletal injuries are referred to in the medical community as repetitive strain injury (RSI) and are classified under the broader term cumulative trauma disorder.

RSI symptoms may include pain, weakness, numbness, or impairment of motor control stemming from prolonged repetitive, forceful, or awkward hand movements. Known as “the occupational disease of the ’90s,” carpal tunnel syndrome is the disorder most commonly synonymous with RSI; however, it is just one of a variety of cumulative trauma disorders caused by overuse of the hand and arm (Pascarella and Guiller, 1994).

What is carpal tunnel syndrome?

At various sites throughout the body, nerves pass through “tunnels” composed of bones, ligaments, and other tissue. If this tissue swells and presses on a nerve, interference of fluid circulation throughout the area occurs as well as impairment to normal nerve function.

The site of the carpal tunnel is a “bracelet” of bone and tough ligament just below the wrist at the heel of the hand. Extreme, repetitive hand movements can irritate the tissues inside the carpal tunnel and produce swelling. The rigid-structured carpal tunnel cannot expand to accommodate this swelling, and the pressure produced on the median nerve passing through the carpal tunnel results in the numbness and tingling associated with the disorder.

**Warning signs of RSI**
- pain
- fatigue or lack of endurance
- weakness in the hands or forearms
- tingling, numbness, or loss of sensation
- heaviness
- clumsiness
- difficulty opening and closing hands, stiffness
- difficulty using hands
- lack of control or coordination in hands
- cold hands
- hypersensitivity

**Figure 1. Neutral Zone of Hand Movement**

[Diagram showing neutral zone of hand movement with 15° extension, 15° ulnar deviation, 15° radial deviation, and 15° flexion.]
What work activities can cause carpal tunnel syndrome?

Deviated hand positions increase the pressure in the carpal tunnel, maximizing the risk of an RSI to the hand and wrist. When hands are in a neutral posture (Figure 1), fluids circulate freely throughout the hand, there is minimal pressure on the articular surfaces of the wrist, and the ligaments remain slack. Whereas when the hands are deviated, this can intensify carpal tunnel pressure. One of the most common movements that restricts fluid circulation to the palm occurs when wrist extension exceeds 15-20 degrees, with the palm at an upright angle to the wrist (dorsiflexion). This movement is safe within a limited extension zone of 15 degrees, called the neutral zone. If you place your hand flat on a table and begin to raise the palm while maintaining wrist position flat against the surface of the table, dorsiflexion can be comfortably sustained in a 15 degrees range before fluid circulation to the hand decreases. Hand movements outside this range can significantly increase carpal tunnel pressure to a level producing pain in the wrist and shoulder as well as discomfort in the upper and lower arm.

Studies indicate that sustained high levels of carpal tunnel pressure, incurred during a normal 8-hour workday, can result in complete blocking of nerve signals. Not only can typing itself cause a wrist extension beyond 15 degrees, but the frequent microbreaks (raising fingers and hands off the keyboard) characteristically occurring between bursts of typing, exacerbate the wrist extension. For example, when users stop typing for a moment to review their work or to look at someone who has just entered the office, they do not position their fingers flat on the keyboard; rather, they tend to dorsiflex the hand, exceeding the 15-degree extension angle.

Using a mouse can be more demanding on the hands than using a keyboard; instead of distributing the work between 10 fingers, the burden is placed on one. Also, manipulation of the mouse requires sustained fine movement and continuous contraction of various small muscles. Individuals are particularly at risk if they grip the mouse too hard, if they skew the mouse with rapid wrist movements, or if they work with their arm bent out (abduction) and reaching forward. The excessive stress these movements place on the joint at the base of the thumb can give rise to several RSIs.

Who is susceptible to carpal tunnel syndrome?

Individuals operating a computer most of the time in a full-time job, particularly people performing data entry operations, are susceptible to carpal tunnel syndrome as well as other RSIs. According to a recent New York Times article (Brody, 1996), attention was first drawn to this problem when a large number of news reporters and editors who work at the computer all day became afflicted with RSI symptoms. Before people worked almost exclusively at the computer, primarily blue collar workers in occupations such as construction, carpentry, and assembly-line work and others such as pianists, bank tellers, and dental hygienists were subject to this disorder. The problem has received substantial attention recently because of widespread computer use.

A Case Study

Cornell University employee illustrates how ergonomic intervention with the computer workstation can help correct a medical condition.

1. Abducted arm
   Extended wrist

2. Abducted arm
   Extended wrist

JS is right-handed and works almost exclusively on the computer. She was experiencing increasing pain in her right shoulder and wrist and discomfort in her right upper and lower arm. Physical therapy and a wrist brace proved ineffective, and her physical condition continued to decline. She contacted the Cornell Ergonomics Group for advice.

Group members made an assessment of JS’s workstation and determined that the keyboard and mouse arrangement forced deviation from the established comfort zone and were the source of her musculoskeletal problems (Figs. 1–2). They concluded that JS needed a keyboard and mouse arrangement to fit a 27-inch desk and which would allow her to work while sitting in her chair with arms relaxed and wrists in a neutral position. The Preset Tilt Down Keyboard system was selected as meeting the parameters determined through analysis (Figs. 3–4).
What can be done to avoid carpal tunnel pressure or risk of other RSIs?

Because the best cure is prevention, we will focus on how computer users can avoid the risk of carpal tunnel syndrome. When working at a computer, users ideally should not extend their wrists beyond 15 degrees—typing with the hands “floating” over the resting surface can decrease carpal tunnel pressure. Another proven approach is the incorporation of the Preset Tilt Down (PT) Keyboard system into the computer workstation. This system consists of a fixed-angle keyboard platform with a negative slope and an adjustable support platform for a mouse located within the immediate-reach zone. By encouraging typing within the neutral wrist extension zone below 15 degrees, the PT keyboard produces minimal pressure on articulatory surfaces. The adjustable mouse platform prevents shoulder and elbow abduction, maintaining the “mouseing” arm within a prescribed comfort zone.

The benefits of the PT system are not limited to improved wrist posture. Users of the system have measurably improved seated work posture and report a reduction of musculoskeletal discomfort. They also report that the PT system is easy to operate and adjust, encouraging good work performance. In addition, recent research has found that a correctly installed, downward sloping split keyboard (mounted onto the arms of a user’s chair) can also reduce the risk of carpal tunnel syndrome (Hedge & Shaw, 1996). The following guidelines are provided for an ergonomically correct workstation setup:

**Keyboard position.** Traditional computer keyboards usually are designed to slope at a positive angle of around 15 degrees to the horizontal. When placed on a desktop or conventional adjustable keyboard tray, these keyboards create extremes of wrist extension beyond 15 degrees for many users. Reducing the keyboard angle using a negative-slope keyboard support and lowering the height of the keyboard relative to the normal work surface minimizes hand excursions beyond the neutral zone for the wrist during typing.

**Mouse position.** The same general principles that apply to keyboard position also apply to mouse position.

Preliminary studies indicate a dramatic increase in surface electromyography activity to the shoulder muscle as the degree of arm abduction is increased. In other words, as the distance between your body and “mousing elbow” increases, shoulder strain increases in an almost 1:1 linear ratio. A 10- to 20-degree range of shoulder abduction, which locates the elbow close to the body, is recommended for minimal stress.

Other recommendations for proper mouse-handling techniques include 1) hold the mouse loosely with all fingers—gripping can create overall finger tension and lifting the pinkie can produce stress as well, 2) maintain a neutral wrist position and refrain from resting wrist or forearm on the table while guiding the mouse, 3) use the entire arm and shoulder to move the mouse, rather than “flicking” the wrist, 4) use a light touch when you click, and 5) do not work with the mouse to the side of the keyboard if this puts your arm into abduction.

**Correct sitting posture.** The chair should be adjusted to permit comfortable yet not rigidly vertical upright posture. Thighs should be parallel to the floor. Refrain from hunching over the keyboard. Proper chair height will permit the feet to rest firmly and evenly on the floor and slightly in front of the body (opening the angle behind the knee).

**Monitor, central processing unit, and copy holder position.** Put the monitor directly in front of the body, approximately at arm’s length. The top of the monitor screen should be slightly below eye level. The copy holder should be located close to the monitor so that your eyes do not have to focus as you switch from page to screen. Put the central processing unit to the side rather than underneath so that the monitor height can be adjusted easily.

**Ineffective equipment.** Learn which computer workstation equipment is ineffective in alleviating symptoms of...
carpal tunnel pressure. Studies show that wrist rests do not improve wrist posture. Some of these devices may even induce wrist deviation, increase pressure on the carpal tunnel, and reduce support for the hands. Furthermore, wrist rests have no significant effect on overall seated work posture or comfort.

Adjustable keyboards alone do not necessarily improve wrist posture. Research on several adjustable keyboard designs has demonstrated no significant results in discouraging typing within the recommended neutral wrist zone or improvement of overall seated work posture. Just because something says it is “ergonomically designed” doesn’t always mean it will work effectively to help you.

Why should your business address RSI issues?

RSI is a serious public health problem; it accounts for 80 percent of all job-related injuries, according to the U.S. Department of Labor. A 1992 report noted that RSI cost businesses $20 billion a year; and according to the National Council on Compensation Insurance, the average compensation of an RSI victim is $29,000. It is predicted by the year 2000 three-quarters of all jobs will probably require use of a computer (Pascarelli and Quitler, 1994).

Beyond the enormous financial deficit RSI potentially presents to businesses, the health and morale of employees cannot be measured in dollars.

Conclusion

Carpal tunnel pressure compresses the median nerve in the hand, restricting fluid circulation into the palm. Sustained wrist extension beyond 15 degrees increases carpal tunnel pressure, and this increases the risk of carpal tunnel syndrome.

Anyone operating a keyboard for prolonged periods who is working in a poor posture runs the risk of developing an RSI. The Preset Tilt Down Keyboard system has been proven to provide relief for computer users. By locating the keyboard on a slight negative slope and providing a support platform for the mouse, wrist and overall seated work posture are improved. Musculoskeletal discomfort is also reduced.

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References


Future topics

In Facilities Planning and Management Notes, we would like to address the concerns of readers involved in the planning, design, and maintenance of facilities. Let us know what topics you would like to see in future issues.

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