Industrial Medicine and Acute Musculoskeletal Rehabilitation. 3. Cumulative Trauma Disorders of the Upper Limb in Computer Users

Patrick M. Foye, MD, John C. Cianca, MD, Heidi Prather, DO


This self-directed learning module highlights various cumulative trauma disorders of the upper limb that may be seen in computer users. The biomechanics and ergonomics of computer users are addressed in relationship to specific neurologic and musculoskeletal conditions within the neck and upper limbs. In addition to a general overview of these conditions, a case presentation is used to show the evaluation and treatment of a computer user who has carpal tunnel syndrome and concomitant de Quervain tenosynovitis.

Overall Article Objectives: (a) To review the important anatomic and ergonomic basis for upper limb cumulative trauma disorders in computer users and (b) to provide an example of evaluation and treatment.

Key Words: Carpal tunnel syndrome; Computers; Cumulative trauma disorders: Human engineering; Rehabilitation. © 2002 by the American Academy of Physical Medicine and Rehabilitation

3.1 Clinical Activity: To evaluate the ergonomics of a 30-year-old female computer programmer with upper limb dysesthesias.

BIOMECHANICS, ERGONOMICS, AND CUMULATIVE TRAUMA DISORDERS

Although many employees who spend most of the workday at a computer would be classified as having a "sedentary" job, they are still at risk for work-related musculoskeletal disorders. Unlike falls, lifting injuries, and many other work-related injuries that occur suddenly at a specific time, musculoskeletal disorders from ergonomic problems usually arise from cumulative trauma disorders (CTDs), also known as repetitive overuse disorders, repetitive motion disorders, repetitive strain disorders, repetitive strain injuries, or occupation overuse injuries. A CTD can be defined as a condition that develops because of repetitive tissue microtrauma that exceeds the tissue’s ability to heal itself. Some investigators report that as many as 60% of occupational illnesses involve repetitive trauma, usually of the upper extremity. Because employees at computer workstations, that is, at a video display terminal, often spend most of their workday performing repetitive activities in a relatively static position, these factors may lead to CTDs. The US Department of Labor has determined that, "Intensive computer use accounts for a significant number of musculoskeletal disorders each year and occupational computer use is growing." CTDs in computer users commonly affect a variety of different tissues, including muscles, tendons, bursae, and nerves. Clinical examples include cervical myofascial pain, rotator cuff tendinitis, epicondylitis at the elbow, de Quervain tenosynovitis, and carpal tunnel syndrome (CTS). The number of cases of CTDs that have been reported to the Bureau of Labor Statistics as occupationally induced injuries has been increasing dramatically since the 1980s.

Biomechanics is an essential basis for accurately assessing, diagnosing, and treating each type of CTD that may occur with computer use. Physiatrists appreciate the relation between human anatomy and the physical demands of the workstation. CTDs appear to develop because of repetitive tissue microtrauma, often related to sustained or frequently repeated tasks in the setting of suboptimal ergonomics.

Ergonomics is the study of fitting the job to the worker and the worker to the job by understanding how human anatomy interacts with the physical environment during functional tasks. Some debate exists within the medical, political, and business arenas regarding the strength of the associations between repetitive, work-related activities and musculoskeletal disorders. It is important for the clinician to understand these associations and mechanisms so that an educated decision regarding causality can be made in each case. Further, regardless of how much the work-related computer use may have influenced onset of the symptoms, continuing those repetitive tasks (especially in a setting of poor ergonomic design) is likely to cause work-related exacerbations. If the disorder goes untreated or is inadequately treated, the symptoms can eventually spread to other body regions or occur even at rest. When possible, ergonomic arrangements should be adjustable, allowing workers of various anatomic proportions to modify the workstation.

Physiatrists should consider ergonomic factors affecting the cervical region, in which neurologic or muscular tissue may cause pain referral into the upper limb. Cervical extension and/or lateral bending cause narrowing of the neuroforamina, compressing the spinal nerve roots and thus causing dysesthesias. Activities requiring such positions could include extending the neck to look up at a computer monitor that is too high for the employee's line of sight or tilting the neck to hold a phone between the ear and shoulder while using both hands for typing.

Cervical myofascial pain syndrome can produce pain and trigger points within muscles, including the cervical paraspinal muscles, scalenes (anterior, middle, posterior), and shoulder-
girdle muscles such as the 3 heads of the deltoid, 3 divisions of the trapezius, rhomboid major and minor muscles, rotator cuff muscles, serratus anterior, and latissimus dorsi. Myofascial pain of the neck and shoulder region may occur because of prolonged periods of awkward positioning, such as cervical rotation to view a monitor that is not located directly in front of the typist. The employee’s chair should provide adequate support for the upper back to minimize muscle fatigue.

Rotator cuff tendinitis and impingement, with associated subacromial bursitis, may occur as a result of repetitively reaching for a mouse located in a suboptimal place, such as a mouse that is too far off to the side or on a desktop that is higher than the keyboard. Such ergonomic arrangements force the employee to repetitively abduct and/or flex the shoulder countless times per day. These repetitive activities can cause cumulative relative narrowing of the supraspinatus outlet, ultimately resulting in impingement pain.

Thoracic outlet syndrome (TOS) is a neurovascular condition caused by compression of the brachial plexus or subclavian vessels as they pass from the cervical region toward the axilla. Neurovascular tissue can be compressed by adjacent structures such as the first rib, the clavicle, scalene muscles, or the pectoralis minor muscle. Neurologic compromise usually involves the lower trunk of the brachial plexus. It presents with neck or shoulder pain that radiates to the medial (ulnar) aspect of the forearm and hand (C8–T1 distribution). Although a clear causal relationship between TOS and computer use has not been firmly established, 1 risk factor for TOS appears to be occupations requiring prolonged static neck positions. Possible mechanisms may include neurovascular compression during postures such as looking at a computer monitor that is positioned off to the side rather than directly in front of the user.

The elbow region may also become painful with prolonged computer use. The ulnar nerve passes within the ulnar groove at the medial elbow, in which compression (eg, against the arm of the employee’s chair) could cause hand weakness and numbness and dysesthesias radiating into the 4th and 5th digits. The ulnar nerve can also be irritated by prolonged elbow flexion combined with pronation from using a keyboard too close to the body. The lateral epicondyle is the origin for the wrist and finger extensors, as well as the forearm supinators. If the computer keyboard is too low, prolonged extension of the wrist and fingers may result in lateral epicondylitis, with lateral elbow pain that may radiate distally. If there is repetitive friction of the posterior elbow on an unpadded surface (eg, a desktop), local irritation may cause olecranon bursitis (student’s elbow, draftman’s elbow).

The median nerve is subjected to increased pressure within the carpal tunnel during excessive wrist flexion or extension, which can occur when typing on a keyboard that is too high or low, respectively. Chronic, repetitive wrist motions have been associated with CTS. However, not all wrist or hand symptoms are related to CTS. Physiatrists must evaluate the entire upper quarter kinetic chain for the source of hand symptoms, including the neck, shoulder, elbow, and forearm.

At the lateral aspect of the distal forearm and wrist, the tendons of the extensor pollicis brevis and the abductor pollicis longus share a common tendon sheath, forming the first dorsal compartment. Inflammation at this site results in de Quervain tenosynovitis, which may occur as a result of repetitive or prolonged ulnar deviation of the wrist, such as occurs while typing or especially while using a mouse that is placed too far lateral to the keyboard.

Biomechanical evaluation includes a detailed understanding of the posture, positions, and physical layout of the worker and workstation. Determining the frequency and duration of repetitive activities is essential. Also, it is important to understand the potential role of underlying degenerative changes because preexisting pathology may predispose the employee to work-related exacerbations.

3.2 Clinical Activity: To formulate a diagnostic and treatment plan for a 30-year-old female computer programmer with upper limb dysesthesias.

COMPUTER-RELATED CTD: ASSESSMENT AND INTERVENTION

Because CTD is an umbrella term that includes a wide variety of conditions, a much more specific diagnosis is needed before appropriate interventions can be devised. Once CTD symptoms develop, the first step is prompt medical evaluation. Performing a thorough history and physical examination, supplemented when necessary with diagnostic testing to confirm or differentiate between diagnoses, enables the physiatrist to determine an accurate diagnosis and to develop a specific treatment plan.6

Medical History

The musculoskeletal history should include questions regarding symptom onset, frequency, duration, specific location, referral patterns, prior work-up or treatments, and any factors that appear to exacerbate or relieve the symptoms. Special attention should be given to the work history, including details about the job duties performed and the frequency, duration, and conditions under which they are performed, including the physical layout of the worksite and the patient’s knowledge of proper ergonomics. Collecting information regarding the time course of the pain syndrome, particularly related to qualitative and quantitative changes in job tasks, is essential. The relationship between symptoms and days off from work or holiday time off is particularly important because CTDs typically remit in response to rest.

Physiatrists are also responsible for eliciting and documenting history of preexisting conditions or symptoms, as well as sports, hobbies, or other non–work-related activities or injuries that might account for the patient’s symptoms. Musculoskeletal discomfort arising from an underlying, degenerative condition is more likely to continue or progress regardless of time away from repetitive work tasks.

Symptoms of work-related musculoskeletal disorders include numbness, tingling, pain, burning, stiffness, and cramping.7 In this patient, the physiatrist should ask about the exact location of the dysesthesias, with special attention to whether they fit the distribution of any particular bursa, tendon, dermatome (ie, root level), peripheral nerve, or myofascial pain referral pattern. If there is any associated numbness or weakness (suggesting a neurologic origin), then the distribution of these symptoms should be carefully evaluated.

In this patient, further details of the history revealed pain and dysesthesias at the lateral wrist and vague dysesthesias within her fingers, although she was unable to identify clearly which digits were most involved. She denied any significant repetitive activities involving the upper limbs other than the tasks performed at her workplace.

Physical Examination

A directed physical examination balances 2 elements: (1) a focus on the relevant body regions and (2) sufficient thoroughness to investigate alternative diagnoses that might account for the patient’s symptoms. Neurologic assessment localizes nerve
pathology, if present, by investigating for dermatomal, myo-
tomal, or peripheral nerve abnormalities. Provocative maneu-
vers may help localize pathology by reproducing symptoms.
Examples include the Spurling sign for cervical radiculopathy,
Neer and Hawkins maneuvers for shoulder impingement, re-
sisted wrist or finger extension for lateral epicondylitis, the
Tinel sign at the ulnar groove for ulnar neuritis, and the
Finkelstein test for de Quervain tenosynovitis. Various provo-
cative maneuvers are used to assess for CTS, such as Tinel sign
at the wrist, Phalen test, reverse Phalen test, and the carpal
compression test. Thorough examination of soft tissues in-
cludes identifying painful restrictions in range of motion as
well as myofascial pain and trigger points.

Diagnostic Tests

Diagnostic tests are ordered if the diagnosis is not clear after
the history and physical examination, if the results of such
testing will change management, or if it is needed for medico-
legal reasons. Radiographs of the suspected site of pathology
will generally not reveal a fracture in the absence of blunt
trauma, but may reveal underlying degenerative changes. Bone
scan or single photon emission computerized tomography can
reveal fractures that have not yet appeared on plain radi-
ographs. Magnetic resonance imaging of the cervical spine may
reveal disk pathology, spinal canal stenosis, neuroforaminal
stenosis, or other underlying conditions. Computerized tomog-
raphy of the cervical spine and computed tomography myelo-
gram can assess for cervical spinal stenosis. Magnetic reso-
nance imaging is the study of choice if imaging becomes
necessary to evaluate the shoulder for rotator cuff pathology,
although arthrogram may be needed to assess for labral pathol-
ogy.

Electrodiagnostic studies (nerve conduction studies, needle
electromyography) are not always necessary, but they are often
quite valuable because they can identify nerve pathology, lo-
calize the site of the lesion, and provide information regarding
the severity of the nerve involvement. An injured worker may
have substantial secondary gain and, unfortunately, many phys-
ical examination maneuvers used to assess nerve status rely on
the patient for adequate effort (for strength testing) or for
honesty (in reporting sensory function or symptoms experi-
enced with provocative maneuvers). In such cases, electrodi-
agnostic studies provide the distinct advantage of offering
objective data. Electrodiagnostic data can also objectively
quantify the degree of impairment in a manner independent of
the patient’s pain behaviors.8,9

Treatment

Therapeutic interventions are based on the specific medical
diagnosis. In general, acute inflammatory conditions are often
treated with the PRICE regimen: protection (preventing further
injury, perhaps via bracing, altered weight bearing); rest (eg,
by activity limitation or modification); ice (to decrease pain and
inflammation); compression (to minimize swelling); and ele-
vation (to minimize swelling). Oral nonsteroidal anti-inflam-
matory drugs (NSAIDs) are often used. If needed, local anes-
thetic combined with corticosteroid can be injected for diag-
nostic and therapeutic purposes (eg, for lateral epicondy-
liitis, de Quervain tenosynovitis, CTS). Trigger point injections
using only local anesthetic or dry needling are often used as
part of the comprehensive treatment of myofascial pain.

Bracing in the upper limb may include a tennis elbow
counterforce strap for lateral epicondylitis, a wrist splint for
CTS, or a thumb spica splint for de Quervain tenosynovitis.
Some patients find wrist and hand splints cumbersome while
writing or typing.

Occupational therapy or physical therapy often comprise an
important component of the treatment plan. Initially, occupa-
tional therapy or physical therapy may provide short-term
modalities, such as ice or electric stimulation to decrease pain
and thus facilitate active stretching or strengthening. Patient
education regarding proper body mechanics is also important.
Some therapists are trained to perform worksite analysis, which
can provide information critical for decisions about return to
work.

Fortunately, only a small minority of computer-related
CTSs of the upper limb will fail conservative treatment. A
subset of this failure group might benefit from surgical treat-
ment. Included in this group are cases requiring carpal tunnel
release for CTS or decompression of the first dorsal
compartment for de Quervain tenosynovitis.

3.3 Educational Activity: To design a workstation mod-
ification for the 30-year-old female computer pro-
grammer with upper limb dysesthesias.

ERGONOMIC MODIFICATIONS

Decisions regarding work site modifications are based on
accurate diagnosis. Many employers initially respond to em-
ployee symptoms by modifying a worksite but delaying med-
ical evaluation. These employers risk wasting resources on
work site modifications that may be totally unrelated to the
employee’s condition. Without medical care, the condition may
progress, thus worsening the employee’s prognosis for a quick
and complete physical and functional recovery.

In this particular employee, further history indicated dyses-
thesias mainly into the thumb and to a lesser extent into digits
2 and 3. On physical examination, the Finkelstein test was
clearly positive for de Quervain tenosynovitis at the symptom-
atic wrist and was negative on the contralateral side. It was
possible that the dysesthesias into the fingers were merely
referred pain from the de Quervain tenosynovitis, but this point
was uncertain because provocative maneuvers for CTS were
mildly positive. Electrodiagnostic testing confirmed the pres-
ence of mild, unilateral CTS as a concomitant diagnosis. There
was no evidence of cervical radiculopathy, ulnar neuropathy,
or diffuse peripheral polyneuropathy. She responded well to oral
NSAIDs, 1 corticosteroid injection within the tendon sheath at
the first dorsal compartment, and bracing of the wrist and
thumb with a thumb spica. However, when she returned to
work, her symptoms soon returned. Although her symptoms
were less severe than previously (perhaps because she was still
taking the NSAIDs and wearing the splint), they gradually
increased after returning to work. At this point, the employer
agreed to provide a formal ergonomic assessment.

A wide variety of ergonomic factors are relevant to the
employee who uses a computer. Although there is some debate
regarding the strength of the published research to confirm the
usefulness of ergonomic interventions in video display terminal
users, it seems probable that such interventions are a worth-
while component of a comprehensive rehabilitation plan. The
published studies and anecdotal accounts combined with physi-
atic understanding of basic human anatomy along with prin-
ciples of dynamic, functional activities makes it logical and
likely that wisely selected ergonomic interventions can offer
benefit. In this particular case, ergonomic intervention should
focus on hand and wrist positioning. Also, if a modified duty
job is available that permits the employee to alternate her work
duties with less repetitive activities, then this should be imple-
mented.

Because increased pressure on the median nerve within the
carpal tunnel has been associated with excessive wrist flexion

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or extension, these positions should be avoided. If the keyboard is too low or too high (relative to the forearms), the computer user will excessively extend or flex the wrists while typing. Thus, interventions in this case require coordination between the chair height, forearm supports, forearms, wrists, hands, and keyboard. The forearms should be relatively horizontal to the floor and the wrist should be in a neutral position. The volar aspect of the wrist can be supported during typing by a wrist support placed on the desktop or support tray in front of the keyboard. The wrist support should be padded and without sharp or square edges. The mouse position also needs consideration to ensure that it meets the same criteria outlined for the keyboard (ie, located at a height that fosters a neutral wrist position [no excessive extension or flexion] and perhaps with a padded wrist support on the desktop or support tray just in front of the mouse).

Various typing positions affect the tendons of the extensor pollicis brevis and the abductor pollicis longus. These tendons are located at the lateral aspect of the wrist, within the first dorsal compartment, in which the common tendon sheath can become stretched, inflamed, and painful as a result of repetitive or prolonged ulnar deviation of the wrist. If the keyboard is incorrectly located off to the side rather than directly in front of the typist, then the forearm from the opposite side must adduct and cross the body to reach the keyboard. When that distal forearm reaches the keyboard, the wrist ulnar deviates so the fingers are positioned on the keyboard for typing. In the described case, typing in this position for prolonged or repetitive periods may cause or exacerbate de Quervain tenosynovitis at that wrist. The keyboard should be relocated to a position directly in front of the typist, thus minimizing ulnar deviation of either wrist. Also available are split keyboards, which allow both wrists to assume a more neutral position, rather than the slight ulnar deviation fostered by traditional keyboards. Although there is not sufficient published research to confirm that split keyboards decrease the incidence, prevalence, or severity of de Quervain tenosynovitis in typists, anecdotal accounts and anatomic principles imply that these devices should offer some benefit.

Aside from the keyboard, the mouse position is also important for a computer user with de Quervain tenosynovitis. If the mouse is placed too far to the keyboard, there may be a tendency to reach for it and cause ulnar deviation at the wrist. Repetitively performing such ulnar deviation for every set of mouse clicks may initiate or exacerbate de Quervain tenosynovitis. The mouse should be positioned closer to the midline. Keyboards are available without the numbers keypad, thus allowing the mouse to occupy a position closer to the main typing keys. Other keyboards provide a trackball embedded within the keyboard, removing the need for an adjacent mouse.

Because home computer use is common, physiatrists must determine how much time the patient spends using a computer at home. Many home computers are set up on furniture not intended for such use, and ergonomic design is often lacking. The employer or workers' compensation insurance carrier would generally not be expected to coordinate or pay for ergonomic evaluation or intervention for personal home computers that are not officially being used for work-related activities. However, patient education regarding proper ergonomics should empower them to make lost-cost changes on their own. If the issue of home computer use is not understood and addressed, a patient may fail to improve in the expected manner.

References
Suggested Readings

*Key References