Occupational Cumulative Trauma Disorders of the Upper Extremity

Renee Williams, Muriel Westmorland

Key Words: occupational therapy • occupations • patient education • physical therapy

The umbrella term cumulative trauma disorders (CTDs) (also known as repetitive strain injuries, overuse syndromes, and repetitive motion disorders) covers a number of similar conditions arising from overuse of the joints or soft tissues of the upper extremity. Occupational CTDs have become a common problem in the workplace. These disorders are costly to the employer, the worker, and society in terms of time lost from work and resulting disability. Within the past decade, occupational therapists and physical therapists specializing in rehabilitation of work-related musculoskeletal injuries have seen an increase in the incidence of CTDs of the upper extremity in the workplace. Therapists are called upon not just to treat these injured workers, but also to help them regain a functional level for work reentry and to educate them to prevent reinjury. This article reviews the literature on the epidemiology, etiology, pathophysiology, and management of upper-extremity occupational CTDs. Because the ultimate goal of the workplace is to maintain the health and safety of the employee, an educational approach to hand, wrist, elbow, and shoulder use is essential to prevent, decrease, or eliminate the risk of occupational CTDs of the upper extremity.

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itive work tasks need to be taught the correct way to use their upper extremities so that the risk of incurring CTDs is minimized. Because occupational therapists have skills in task analysis and adaptation, biomechanics, and relaxation, whereas physical therapists have expertise in job analysis, exercise therapy, biomechanics, and pain management, both occupational therapists and physical therapists need to become more aware of and incorporate client education strategies into the treatment and prevention of these injuries. Education about work activities is also applicable to homemaking tasks and recreational pursuits, as these movements may lend themselves to stressful conditions.

The purpose of this article is to selectively review some of the relevant literature on occupational CTDs of the upper extremity. The epidemiology, etiology, pathophysiology, and management of work-related musculoskeletal upper extremity injuries are briefly summarized and the literature on educational programs for CTDs is critically reviewed. The benefits of an educational approach to upper extremity use in the treatment and prevention of CTDs are discussed.

Magnitude of the Problem

Musculoskeletal disorders are the leading cause of disability among persons during their working years (18 to 64 years of age) (Bernard, Sauter, Fine, Peterson, & Hales, 1992; Millar, 1988). These disorders, which include occupational CTDs, constitute an increasing problem in modern industry (Berryhill, 1990; Flinn-Wagner et al., 1990; Zimmerman, Zimmerman, & Clark, 1992). The incidence of occupational disorders has steadily increased over the past decade and evidence indicates that the trend will continue (Kroemer, 1992; Louis, 1987; Siebenaler & McGovern, 1992). In 1991, workers experienced approximately 6.3 million job-related injuries at a rate of 8.4 per 100 full-time workers; this is an increase from the 1985–1986 rate of 7.9 injuries per 100 full-time workers (U. S. Department of Labor, 1993). The number of injuries reported in any given year may be influenced by factors such as changes in working conditions, work practices, the number of hours worked, worker experience, and training. Louis (1987) reported that there were more than 12 million annual visits to physicians in the United States for musculoskeletal injuries and conditions. He further demonstrated that the costs of these disorders, one third of which were due to upper extremity conditions, exceeded $65 billion in 1984 alone.

In Canada, the leading cause of long-term disability is musculoskeletal disorders (Spasoff et al., 1987). In 1991, there were 520,547 work-related injuries for which all Workers’ Compensation Boards and Commissions in Canada accepted claims for time loss and permanent disability (Statistics Canada, 1992). This is a decrease of 12% from 1990 and results mainly from a deterioration in labor market conditions. Canadian work injury data revealed that the total number of lost time injuries caused by work-related strains and sprains in 1990 and 1991 were 251,106 and 228,161 respectively (Statistics Canada, 1992). Of the total number of injuries, the most frequent injuries (44%) were strains and sprains. The back was the part most frequently injured (29%), followed by the wrist, hand, or fingers (20%).

The situation is similar in Australia. In a retrospective study, Hocking (1987) gathered data from accident reports and internal surveys and described the epidemic of repetitive strain injuries in Australia. He cited the increased incidence of such injuries in Telecom, a government authority that employed nearly 90,000 telecommunications workers. Hocking reported rates of 343 cases of repetitive strain injuries per 1,000 keyboard staff members from 1981 to 1985. Other employees, including clerical workers, telegraphists, and process workers were also affected. Sixteen percent of the affected group experienced symptoms for more than 26 weeks. The overall costs of the epidemic exceeded $15 million.

The magnitude of the problem is immense. These data do not consider the emotional and psychological effect on the family of a person with a musculoskeletal injury. Additionally, the costs of lost productivity, absenteeism, poor job performance, employee turnover, poor morale, and replacement training need to be considered. These factors contribute to the costs of injury for the worker, the employer, the compensation system, the health care system, and society. As it is difficult to calulate these indirect costs, the total economic effect of occupational CTDs is probably much higher.

Etiology of Occupational CTDs

The etiology of occupational CTDs of the upper extremity is complex. The major risk factors associated with increased risk of work-related CTDs include (a) forceful exertions, (b) repetitive or prolonged activities, (c) awkward postures, (d) localized contact stresses, (e) vibration, and (f) cold temperatures (Keyserling, Armstrong, & Punnett, 1991; Sommerich, McGlothlin, & Marras, 1993).

Forceful Exertions

Forceful exertions of the upper extremities (e.g., using knives, wrenches, and other hand tools; using fingers and hands to shape or surface finish materials and parts) may cause work-related CTDs (Keyserling, Armstrong, & Punnett, 1991). The greater the force exerted, the greater the risk of developing a CTD. Pinch grips, heavy tools, poorly balanced tools, poorly maintained tools (e.g., dull knives and scissors), and a low coefficient of friction between the hand and the tool handle can increase the force requirements of manual work. Gloves may also increase the muscular effort required to perform gripping tasks because of
reduced tactile feedback, reduced friction between the hand and the object being grasped, resistance of the glove material to stretching compression, or a combination of these factors (Johnson, 1993a).

**Repetitive or Prolonged Activities**

Repetitiveness has been frequently cited as a risk factor associated with the development of occupational CTDs of the upper extremities (Keyserling et al., 1991). Jobs that require repeated motion patterns or prolonged postures within a work cycle or both may be repetitive. Silverstein et al. (1987), in a cross-sectional study, evaluated 652 workers from 39 jobs in seven different industrial sites. The jobs were categorized into the following force and repetition exposure groups: low force–low repetition, high force–high repetition, low force–high repetition, and high force–low repetition. The categorization of jobs and identification of CTDs were carried out independently by investigators who were blind to the subjects’ exposure and outcome. Videotapes and electromyography were used to estimate hand force and repetition. All subjects completed a structured interview and a standardized physical examination by examiners who were blind to the subjects’ medical history and exposure. The prevalence of carpal tunnel syndrome was 0.6% for workers in low force–low repetition jobs and 5.6% for workers in high force–high repetition jobs. The odds ratio for the development of carpal tunnel syndrome for the high force–high repetition jobs was more than 15, compared with that of the low force–low repetition group; thus those workers performing high force–high repetition job activities were 15 times more likely to sustain a CTD than workers in the low force–low repetition group. Repetition appeared to be a greater risk factor for the development of carpal tunnel syndrome than was force. Although the identification of CTDs and the categorization of jobs were evaluated by blinded observers, observer bias may have occurred as subjects may have discussed their jobs during the interview or examination. Awkward hand postures, which may be risk factors in CTDs (Feldman et al., 1985), were not controlled for. It is possible that those workers in the high force–high repetition jobs had to perform more awkward hand postures than those in the other categories. In addition, subject selection was limited to active workers, thus those away from their jobs at the time of the study (i.e., those workers with more severe cases) were eliminated.

In another cross-sectional study, Armstrong et al. (1987) evaluated the relationships among repetition, forcefulness, and CTDs of the hand and wrist in 652 workers from jobs requiring the following combinations of force and repetition: low force–low repetition, high force–high repetition, low force–high repetition, and high force–low repetition. The findings showed a highly significant association between signs and symptoms of hand and wrist tendinitis and the repetition and forcefulness of manual work. The odds ratio for the high force–high repetition group was 29.4 times greater than that of the low force–low repetition group. Because this study was a cross-sectional design, it is difficult to determine whether there was a causal relationship between high force–high repetition movement and CTDs. Confounding factors, such as mechanical factors and certain hand postures, which may be important in hand and wrist tendinitis (Armstrong, Radwin, Hansen, & Kennedy, 1986), were not controlled for.

**Awkward Postures**

Exposure to awkward postures for prolonged periods may lead to a variety of potentially disabling injuries and disorders of the musculoskeletal tissues or peripheral nerves or both (Armstrong, 1986; Johnson, 1993a). Awkward postures of the shoulder, elbow, wrist, and hand may result in occupational CTDs. Common examples of awkward posture include excessive shoulder elevation, extreme elbow postures (e.g., flexion, extension, pronation, supination), deviated wrist postures (e.g., excessive flexion, extension, radial deviation, ulnar deviation), and pinch grips (Johnson, 1993a; Sommerich, McGlothlin, & Marras, 1993). Awkward postures may be caused by poor work station layout and equipment design. The shape of hand tool handles in combination with work location and orientation may also be a factor.

**Localized Contact Stresses**

Localized mechanical stresses are caused by physical contact between body tissue and an object or tool. Contact stresses may also be considered a force (Johnson, 1993a). These stresses are associated with work activities in which a body part is in contact with a hard or sharp object (e.g., resting the forearms on a sharp, hard surface like a work bench) or in which a body part is used as a tool (e.g., using the hand as a mallet when positioning or fitting a part). Forceful gripping of tools and small diameter handles can also produce localized pressure on underlying tendons and muscles. Tools that are supported by the base of the palm may produce pressure on the median nerve and contribute to the development of carpal tunnel syndrome (Szabo & Gieberman, 1987).

**Vibration**

Vibration is a frequently reported cause of upper extremity occupational CTDs (Chatterjee, 1987; Pedersen et al., 1989; Silverstein et al., 1987). Vibration exposure may result from gripping power tools, holding the controls of a powered machine, holding parts against grinding wheels, or using percussion tools, such as hammers and chisels (Armstrong, 1992; Falkenburg & Shultz, 1993).
Vibration effects may cause the worker to use excessive force to hold the vibrating tool, and consequently, may increase the risk of CTDs (Frederick, 1992).

Brammer, Piercy, Auger, and Nohara (1987) evaluated 10 forest workers who were exposed to chain saw vibration and 7 laboratory workers who had not been exposed to chainsaw vibration to determine the tactile sensation in their hands. These workers completed a questionnaire about their present and past occupations, a medical history, and a physical examination. Although the measurements of vibrotactile perception and tactile spatial resolution revealed some evidence of vibration-induced neuropathy in the forest workers, only descriptive statistics were provided. The generalizability of the results of this study may be questionable because of the small sample size. Silverstein et al. (1987), in the abovementioned cross-sectional study of 652 active workers in 39 jobs from seven different industrial sites, showed that vibration exposure occurred in 6 of the 11 jobs in which carpal tunnel syndromes were identified on physical examination and interview. These jobs consisted of high force–high repetition activities. A major limitation of this study was that it was impossible to isolate the factor of vibration from high force and high repetition. Therefore, it is difficult to determine whether the disorder was due to vibration, repetition, force, or a combination.

**Cold Temperatures**

Cold temperatures have been suggested as another possible risk factor (Armstrong, 1992; Falkenbug & Shultz, 1993; Sheifer, Kok, Lewis, & Meese, 1984). Working in a cold environment, handling cold parts, or exposing the fingers to cold exhaust from pneumatic tools may reduce manual dexterity and tactile sensitivity. Sources of cold exposure include ambient air, work materials, and exhaust from air tools. Cooling of the highly innervated skin of the fingers to 0° to 10° centigrade has been shown to profoundly affect strength, dexterity, and sensitivity (Sheifer et al., 1984). Cold environments (about 10° centigrade) reduce an employee's hand flexibility and manual dexterity, creating the potential for muscle strains and sprains (Falkenbug & Shultz, 1993). When working in a cold environment, people with normal finger sensation usually exert slightly more force than is required to keep objects from slipping out of their hands. It has been estimated that subjects without disabilities exerted pressure of about 4 lb per square inch on the handle of a hammer; however, when their hands were anaesthetized, they responded by exerting as much as 16 lb per square inch (Armstrong, 1992). Therefore, it seems reasonable that increased force due to cold temperatures may make the job more stressful. Although gloves may be used to protect the hands and fingers from cold temperatures, they may increase the force required to perform a work task.

In summary, because the risk factors associated with occupational CTDs of the upper extremity are multifactorial, it is difficult to isolate the contributing factors. There seems to be evidence of causal relationships among repetitive, forceful, awkward work postures; localized contact stresses; cold temperatures; exposure to vibration; and work-related CTDs. Further studies are necessary to clarify the relationships among repetition, force, localized contact stresses, joint position, and hand use. Improved techniques for measuring vibration and cold temperature exposures in various jobs need to be developed. The roles of vibration and cold as causative factors in the development of CTDs could also be explored.

**Pathophysiology**

The onset of upper-extremity CTD symptoms may be gradual or sudden. Clients may complain of tenderness, pain, swelling, weakness, loss of sensation, or temperature change (Chatterjee, 1987; Louis, 1987; McDermott, 1986; Sikorski, 1988). Putz-Anderson (1988) cited tendon, nerve, and neurovascular disorders as three common classifications of work-related CTDs.

Table 1, which was developed by Kroemer (1992), lists those conditions that are frequently identified with CTD. This table summarizes the CTD by location and description and outlines the typical job activities carried out by persons with the disorders.

Tendinitis, tenosynovitis, de Quervain’s disease, golfer’s elbow, and rotator cuff pain or strain are some commonly reported tendon disorders related to CTDs (Chatterjee, 1987; Dimberg et al., 1989; Kroemer, 1992; Pedersen et al., 1989). Typical examples of tendon disorders may occur at the flexor retinaculum, extensor retinaculum of the wrist, or both. The extensor retinaculum is a synovial lined structure with six separate dorsal compartments that enclose the wrist, thumb, and digital extensors. On the volar aspect, nine flexor tendons pass through the carpal canal (Siebenaler & McGovern, 1992; Stern, 1990). It is in this area that tendinitis, or inflammation of tendons and muscle attachments, may occur. As a result of isometric loading during repetitive activities, tissue ischemia and accumulation of metabolites that lead to an inflammatory process may occur (Chatterjee, 1987).

Nerve disorders and other compressive neuropathies may be exhibited as symptoms of pain, numbness, or tingling. Swelling of the tendon sheaths may also cause pressure on the median nerve (Carragee & Hentz, 1988; Herrick & Herrick, 1987). A common example of nerve compression at the wrist is carpal tunnel syndrome. Because the space in the tunnel is limited, any enlargement of the tendons will exert pressure on the median nerve. This may cause sensory symptoms such as pain and burning in the wrist, frequently radiating to the fingers and forearm. In addition, there is usually numbness or tingling in the median nerve distribution of the hand (Sieb-
<table>
<thead>
<tr>
<th>Disorder Name*</th>
<th>Description</th>
<th>Typical Job Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpal tunnel syndrome (writer’s cramp, neuritis, median neuritis) (N)</td>
<td>The result of compression of the median nerve in the carpal tunnel of the wrist. This tunnel is an opening under the carpal ligament on the palmar side of the carpal bones. Through this tunnel pass the median nerve, the finger flexor tendons, and blood vessels. Swelling of the tendon sheaths reduces the size of the opening of the tunnel and pinches the median nerve and possibly blood vessels. The tunnel opening is also reduced if the wrist is flexed or extended, or ulnarily or radially pivoted.</td>
<td>Buffing, grinding, polishing, sanding, assembly work, typing, keying, cashiering, playing musical instruments, surgery, boxing, housekeeping, cooking, butchering, hand washing, scrubbing, hammering</td>
</tr>
<tr>
<td>Cubital tunnel syndrome (N)</td>
<td>Compression of the ulnar nerve below the notch of the elbow. Tingling, numbness, or pain radiating into ring or little fingers.</td>
<td>Resting forearm near elbow on a hard surface and/or sharp edge, also when reaching over obstruction</td>
</tr>
<tr>
<td>de Quervain’s syndrome (or disease) (T)</td>
<td>A special case of tendosynovitis that occurs in the abductor and extensor tendons of the thumb where they share a common sheath. This condition often results from combined forceful gripping and hand twisting, like in wringing clothes.</td>
<td>Buffing, grinding, polishing, sanding, pushing, pressing, sawing, cutting, surgery, butchering, use of pliers, “turning” control such as on a motorcycle, inserting screws in holes, forceful hand wringing</td>
</tr>
<tr>
<td>Epicondylitis (“tennis elbow”) (T)</td>
<td>Tendons attaching to the epicondyle (the lateral protrusion of the humerus bone) become irritated. This condition is often the result of impacting or jerky throwing motions, repeated supination and pronation of the forearm, and forceful wrist extension movements. The condition is well known among tennis players, pitchers, bowlers, and people hammering. A similar irritation of the tendon attachments on the inside of the elbow is called medical epicondylitis, also known as “golfer’s elbow.”</td>
<td>Turning screws, small parts assembly, hammering, meat cutting, playing musical instruments, playing tennis, pitching, bowling</td>
</tr>
<tr>
<td>Ganglion (T)</td>
<td>A tendon sheath swelling that is filled with synovial fluid, or a cystic tumor at the tendon sheath, or a joint membrane. The affected area swells up and causes a bump under the skin, often on the dorsal or radial side of the wrist. (Because it was in the past occasionally smashed by striking with a Bible or heavy book, it was also called a “Bible Bump.”)</td>
<td>Buffing, grinding, polishing, sanding, pushing, pressing, sawing, cutting, playing musical instruments, playing tennis, pitching, bowling</td>
</tr>
<tr>
<td>Neck tension syndrome (M)</td>
<td>An irritation of the levator scapulae and trapezius group of muscles of the neck, commonly occurring after repeated or sustained overhead work.</td>
<td>Belt conveyor assembly, typing, keying, small parts assembly, packing, load carrying in hand or on shoulder</td>
</tr>
<tr>
<td>Pronator (teres) syndrome (N)</td>
<td>Result of compression of the median nerve in the distal third of the forearm, often where it passes through the two heads of the pronator teres muscles in the forearm; common with strenuous flexion of elbow and wrist.</td>
<td>Soldering, buffing, grinding, polishing, sanding</td>
</tr>
<tr>
<td>Shoulder tendinitis (rotator cuff syndrome or tendinitis, suprascapular tendinitis, subacromial bursitis, subdeltoid bursitis, partial tear of the rotator cuff) (T)</td>
<td>This is a shoulder disorder at the rotator cuff. The cuff consists of four tendons that fuse over the shoulder joint where they pronate and supinate the arm and help to abduct it. The rotator cuff tendons must pass through a small bony passage between the humerus and the acromion, with a bursa as cushion.</td>
<td>Soldering, buffing, grinding, polishing, sanding</td>
</tr>
<tr>
<td>Tendonitis (tenosynovitis) (T)</td>
<td>An inflammation of a tendon. Often associated with repeated tension, motion, bending, being in contact with a hard surface, vibration. The tendon becomes thickened, bumpy, and irregular in its surface. Tendon fibers may be frayed or torn apart. In tendons without sheaths, such as within the elbow and shoulder, the injured area may calcify.</td>
<td>Punch press operator, assembly work, wireing, packaging, core making, use of pliers</td>
</tr>
<tr>
<td>Tendosynovitis (tenosynovitis, tendovaginitis) (T)</td>
<td>This disorder occurs to tendons that are inside synovial sheaths. The sheath swells. Consequently, movement of the tendon within the sheath is impeded and painful. The tendon surfaces can become irritated, rough, and bumpy. If the inflamed sheath presses progressively onto the tendon, the condition is called stenosing tendosynovitis. De Quervain’s syndrome is a special case occurring in the thumb; the trigger finger condition occurs in fingers of the fingers.</td>
<td>Buffing, grinding, polishing, sanding, punch press operation, sawing, cutting, surgery, butchering, use of pliers, “turning” control such as on a motorcycle, inserting screws in holes, forceful hand wringing</td>
</tr>
<tr>
<td>Thoracic outlet syndrome (neurovascular compression syndrome, cervicothoracic disorder, brachial plexus neuritis, costoclavicular syndrome, hyperabduction syndrome) (N)</td>
<td>A disorder resulting from compression of nerves and blood vessels between clavicle and first and second ribs at the brachial plexus. If this neurovascular bundle is compressed by the pectoralis minor muscle, blood flow to and from the arm is reduced. This ischemic condition makes the arm numb and limits muscular activities.</td>
<td>Buffing, grinding, polishing, sanding, overhead assembly, overhead welding, overhead painting, overhead auto repair, typing, keying, cashiering, wiring, playing musical instruments, surgery, truck driving, stacking, material handling, postal letter carrying, carrying heavy loads with extended arms</td>
</tr>
</tbody>
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Table 1 (cont'd.)
Common Repetitive Strain Injuries, Primarily to Nerves (N), Tendons and Tendon Sheaths (T), Muscles (M), or Blood Vessels (V)

<table>
<thead>
<tr>
<th>Disorder Name*</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Trigger finger or thumb (T)</td>
<td>A special case of tendosynovitis where the tendon becomes nearly locked, so that its forced movement is not smooth but in a snapping, jerking manner. This is a special case of stenosing tendosynovitis crepitans, a condition usually found with digital flexors at the A1 ligament.</td>
<td>Operating finger trigger, using hand tools that have sharp edges pressing into the tissue or whose handles are too far apart for the user's hand so that the end segments of the fingers are flexed while the middle segments are straight.</td>
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<tr>
<td>Ulnar nerve entrapment (Guyon tunnel syndrome) (N)</td>
<td>Results from the entrapment of the ulnar nerve as it passes through the Guyon tunnel in the wrist. It can occur from prolonged flexion and extension of the wrist and repeated pressure on the hypothenar eminence of the palm.</td>
<td>Playing musical instruments, carpentering, bricklaying, use of pliers, soldering, hammering.</td>
</tr>
<tr>
<td>White finger (&quot;dead finger,&quot; Raynaud's syndrome, vibrations syndrome) (V)</td>
<td>Stems from insufficient blood supply bringing about noticeable blanching (finger turns cold, numb, and tingles); sensation and control of finger movement may be lost. The condition is due to closure of the digit's arteries caused by vasospasms triggered by vibrations. A common cause is continued forceful gripping of vibrating tools, particularly in a cold environment.</td>
<td>Chain sawing, jack hammering, use of vibrating tool, sanding, paint scraping, using tool too small for the hand, often in a cold environment.</td>
</tr>
<tr>
<td>Ulnar artery aneurysm</td>
<td>Weakening of a section of the ulnar artery as it passes through the Guyon tunnel in the wrist; often from pounding or pushing with heel of the hand. The resulting &quot;bubble&quot; presses on the ulnar nerve in the Guyon tunnel.</td>
<td>Assembly work.</td>
</tr>
</tbody>
</table>

* N = nerve, T = tendon, M = muscle, V = vessel disorders.

Reprinted with permission from K. H. E. Kroemer (1992); medications (analgesics or nonsteroidal anti-inflammatory drugs or both) (Hadler, 1992; Louis, 1987; Stern, 1990); conservative therapy, such as exercises, splinting, cryotherapy, thermotherapy, transcutaneous electrical nerve stimulation, and ultrasound (Johnson, 1993b; Puffer & Zachazewski, 1988; Sikorski, 1988); ergonomic modifications of workplace tools, equipment, and work stations (Feuerstein et al., 1993; Flinn-Wagner et al., 1990; Fraser, 1991; Higgs et al., 1992; Kroemer, 1992); work-hardening and conditioning programs (Bettencourt, 1990; Feuerstein et al., 1993; Niemeyer & Jacobs, 1989); cognitive-behavioral therapy (Siebenaler & McGovern, 1992; Spence, 1991); and client-worker education programs (Aia, 1991; Corlett, 1991; Dortch & Trombly, 1990; Feuerstein et al., 1993; Siebenaler & McGovern, 1992; Sluchak, 1992).

Another common CTD of the upper extremity is thoracic outlet syndrome. This disorder is a general term for the compression of the neurovascular component of the brachial plexus (Chatterjee, 1987). The effect of repetitive motion exerting pressure on thoracic blood vessels can cause ischemia. This deprivation of oxygen to forearm and hand muscles, coupled with the fact that the tendons in the shoulder and elbow do not have sheaths, tends to result in tenderness (and sometimes swelling) in the area of the tendon and restricted movement of the affected joints (Frederick, 1992; Putz-Anderson, 1988).

Management

The management of occupational CTDs of the upper extremity may vary from surgical procedures (Hales & Bertsche, 1992); medications (analgesics or nonsteroidal anti-inflammatory drugs or both) (Hadler, 1992; Louis, 1987; Stern, 1990); conservative therapy, such as exercises, splinting, cryotherapy, thermotherapy, transcutaneous electrical nerve stimulation, and ultrasound (Johnson, 1993b; Puffer & Zachazewski, 1988; Sikorski, 1988); ergonomic modifications of workplace tools, equipment, and work stations (Feuerstein et al., 1993; Flinn-Wagner et al., 1990; Fraser, 1991; Higgs et al., 1992; Kroemer, 1992); work-hardening and conditioning programs (Bettencourt, 1990; Feuerstein et al., 1993; Niemeyer & Jacobs, 1989); cognitive-behavioral therapy (Siebenaler & McGovern, 1992; Spence, 1991); and client-worker education programs (Aia, 1991; Corlett, 1991; Dortch & Trombly, 1990; Feuerstein et al., 1993; Siebenaler & McGovern, 1992; Sluchak, 1992).

Ergonomics and human factors in the workplace are gaining increasing importance in the management of CTDs of the upper extremity (Hadler, 1992; Higgs et al., 1992; Siebenaler & McGovern, 1992). Sluchak (1992) defined ergonomics as "the study of human, behavioral, and biological characteristics for the appropriate design of the living and working environment" (p. 105). The emphasis in ergonomics is not only on dealing with the CTD once it has occurred, but also on prevention (Kroemer, 1992). Several authors have stressed that ergonomics is not just fitting the job to the worker (e.g., changing the layout or height of the work station) but also examining how the job is done, the activities involved, and the employer's role (Kroemer, 1992; Siebenaler & McGovern, 1992; Travers, 1992). Inherent in the ergonomic process is the importance of communicating the facts related to the specific issues surrounding the CTD problem, whether it be biomechanical factors or work design details (Dortch & Trombly, 1990; Frederick, 1992; Sluchak, 1992; Stubbs & Buckle, 1991).

Education programs are being increasingly used as a treatment and prevention strategy for workers with CTDs of the upper extremity (Hadler, 1992; Higgs et al., 1992; Siebenaler & McGovern, 1992). Training and employee participation sessions are terms often used synonymous with education when referring to programs in industry (Corlett, 1991; Halcs & Bertsche, 1992). There also has been increased recognition of the importance of manager involvement and worker participation through education.
programs in making the workplace healthier and safer (Corlett, 1991; Hales & Bertsche, 1992). Three levels of preventative strategies in the natural history of work-related CTDs of the upper extremity can be applied to the prevention of this disorder. These levels are primary prevention (preventing the development of CTDs), secondary prevention (preventing the development of impairment through early detection and intervention), and tertiary prevention (preventing recurrence) (Siebenaler & McGovern, 1992).

The health education literature has shifted from a compliance-related focus, in which the client complies with the health professional's prescription (Mazzuca, 1982), to a self-management focus, in which the client uses the health professional as a resource and complies only if he or she understands the regime and agrees with it (Gilroth, 1990; Lawrence & McLeor, 1986). The emphasis is on educating clients to take control of their own health (Feuerstein et al., 1993; Glanz, Marcus Lewis, & Rimer, 1990; Graff-Radford, Reeves, & Jaeger, 1987). Herbert (1989) advocated a comprehensive education program that emphasized several educational sessions with employees, supervisors, and managers. Participants learned not only about the anatomy and physiology of the upper extremity, but also about how to work smart through proper positioning techniques during work tasks and exercises that did not put the affected area at risk. For instance, if a worker had tendinitis of the wrist, he or she was encouraged to keep the wrist in line with the forearm during work activities and was instructed to avoid frequent motions of the fingers, wrists, forearms, and shoulders. Unfortunately, Herbert did not provide any evidence to support the positive outcomes of these programs.

Corlett (1991) described a program undertaken at a textile company in the United Kingdom that employed 38,000 workers. The company had identified an increase in the incidence of CTDs of the upper extremity. Personnel from safety and industrial engineering worked closely with experts from the Institute of Occupational Ergonomics at the University of Nottingham, United Kingdom. The major thrust of this project was not only to educate management but also to train company personnel. A 1-day course was designed for management to review the issue of CTDs of the upper limb and their prevention. A 2-day course on ergonomics was held with the company's industrial engineers that focused on what kind of education would be needed for union personnel and the work force at the textile company. Within 5 months, more than a quarter of the entire work force had been involved in the presentations and had received information related to CTD. The survey team collected epidemiological data (e.g., sick time, absences, severity, body part discomfort), data from managers (e.g., plant working conditions, overtime), and data from employees (e.g., attitudes toward work, cooperation). Anthropomorphic data (e.g., height and weight of workers), photographs and videos of work tasks, posture, force, and movement also were obtained. As a result of the study, hazardous areas were identified and discussed with the plant administrators and industrial engineers, and action plans were drawn up. Throughout the review process, Corlett emphasized the importance of "close management control" (p. 184), which was achieved through education and training. Although Corlett did not include statistical data supporting the positive effect of this approach, he stressed the importance of a comprehensive education and training program as an essential component of initiating preventative change with regard to CTDs within an industrial setting.

Dorch and Trombly (1990) evaluated the effects of two education programs on hand use patterns of 18 electronic assembly workers who performed repetitive jobs and were at high risk for developing CTDs. The goals of the educational program were aimed at decreasing the incidence of CTDs by changing the way people used their hands while they worked. Subjects were randomized into three groups. Group 1 received a handout that described the potential risks of performing highly repetitive movements with their hands and wrists. Simple anatomy and physiology of the wrist and hand and the causative factors of CTDs relating to improper hand use were discussed. Each subject in Group 1 was left with the responsibility of reading the handout and practicing its concepts. Group 2 also received the handout plus a hands-on demonstration of the concepts in the handout. These subjects also engaged in a simulated performance of their job. Individual instruction was given to each subject and the entire group observed each subject's lesson. Group 3 (the control group) did not receive any treatment. Pretests and posttests of the frequency of movements identified with CTDs of the hand and wrist during work were recorded for all subjects. The findings showed that both educational programs were significantly effective in reducing the number of at-risk repetitive movements performed by workers tested 1 week after receiving the education. Although the methodology and the measures were well described, the sample size may be too small to draw any conclusions. Furthermore, because this study only examined the short-term effects of an educational program, it would be beneficial to determine whether workers permanently changed their hand use habits to less harmful patterns as a result of educational programs and whether the change of hand use pattern was associated with a decreased incidence of CTDs.

Feuerstein et al. (1993) explored the long-term impact of a multicomponent rehabilitation program that included physical conditioning, work conditioning and simulation, ergonomic consultation, physical conditioning, pain and stress management, and vocational counseling and placement among 34 workers with chronic CTDs of the upper extremities. The control group consisted of 15 clients who received usual care. 19 clients participated...
in the multidisciplinary rehabilitation program. Clients in
the usual care group received physical therapy modalities,
therapeutic exercise, hand therapy, chiropractic treatment,
rehabilitation counseling, pain treatment, or a combination.
Seventeen months after treatment, 74% of the
treatment group were working full time, in contrast
to 50% of the control group. Unfortunately, the control
group consisted of cases that were considered inappro-
appropriate for the program because of insurance carrier denial
or client refusal. This selection criteria might have con-
tributed to the poorer outcome in this group, as it may be
argued that members of the usual care group might have
been less motivated to return to work than members of
the group who were offered and accepted the rehabilita-
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