The workplace athlete

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ABSTRACT: *Repetitive strain injury is rapidly becoming a problem of epidemic proportions in today's high technology workplace. It can take many forms and require a variety of different treatments. However, it is only with a combined, multidisciplinary approach that this problem can be prevented and tackled.*

Thinking of an athlete, one imagines an individual in a brightly colored, numbered uniform; running, throwing, catching, jumping, or performing other feats of strength, speed, and/or artistic finesse, usually before

Table 1. Disorders of muscle, tendons, and bone associated with repetitive strain injury

- myalgia
- myofacial pain syndrome
- tendinitis
- tendinosis
- peritendinitis
- tenosynovitis
- trigger fingers
- impingement syndrome
- tennis elbow
- golfers elbow
- stress fractures
- periostitis (shin splints)

crowds of delighted spectators. From a physiologic point of view, however, athletes are simply those who are able in a coordinated manner to marshal their musculotendinous systems to perform with a high degree of proficiency and accuracy for extended periods of time. Although many of the neuromuscular connections are governed by genetics to achieve a high level of performance, a long training period is mandatory. However, performance or training can be interrupted or curtailed by injury. An acute injury results from trauma that disrupts bone, nerve, tendon, or muscle. Such injuries typically have a definitive onset and respond to treatment in a set pattern. Injuries can, however, also be caused by over training or overuse; when that happens, injury presentation and treatment is far less defined.

The same kind of injuries that are sustained by "sport athletes" can also be incurred by a different kind of athlete—the workplace athlete. Society and the media have a great deal of awe and admiration for athletes such as Cal Ripken, Jr., who can play in more than 2,000 baseball games without taking a break. Far less attention is paid to the millions of Americans who go to work each day and perform the same highly repetitive tasks for years at a time. For example, a data entry typist working at a speed of 60 words per minute will hit the keys of the computer more than 100,000 times in a six-hour period, and an assembly line worker may repeat the same task 25,000 times per day.[1] For all these workers, each exertion requires a specific movement of the upper or lower extremity, usually with static contractions of the rest of the body. Over time, the amount of physical effort required to accomplish such seemingly mundane tasks is extraordinary. With millions of Americans at computer keyboards each day, it is not surprising that the terms repetitive strain injury (RSI), cumulative trauma disorder (CTD), and overuse syndrome have come into media focus and attention.

Repetitive strain injuries are disruptions of muscle, tendon, bone, or nervous system precipitated or exacerbated by repeated exertions, body movements, or sustained postures. The disruptions are on a microscopic level, but when allowed to progress, they may assume gross macroscopic characteristics. During the past 15 years, RSIs have become an umbrella concept that encompasses many different diagnoses (**Tables 1 and 2**).

Patients with upper extremity RSIs typically present with pain, usually in the neck, shoulder, arm, or hand; fatigue, either generalized or localized; and weakness, numbness or tingling, loss of dexterity, and depression with concomitant loss of sleep. Many patients relate this to the duration and intensity of their work. Symptom development may take weeks, months, or years, and patients commonly cannot pinpoint a specific time of onset. Symptoms may be poorly localized, nonspecific, and episodic, and the causes may be multifactorial. Patients initially may appear to be suffering from simple fatigue. The difference between simple fatigue and RSI, however, is believed to be related to the duration and intensity of symptoms.[2] Fatigue can occur after a work shift and is short-lived, and recovery usually takes place before the next shift.[3] With RSI, recovery between work shifts does not occur and patients may begin their day or week with pain.

Epidemiology

The fundamental question is why so much attention is being paid to RSIs now, when workers have been toiling on assembly lines for nearly 100 years. The answer has to do with the dramatic rise in the reporting of such injuries, which has resulted in skyrocketing health care costs in dealing with these patients. The Bureau of Labor Statistics reported in 1993 that in private industry alone there were 300,000 illness claims for repetitive strain, which represents a 1300% increase since 1982, when just 22,600 cases were reported.[4] It is now estimated that at least $20 billion is spent each year on workers' compensation claims for RSIs of the neck and upper extremity. Taken together, these now represent more than 50% of all occupational injuries.[5] In 1994, the total cost of treatment nationwide for carpal tunnel syndrome alone exceeded $3.5 billion; the average carpal tunnel case cost approximately $27,000 when one includes the medical and legal costs, as well as intangible costs such as lost productivity.[6]

Large epidemiologic studies of the presentation of cumulative trauma disorders indicate a wide variety of workers have been reported as "high risk" for these conditions, including meat packers, cashiers, data entry clerks, musicians, construction workers, electricians, cake decorators, postal workers, assembly workers, garment workers, glass cutters, punch press operators, automobile workers, light bulb manufacturers, and many others. The Occupational Safety and Health Administration (OSHA) estimates that by the year 2,000, fifty cents of every dollar spent on medical costs for workers will be for treating cumulative trauma disorders unless business and industry are willing to meet ergonomic needs in the workplace.[7]

The problem of cumulative trauma disorders is exacerbated by the fact that research in this area is still in its infancy and treatment for these problems by the medical community is haphazard at best, highly invasive, and largely unsuccessful despite our best efforts and intentions. For example, Hadler[8] found vast discrepancies in various parts of the country in the cost of treatment and its degree of invasiveness in patients with the same diagnosis.

There are many theories about the rise of RSIs in this country, some scientific, some cynical. The use of video display terminals (VDTs) in the workplace has risen dramatically during the past ten years. The Census Bureau's figure on domestic personal computer sales and use in the workplace shows an increase from $1.42 billion in 1981 to $15.18 billion in 1987 to approximately $50 billion in 1993. More than 85% of people in offices today use computers in some fashion.[3] With increased pressure to produce more in less time, many tasks have been reduced to their simplest components, and individual workers may have to perform fewer tasks at ever increasing rates. Thus, tasks are less varied and more repetitive. The computer has also increased efficiency in employee monitoring, and workers are thus less able to take necessary breaks.

Many people ask why cumulative trauma disorders did not appear with the use of typewriters. The answer is that many more steps are required to use a typewriter than to operate a computer. Manual typewriters required turning the carriage and pushing a return lever. Even electric typewriters required the user to feed in each sheet of paper and the fingers moved much slower than on a computer keyboard. It is therefore the increased use of the computer that may be the fundamental cause of the problem. Scientific studies have shown that people who use computers for more than four hours at a time are at approximately three times the risk of developing shoulder, arm, or hand disorders.[9] The odds are significantly higher for shoulder- and hand-related musculo- skeletal disorders among supermarket cashiers. Keyboard operators have three times the rate of tension neck syndrome compared to other workers.[5]

Physiology

To understand strategies for dealing with RSI, it is necessary to understand the physiology of this condition and its effects on muscles, tendons, and nerves. While keyboarding, the small muscles of the hands and forearms are constantly moving and contracting in a dynamic fashion, while the muscles at the wrist, elbow, shoulder, and neck are in static contraction to support the moving articulating elements. Prolonged static contraction may increase intramuscular pressure and diminish blood flow. Although static loading of the trapezius reaches only 20% to 30% of maximal contractions, contractions performed over a long enough period of time can result in fatigue.[10] Micro tears eventually occur in the muscle tissue, causing low-grade incomplete inflammatory states. With continued use, continued injury results with chronic pain. In computer users, the tendons of the wrist and fingers are subjected to traction and shearing forces that are related to the degree of muscle contraction, the velocity of tendon movement, the friction between the tendon and adjacent surfaces, and compressive stresses related to contact between tendons and overlying retinacular tissues.[11] Goldstein[10] found that after 500 work wrist cycles, at submaximal exertions and light work activities, the elastic strain on a tendon was equivalent to what would be accomplished by an 80% increase in load. Thus, the tendons begin to fibrillate and shred. There is fibrous thickening of tendon sheaths and tenosynovium and an attempt at

Table 2. Nerve syndromes associated with repetitive strain injury

Syndrome	Affected nerve
• carpal tunnel syndrome	median nerve at wrist
• ulnar tunnel syndrome	ulnar nerve at wrist
• pronator syndrome	median nerve at elbow
• cubital tunnel syndrome	ulnar nerve at elbow
• radial tunnel syndrome	radial nerve in forearm
• anterior interosseus syndrome	motor median nerve in forearm
• posterior interosseus syndrome	posterior interosseus in forearm
• thoracic outlet syndrome	brachial plexus
• vibration hand syndrome	diffuse neuropathy, vasculitis

repair with an aborted inflammatory reaction in the tendons themselves. Blood flow to these tendons is reduced, with fatty degeneration of the tendon tissues. The body is unable to respond with a vigorous inflammatory reaction because there has been no acute injury. With repeated trauma, the tendons continue to deteriorate.[12] The typical stigmata of the "tendon inflammation" as seen in an acute setting frequently are completely absent.

Compressive neuropathy

Nerves that run with tendons in tight fibrous compartments may be affected by repeated micro trauma. Carpal tunnel syndrome forms an interesting model to study for two reasons: it is the most common RSI reported, and it has many of the characteristics of RSI.

The carpal tunnel is a restricted space at the junction of the wrist and hand on the palmar side. The space is bounded on three sides by the carpal bone and on the top by the transverse carpal ligament. Through this space run the median nerve and nine flexor tendons that piston back and forth and power the fingers and the thumb. Filling the space is an investing tenosynovium that surrounds the tendon and the median nerve. This tenosynovium usually is thin and filmy and allows differential gliding of these structures with minimal shear forces, between the median nerve and the tendons. In general, the tendons may move up to 7 cm and the median nerve moves between 10 and 14 mm with extremes of finger flexion and extension.[13] There is normally a pressure differential in the carpal tunnel of 3 mm Hg with the wrist in neutral and 30 mm Hg with wrist extension and flexion.[14] It is believed that repetitive wrist or hand movements can cause prolonged elevated pressure inside the carpal canal. Armstrong[15] described synovial membrane hyperplasia, arteriole and venous hypertrophy with increased epineural density, and increased relative friction between nerve and tendon. This has been shown to occur in the hands held in a fixed position over a prolonged period with repeated wrist or finger flexion. Highly repetitive wrist or finger movement with repeated flexion or hyperextension of the wrist, prolonged strenuous use of the hands with pinching or grasping, wrist ulnar deviation and flexion, wrist extension with forceful pinch, and prolonged exposure to vibration, may result in frictional damage to tendon sheaths with the previously described cellular changes. This may result in pressure of more than 110 mm Hg with hyperextension and resting pressures as high as 35 mm Hg.[14] This has the effect of compressing the nerve in the carpal canal, reducing venous outflow, and causing a miniature compartment syndrome in the median nerve.[16] In addition, there is a marked diminution in the ability of the median nerve to slide normally. Thus, with further movement of the hand and wrist, traction damage to the median nerve results and nerve capacity to accommodate limb movement is reduced. Eventually, shearing occurs in the myelin sheath around the median nerve bundles with displacement and telescoping of myelin away from the center of compression due to these shear forces. This too will interfere with nerve conduction and cause typical complaints of localized pain, numbness, tingling in the distribution at the median nerve (i.e., thumb, index and middle fingers), palm pain, and loss of dexterity. If left untreated, loss of median nerve function will result in permanent dysfunction in the hand.

Carpal tunnel syndrome has been reported to occur more commonly in woman and in those who have more frequent pinching activity with more pinch force or greater extremes of extended or flexed wrist position.[17] Factors reported to be involved in the development of carpal tunnel syndrome include increased forced repetitiveness, sustained abnormal postures, prolonged exposure to vibration, mechanical stress concentration, and prolonged exposure to cold with improperly fitting gloves.[2] Causes for carpal tunnel syndrome that are not occupationally related include rheumatic conditions, diabetes, osteoarthritis, old collies fractures, renal disease, or gout.[18] These factors also must be taken into account when evaluating these patients.

Clinical evaluation

This first step in developing a treatment plan is deciding whether the problem is indeed a manifestation of cumulative trauma or is due to other underlying pathology such as an autoimmune or metabolic disease that affects nerves, tendons, and muscle. It may be difficult to identify the connective tissue involved because often several systems are involved. Most importantly, the clinician must decide if the disorder is work-related or simply work-aggravated. Although some RSIs are highly localized with straightforward methods of treatment, other conditions are very complex. A detailed medical history helps identify possible work-related risk factors (several forms are available to facilitate history taking for these patients). It is necessary to ascertain whether the risk factors have sufficient duration to cause or aggravate the problem and to find an association between the workplace and the onset of the symptoms. It may be impossible to tell whether the patient was truly asymptomatic before beginning the current position.

In some cases, patients have learned the presenting manifestations of RSI and may be using their knowledge for secondary gain. It is necessary to obtain a detailed employ-

ment history to get a sense of the social dynamics at the workplace. It may take several visits to uncover that information because if the problem is diagnosed as resulting from the performance of work-related tasks, the employee is often entitled to workers' compensation benefits.

Employees in a stressful or boring work environment may seek medical attention with an unstated goal of being transferred to another position, being removed from work, or being guaranteed continued medical insurance coverage. Many evaluating physicians are being employed by the workers' companies or by the workers' compensation insurance company. Thus evaluation becomes less objective. Discussing carpal tunnel syndrome will illustrate typical management techniques of RSI and illustrate its pitfalls.

Patients usually present with pain, numbness, and tingling in the thumb and index and middle fingers. Symptoms are frequently worse at night, there may be loss of dexterity, and the patient may complain of being unable to "feel the work" (e.g., computer keys or fine electronic components). Symptoms progress over time and may radiate up the upper arm, which confounds the diagnosis because they could be due to cervical root compression caused by a herniated disc or brachial plexus compression in thoracic outlet. If left untreated, patients frequently begin to complain of injury to their fingers such as burns they do not feel or atrophy of the muscles about the thumb. It may become impossible to abduct the thumb. Symptoms are believed to be caused by work that involves intense repetitive movements of the fingers with the wrist positioned in flexion or extension. Conservative management includes the use of splints, nonsteroidal antiinflammatory drugs, a wrist rest, vitamin B_6, diuretics, and injections of steroids directly into the carpal tunnel. Failing these modes of conservative treatment, a surgical release is recommended. In many cases, the carpal tunnel release alleviates the symptoms, but in approximately 25% residual pain occurs around the base of the incision. This "pillar pain" in the proximal palm can be disabling. Grip strength may also be impaired for many months. When these patients return to work, their symptoms frequently recur.

In a typical case, an employee (who may be asymptomatic) visits the company nurse and asks for ergonomic interventions at the workstation. The nurse may provide an "ergonomic" keyboard or a wrist rest, which may create symptoms because they are used incorrectly. The nurse then refers the patient to the company physician, who advises the worker to take some time off, wear a wrist splint at night, and take antiinflammatory medication. When the employee returns to work, the symptoms also return. The employee is then referred to a specialist. Additional conservative treatment follows. Failing this, electrodiagnostic tests, electromyography, and nerve conduction studies are ordered, which may or may not show the presence of carpal tunnel syndrome (these tests are approximately 85% sensitive and specific). All too frequently, the patient ends up in the operating room. There is initial symptom relief, and the patient returns to light duty, then regular work, and the symptoms recur. The patient is viewed as a high risk workers' compensation case and is eventually laid off. If the workers' compensation claim is denied, an attorney becomes involved and there is a court hearing. A rehabilitation nurse for the insurance carrier steps in for a permanent disability evaluation and a second medical opinion is sought for a permanent disability payoff, which may take many years. The process literally consumes the patient's life; there is a loss of self-esteem and income, causing home strife and depression. Patients see themselves as unemployable and end up as the taxpayers' burden. This scenario, which is played out ten of thousands of times across the United States on a yearly basis, reflects the haphazard and reactive way that cumulative trauma disorders and particularly carpal tunnel syndrome are treated in this country.

The response of the "system"

Because the system was designed to deal with acute injuries, employers and workers' compensation carriers have great difficulty in dealing with workers suffering from RSI. An acute injury has a definite time of onset, an identifiable cause, a clear-cut plan for treatment with specific treatment guidelines, and a clearly defined time when the worker should be able to return to the job. An RSI has none of these clearly defined conditions. Patients frequently cannot determine a definite date of onset, symptoms vary, and workers often have signs of depression. The perception of malingering and secondary gain pervades. Many employers will claim the employee is functioning poorly in general and will search for reasons to lay the employee off. Treatment frequently is protracted and there is no clear-cut time for return to work. In many cases, employers are unwilling to make accommodations and will not allow return to work until the employee is "100%." Unions often get involved, OSHA investigates, litigation follows, and the cost of treatment escalates.

In general, the risk factors for cumulative trauma include abnormal postures, mechanical and physical stresses, repetitiveness, and forcefulness.[12] Ergonomic interventions in the

workplace can lesson risk factors that lead to RSIs; however, a complete discussion of ergonomics is beyond the scope of this review. Pertinent principles will be presented to illustrate the basic concepts. Studies have shown that working in nonneutral postures leads to musculoskeletal disorders. Kilbom[19] concluded that teaching neutral work postures and movements should be given high priority. For example, correct posture for workers using a video display terminal (VDT) include resting the feet flat on the floor or on a foot rest; keeping the knees level and slightly lower than the hips; and maintaining the shoulders in neutral, the elbows in 100 degrees of extension, and the wrists in neutral. The correct height of the keyboard is at the level of the umbilicus. Placement of the keyboard at this level can prevent neck strain, strain on the trapezius muscle, and any increased pressure on the ulnar nerve at the elbow. Caution must be exercised when using a wrist rest as its use may artificially raise the head, increasing neck strain.[20] If the worker's chairs too high or too low, the result may be upper arm abduction or shoulder elevation that can lead to cervical brachial strain and rotator cuff problems.[21] The VDT should be positioned so that the head is tilted downward approximately 10 degrees, and the eyes should be 20 to 26 inches from the screen. Any hard copy work should be elevated to the level of the screen with a document holder to prevent downward flexion of the neck. Employees should be taught to touch type and to avoid looking down at the keyboard.

The back should be well supported and allowed to extend backward from the vertical by approximately 10 degrees. The chair should be easily adjustable and movable with functioning casters. The forearms should rest on a padded surface. Sharp table edges may cause nerve compression; thus, rounding out edges, installing pads or cushions, or using soft elbow supports may be helpful. When using the telephone and keyboard simultaneously, a telephone headset may prevent chronic side-to-side neck bending and neck strain. Excessive force while keyboarding may cause injury; thus, a light keyboard touch may significantly increase worker speed and at the same time "lighten the load."

Managing repetitive strain injuries

To win the battle against RSIs, a global, coordinated, multidisciplinary approach is mandatory. Treatment may require weeks, months. or years to rehabilitate fully. It involves workers and management working with occupational physicians, ergonomic engineers, industrial psychologists, and employee team coordinators. The approach should include surveillance and intervention with preemployment screening, workstation modifications, job rotation, enforced rest periods, work habit modification, and a fitness and exercise program. Employers need to become knowledgeable about ergonomics and employees need to be trained to modify their workstations and practice neutral postures. There needs to be a closer working relationship between industry and medicine. Such a relationship could facilitate preemployment testing of prospective workers and help determine the ability of individual workers to perform specific tasks. Once employment begins, there are various methods available for assessing the risk of developing repetitive strain and monitoring these risks.[22]

Worker education

Training employees about risk factors associated with repetitive strain and measures needed to combat them allows workers to design their own optimal work environment. Development and instruction on specific guidelines, which should be monitored by management, and continuing education need to take place in the actual workplace. Team leaders from the working group can assist, monitor, and augment the ergonomic measures that have been implemented and stress the necessity of workers' taking regular stretching breaks. The education of managers and supervisors assures that there is continued management support to provide meaningful alternatives to work and job restrictions in the company. The ideal ergonomic team comprises management, company safety officers, team leaders, professional ergonomists, and even medical practitioners to coordinate all ergonomic interventions.[23]

Employee exercise program

Studies have shown that RSIs occur more frequently in people who do not follow a regular exercise program. Studying computer workplace design and fatigue, Tadano[24] suggested that mini exercise breaks throughout the work day not only diminish the incidence of repetitive strain, but actually increase worker productivity and prevent productivity "drop off" that frequently occurs towards the end of the day. In general, workers should not keyboard for more than 30 minutes at a time without taking a two-minute break. There are many published "mini break" exercise programs that allow workers to stretch the neck, shoulders, forearms, hands, and wrist muscles at the work station. There are also "maxi exercise breaks" (five minutes) that employees can do twice during the day.[25] Other options are job rotation, introduction of other tasks into a job cycle, and limitation of work hours. Many companies have adopted in-house fitness programs and facilities to increase employee fitness capac-

ity. Any exercise program should include stretching and relaxation techniques to reduce stress in the neck, shoulders, arms, hands, and low back. The benefits of such programs include improved posture, breathing, joint flexibility, muscle flexibility, and blood flow. Pictorial exercise handouts and posters displayed throughout the workplace may also be useful. Many software companies have developed on-line exercise programs that flash on the screen "reminding" the worker to stop work and exercise.

Socioeconomic impact of ergonomic intervention and education

Studies have shown that an ergonomically correct work environment, employee education, and the adoption of a simple exercise program can significantly decrease workers' compensation costs. Indeed, the study by Tadano[24] in 1990 demonstrated a dramatic decrease in the incidence of repetitive strain in a company that used only employee monitoring and job rotation. Schierhout and coworkers[22] also showed a reduction in RSIs simply with surveillance methods and ergonomic educational programs. Employers are finding that money spent on ergonomic changes is repaid in lower disability costs and increased productivity. OSHA studies have shown that an ergonomically designed work station can increase an individual's performance by an average of 24%.[26] Francis[27] found that among government procurement clerks, an ergonomically designed environment resulted in a 20% increase in productivity. Another study found that a good quality ergonomic chair can increase VDT user productivity by 40% to 80%.[28]

Oxenberg[29] calculated that a daily increase of only 20 minutes of work due to ergonomic intervention may benefit the company up to $2,000 per year per employee. The cost savings of ergonomic interventions are evident immediately in terms of increased productivity and have been shown to reduce significantly the occurrence of injuries. Schneider[30] showed that when one insurance company with 800 workers improved its work station design, it decreased absenteeism from 4.4% to 1.6%, increased efficiency in processing paperwork by 137%, and saw a 9% decrease in errors. A study at a major European telephone company found that introducing ergonomic furniture cut operator turnover rates from 35% to 2% per year, saving the firm extensive recruiting and training costs.[31] Although many of these reports are anecdotal, they tend to demonstrate that ergonomic workplace interventions can significantly decrease the incidence of workplace injuries and reduce the need for extensive medical treatment.

Controversies

There is still international controversy about the true nature of RSIs and whether they should be considered work-related. This is in part due to the lack of outcome-based, prospective, controlled studies to determine effective treatment, which in turn is partly due to lack of consensus among practitioners as to how best to deal with the problem. Several states (notably Virginia) have followed concepts proposed in Australia claiming that RSIs are not work-related at all. In Australia, workers with RSIs do not receive workers' compensation benefits. This presupposes that RSI is purely a psychosocial illness with no basis in organic medicine. That view is further supported by the fact that many clinical presentations of RSI have no neurologic or physical findings, although the patients complain of pain, numbness, and discomfort. Objective tests often are negative as well. The lack of definitive physical findings, however, may be because tools have not yet been developed to detect the pathology. It has been suggested that RSIs occur primarily in individuals who have low pain tolerance; work in repetitive, monotonous jobs; and have many personal problems unrelated to their occupation.[32] Although that may be true for some patients, no scientific evidence suggests that it is true for the majority of patients. In my experience, repetitive strain problems commonly occur in those who are self-employed and highly motivated and who have a great deal of job satisfaction. They are terribly distressed over their inability to function properly.

Repetitive strain injury is a broad, multifaceted condition. Sweeping it under the legislative carpet will not lower the incidence of employee pain or increase worker productivity. It will merely silence the complaints or shift medical coverage for the problem to private insurance carriers; managed care in turn will deny benefits for these problems. Without a system to prevent and when needed treat repetitive stress injuries, patients will not improve and ultimately company productivity suffers. These problems must be addressed directly and primarily in the workplace. Every attempt must be made to return workplace "athletes" to their jobs with the appropriate modifications.

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