Introduction

Repetitive Strain Injury (RSI) is often unrecognized, the nature of the injury misunderstood and preventive measures not widely followed. Repetitive Strain Injury (RSI) is a term used synonymously with Cumulative Trauma Disorder (CTD), Musculoskeletal Disorder (MSD) and also Overuse Disorder (OD). RSI is a neuromuscular illness. The nature of the injury involves soft tissues: nerves, muscles, tendons, ligaments and blood vessels. Repetitive microscopic tears, stress and inflammation sustained over months and years of repetitive motion result in cumulative damage. Often the injured individual is unaware of the damage until it is sufficient enough to cause pain and discomfort. RSI is a general term referring to injury in the upper body, neck, arms and hands. Carpal tunnel syndrome, Epicondylitis (tennis elbow), Thoracic outlet syndrome, and Guyon tunnel syndrome are just a few examples of RSI.

RSI is most often associated with occupational risks involving manual labor but repetitive injury can occur anyplace in which repetitive activity is done. In recent years Carpal Tunnel Syndrome (CTS) has become a unique area of focus because it has affected individuals working in office settings where it seems unlikely to experience a workplace injury. CTS has been linked to use of computer keyboards and due to the widespread use of computers in the workplace the incidence of CTS has increased. According to the U. S. Bureau of Labor Statistics report in 1994 showed a 770% increase in CTS over a 10 year timeframe. The widespread occurrence of CTS has had a dramatic impact on both workers and employers. According to the Institute of Neurological Disorders and Stroke, “During 1998, an estimated three of every 10,000 workers lost time from work because of carpal tunnel syndrome. Half of these workers missed more than 10 days of work The average lifetime cost of carpal tunnel syndrome, including medical bills and lost time from work is estimated to be about $30,000 for each injured worker”. Carpal Tunnel Syndrome remains a significant work injury due to the insidious development, difficulty in recognizing the injury and its overall cost to industry. Understanding CTS, the casual factors and preventative measures are necessary in reducing the incidence of injury among computer users.

Repetitive Strain Injury of the hands and upper body is not new. In 1713 Bernardino Ramazzini, recognized as he father of Occupational Ergonomics, described advanced symptoms of RSI in sedentary workers and writers cramps of scribes. Similar to the scribes of Ramazzini's era, today's computer users suffer from the repetitive use of keyboards. Due to the slow and progressive nature of RSI, Carpal Tunnel Syndrome the most common injury associated with keyboard use is still misunderstood. Understanding the injury process is the first step in stopping the spread of the CTS among office workers.

RSI injuries result from years of repetitive work causing stress, strain, overuse and overloading of soft tissues, often muscles groups work in opposition creating wear and inflammation of the internal components of the human body. In the case of CTS, the bones, tendons, ligaments, nerves and muscles have interacted in a manner causing internal damage. The hand is a complex structure made up of 27 bones. Each hand is comprised of 14 phalanges forming the fingers, 5 metacarpals ending at the knuckles, and 8 carpal bones forming the base of the palm. Sheathed tendons run along the length of each finger extensors above and flexors below providing the means to flex or extend each digit. These tendons are controlled by muscles in the forearm. Tension applied to the end of a flexor tendon will result in pulling the tendon within its sheath potentially over several centimeters, this can result in forces on the tendon that are multiple times greater than what is applied at the finger tip. Thus, internal stress can be much greater than is recognizable by touch.

The carpal ligament stretches across the back of hand covering the extensor tendons and also around the palm side over the base of carpal bones. The channel between the carpal bones and the transverse carpal ligament across the palm side form the carpal tunnel. The flexor tendons, radial artery, blood vessels and the median nerve run through this narrow channel.

Movement and sensation of the thumb and first two fingers is controlled by the median nerve. The median nerve runs from the brachial plexus in the neck under the pectoral muscles, through the armpit and muscles of the forearm and the carpal tunnel extending into the hand. Under normal activity the median nerve remains unobstructed or compressed even as the wrist and forearm are freely rotated. There are many anatomical junctures at which the median nerve can become compressed the most likely point is the passage through the narrow confines of the carpal tunnel.

The carpal tunnel space decreases as the wrist is flexed, extended or laterally rotated. Repetitive hand and finger movement results in inflammation and swelling causing compressing of the median nerve, blood vessels and flexor tendons. Continued activity can cause small tears and the addition of scar tissue to the flexor sheaths further compressing the median nerve.

Recognizing CTS is necessary to address injury treatment and recovery. Carpal Tunnel Syndrome like all RSI syndromes is partly unrecognized because there is no visible sign of injury. The first signs and symptoms are typically related to pain or weakness. Pain, numbness and tingling in the first three fingers are typical symptoms of CTS. In some cases the ability to grasp and pinch are diminished. Symptoms of all RSIs may vary depending on the stage of the injury. Three stages have been distinguished based on symptoms and recovery prognosis.

Stage 1:

- Pain and fatigue at the end of the day
- Symptoms resolve overnight
- No reduction in work performance
- Injury reversible

Stage 2:

- Recurrent pain and fatigue soon after work initiated
- Sleep disturbed by symptoms
- Reduced work capacity
- Physical signs such as swelling visible to a physician
- Persistent conditions extend to months
- May be reversible

Stage 3:

- Pain and fatigue even at rest
- Sleep disturbed by pain
- Reduced work capacity
- Conditions continue for months or years
- Unlikely to be reversed

CTS like all RSIs present a complex array of symptoms that impact not only the afflicted worker physically but also emotionally. Individuals with RSI face skepticism about their illness and may be treated as malingerers. Internally a barrage of emotions is processed as individuals cope with chronic pain, anxiety, depression, panic and the dilemma of permanent disability or choosing a surgical intervention.

Carpal Tunnel Syndrome is just one of many RSIs and can be difficult to diagnose. A number of tests may be used to distinguish and diagnose CTS. Proper diagnosis is important to avoid inappropriate surgery. Use of a pain pictogram and physical examination are the initial steps in diagnosis. A pain pictogram allows the patient to visualize where their pain exists and grade it on a scale of 1 to 10. Physical examination of the hands, wrists and all upper body segments allow the physician to look for predisposing factors such as double-jointedness and evidence of physical damage based on pain, swelling, and lumps, a reduced range of motion or reflex. Patients with CTS often present with a loss of range of motion in their wrists. EMGs and NCVs are considered standard tests but diagnosis should include a pictogram of hand with annotations completed by the patient. Surface EMG or Electromyography measures electrical activity of the muscle by placing electrodes over the muscle groups and then analyzing contractions. Another form of EMG collects electrical impulse data by inserting needles into the specific muscles and measuring contraction potentials then comparing the electrical measures to those of a standard norm. Electroneurography or NCV - Nerve Conduction Velocity is used to demonstrate nerve compression indicated by a slowing of electrical impulses along the nerve fiber. NCV is subject to much variability due to the skill of person performing the test.

Treatment and recovery of CTS as well as other RSI may depend on the stage of injury. Options for treatment range from message, exercise, physical therapy, splints or braces, vitamins, life style change, anti-inflammatory medications and surgery. Surgery as an alternative should be highly scrutinized. Often CTS patients are presented with a surgical option called carpal tunnel release operation in which the transverse carpal tunnel ligament is cut. The healthy ligament mechanically behaves like a pulley through which the flexor tendons run. Once tension is released at this anatomical point pressure moves to a point further up along the tendon, to the fingers. This ultimately increases stress to the fingers of the hand and may result in progressive damage to the fingers.

Identifying the causes of CTS is a crucial step in the effort to prevent further damage to an afflicted worker and to prevent the development of CTS in others. Several contributing factors to consider are: keyboard design, body posture, and technique when using the keyboards. Psychological attitudes towards work and general fitness are also factors in appropriate or inappropriate keyboard use.

The basic design of the modern computer keyboard layout originated from C. Latham Sholes' type writing machine in 1878. Sholes' keyboard consisted of 4 rows of 11 keys each. The third row from the typist presented the letters 'QWERTY' which has become a label for the alphabetic layout. The QWERTY layout is still the most common design in use today as evident on most standard computer keyboards. The modern computer keyboard has additional function keys and a numeric keypad expanding the number of keys from Sholes original 44 to over 100. The original layout of keys are thought to have been purposely arranged to separate letters that are frequently used together in sequence as a means of slowing down the typing sequence in order to avoid mechanical typing bar collisions. In addition, the original typist keyboard like today's standard computer keyboard arranged the keys in flat, straight rows and staggered columns. The alphabetic key layout and physical design of today's standard keyboard like the original typing machine were not designed to accommodate the natural biomechanics of the human body. The standard computer keyboard presents several major problems for the hands and arms of the user.

Dorsiflexion of the wrist occurs when the keyboard is raised at an angle away from the user. Modern keyboards are designed with two folding feet at the edge opposite the user. These feet raise the keyboard at an angle so that they appear to have the same profile as a mechanical typewriter. However, workers today unconsciously rest their arms on the edge of a desk and bend at the wrist to reach the upper row of keys with their fingers. This unnatural bend in the wrist creates several biomechanical problems. First this position shortens the extensor muscles and extends the flexor muscles on the palm side; this creates a constant state of contraction to hold this position and is referred to as a static load. Muscles are contacted and at work although there is no visible activity. Secondly, in order to type the flexor muscles must contract and work against the extensors which are holding the flexed wrist. These two groups of muscles are now working in opposition placing more strain on the effort to flex and strike keys. Thirdly, the bent wrist compresses the carpal tunnel and the various blood vessels restricting blood flow to the muscles in the hand and fingers. Lastly, the extended wrist also has stretched the flexor muscle group of the forearm, so has fingers are flexed to strike keys the muscle group is constantly overstretched. Dorsiflexion is a major culprit of CTS.

Ulnar and radial deviation describes the lateral bend of the wrist either outwardly or inwardly away from the neutral position (windshield wiper wrists). The straight rows of the standard keyboard design prompt the user to bend their wrists to align the fingertips to the “home row” of keys. This occurs because individuals each have a natural angle where the elbow and upper arm meet. This is the carrying angle at the elbow. In men this angle ranges from 5 to 10 degrees and in females the range is slightly greater at 10 to 15 degrees. (Pascarelli, 2004) Limiting the use of the shoulders is an additional factor contributing to ulnar and radial deviation. Forearms are sometimes placed on armrests or the desk remaining stationary consequently leading to bending at the wrist. Ulnar and radial deviation can contribute to CTS by compressing the carpal tunnel and causing friction, swelling and inflammation of the soft tissues within the constricted space. The tendons in the forearms also strain under these conditions and lead to RSI syndromes such as lateral epicondylitis and DeQuervain’s tenosynovitis.

Pronation of the forearm occurs as keyboard users twist the forearm as the thumbs are bent downward in effort to align the hands over the flat surface of the standard keyboard. A 30 degree angle from horizontal would accommodate the neutral position of the palms and forearms. Constant pronation can cause tendonitis.

Finger hyperextension can result from both the organization of the QWERTY alphabetic keys on the standard flat surface and the poor work habit of typing with extended rather than curved fingers. People with short fingers will extend their fingers and strike keys with a flattened rather than curved finger. The pinkie finger can become hyperextended in attempting to reach distant keys. In the state of hyperextension lumbrical muscles in the fingers are used as extensors rather than flexors. The flexor muscles of the forearm must work against the extensor muscles in the hard to strike the keyboard. The result is repetitive strain caused by opposing muscle groups.

Poor posture when using keyboards can contribute to RSI. When the position of the keyboard is too high the user tends to lean forward and rest the forearms on the edge of the desk. The standard desk height is considered too high for the typical keyboard user resulting in an inability to use the upper back or shoulders and placing a constant strain on the forearms. This extreme posture can lead to Postural Misalignment and Neurogenic Thoracic Outlet Syndrome (TOS).

Postural Misalignment is a frequent finding in RSI patients. As people age their posture deteriorates and becomes predisposed if years have been spent hunched over keyboards or other repetitive task without upper body conditioning. The development of postural misalignment includes the head thrust forward, a stretched and weakened upper back and neck muscles. The shoulders are hunched and pulled forward and muscles in the front of the body become shortened subsequently damaging nerve tissue.

Neurogenic Thoracic Outlet Syndrome (TOS) results when nerves from the brachial plexus are pinched in several areas of the upper body due to shortened scalene or pectoralis muscles. Left unchecked TOS can progress into several serious nervous system dysfunctions. If nerves become compressed in the upper body they will undergo pulling or traction as one lifts their arms. This condition can lead to reflex sympathetic dystrophy/complex regional pain syndrome (RSD/CRPS). RSD/CRPS can be caused by excessive typing, trauma to the arms or hands, and sometimes from surgery such as carpal tunnel release. The result is sympathetic overdrive, in stage I sensitivity to touch and heat are increased, stage II characterized by the spread of pain, and stage III in which pain has spread to the legs or opposite side of the body.

Perhaps the most ergonomically incorrect keyboard is that of a laptop computer. Laptop keyboards are small and constricting. The keyboards are flat and cannot correct for ulnar-radial deviation or pronation of the forearms which would be pronounced by trying to compensate for the smaller keyboard. In addition, compact keyboards used in laptops provide a touch pad or eraser cursor control both which are controlled typically by one finger. Both cursor tools are difficult to maneuver leading to award and strained positions of the hand and finger. Regular size keyboards should be attached to laptops whenever possible.

Poor technique when using keyboards is also a contributor to RSI. Finger hyperflexion occurs when an individual maintain their fingers in an overflexed state such as a fist. In this position the fingers are more difficult to spread and reach the various keys. Clacking is a term that describes the action of striking keys with a much greater force than is necessary. Keyboard users that clack can be overheard from a distance. This can be the result of stress or poor work habits and result in injuries similar to vibration syndrome.

The tactile feedback of keystrokes can affect user technique. Modern keyboards are manufactured with plastic or rubber key cushions rather than the traditional spring-loaded keys. This has changed the touch and tactile feedback resulting in greater force in key typing to feel confident the keystroke was complete.

Psychological factors and poor general fitness can also contribute to RSI. Job satisfaction, attitude and motivation can determine whether workers will take preventive steps to avoid or fall into a cycle of continued physical injury.

The root causes of RSI can be broadly defined as:

- Working in one position for months and years
- Millions of repetitions
- Intensity or forceful work
- Aging and predisposition of the tissue
- Physiology and anatomy
- Poor Ergonomics
- Stress prone personality

A view of the root causes from a broad perspective allow us to understand the initial symptoms of RSI, secondary symptoms (compensation, overloading, inflammation and swelling, abrasion and irritation, nerve entrapment and loss of sleep) will consequently cause the ultimate outcome of pain, numbness, anxiety or depression but also serve as negative feedback aggravating the initial symptoms of fatigue, slouching posture, muscle tension and chest compression.

Steps to prevent RSI due to keyboard use must address each of the causal factors following what Damany and Bellis have described as their “Golden Rule of Ergonomics…work as much as possible in an unstressed position, with your upper body balanced, with the least muscle tension, and the lowest impact force…”. To accomplish this goal a great amount of work has been done to address redesign of computer keyboards. Physical redesign of the keyboard and reorganization of the key layout have been the primary approach to better ergonomic design.

Physical redesign of the keyboard has been done to address dorsiflexion, ulnar and radial deviation and pronation of the forearms. Three keyboards that are designed to accommodate the natural position of the wrists, forearms are the fixed split, adjustable split and fully split keyboards. These keyboards account for the natural carrying angle of the elbow and allow the wrists to remain in natural alignment with the forearms through the use of tilted keyboards.

In 1915, Heidner patented a split keyboard. Today the fixed split keyboard provides a 24 degree angle between the two halves of the QWERTY keyboard. A slight downward tilt is also present to allow palms to be slightly rotated out of the palms-down position and into a neutral position so that the hands are no longer held horizontally for extended time. The fixed split keyboard includes a numeric pad and pop-up feet along the front edge. The feet should not be used as these will promote a flexed wrist. The palm apron along the typists edge is not ergonomic appropriate for use. These keyboards may required a larger than typical keyboard tray.

Adjustable split keyboards again, provide a means to tilt the two halves of the keyboard downward and allow the hands to rotate vertically. The difference is that these keyboards can be tented to a greater degree and space apart at a greater angle. Some even resemble an accordion in which case the keys cannot be seen by the typist and keying is done with the palms in a vertical position. Some models include vertical mirrors on each side of the keyboard. An example of an adjustable split keyboards would be the Kinesis Maxim, while an example of a fixed split keyboard would be the Microsoft Natural Keyboard, Natural Keyboard Elite or Keyboard Pro..

A fully split keyboard usually appears to be three separate components connected by an electrical cord. All three pieces are fully adjustable partial keyboards one of which is a numeric pad. The sections can be separated to accommodate differing shoulder widths and can be setup at any angle. An example of a fully adjustable keyboard is the Comfort Keyboard. These keyboards were designed to alleviate pain associated with RSI and CTS. The keyboards come with macros and special functionality can be programmed for any key. Foot pedals can be added to manage complex macros. The programmable memory chip is embedded in the Comfort Keyboard so that even if disassembled and reassembled it will retain the programmed information. This keyboard would offer the widest range of spatial options to either accommodate existing RSI or prevent RSI by providing an individualized ergonomically correct fit.

Several keyboard designs have addressed both the problem of dorsiflexion, ulnar and radial deviation, pronation and finger hyperextension by placing the needed keys in concave surfaces. These redesigned keyboards provide two contoured blocks of keys for the fingers of each hand. There are two additional contoured blocks of keys specifically for each thumb. The contoured bowls are set apart to allow reaching with a neutral wrist position and allow the hands to be turned slightly inward to a neutral position. Examples of this type design can be found in the Maltron 3D Ergonomic and also the Kinesis Classic Contoured keyboard.

The Maltron keyboard was invented by Lillian Malt and Stephan Hobday in the 1970’s. The curved keypad areas were intended to reduce finger travel by 90%. Lillian

Malt designed the keyboard layout after studying the neuromuscular system of the hand. There are several different types of Maltron keyboards. The Maltron 3D, includes a central block of numeric keys in addition to those paired for the fingers and thumb of each hand. The Maltron single-handed keyboard offers one recessed area for either the left or right hand. The contoured area for the hand sets aside a block of keys for the fingers and also one for the thumb. A flat key pad is situated alongside the contoured half of the keyboard.

The shape of the Maltron keyboard was designed to minimize the stress on the hands, arms and back. It accomplishes this by positioning the keys so that they accommodate fingers of different lengths through the concave shapes. The keys of the Maltron are positioned in straight columns rather than staggered as done on the QWERTY keyboards. Reaching for staggered keys creates more strain than reaching keys directly aligned with one another. The Maltron keyboard also makes good use of the thumbs by providing special key blocks such as end, control, enter and delete which on the QWERTY keyboard requires an awkward strain and reach using the little finger. The Maltron keyboard can provide the standard QWERTY key layout or an ergonomically improve key layout created by Lillian Malt.

Chorded keyboards use ternary rather than binary keys, which mean the user must press several keys together to form text or commands. The advantages are that a single hand can be used, the device will take up very little space and some also believe that the fingers do not need to move very far making the device both faster to use and ergonomically better than two-handed input devices. Others contradict that the device is slow to use since unlike a regular keyboard that allows the next key to be pressed while the last key is still down, a chording keyboard requires each chord to be released before the next can be pressed. These input devices were ideal for travel because of their small size. Wheatstone and Cooke developed the first know chord keyboard used to work with untrained telegraph operators.

Widespread use of chord keyboards occurred with the stenotype machines used by court reporters. The stenotype based on a phonetic code was invented in 1868 and is still used today. The six-key chord keyboard was invented by Perkins Brailler in 1951 and used to produce Braille output. Researchers at IBM considered the use of chord keyboards for computer systems in the late fifties. Their design included 14 keys with dimples on the edges and top to allow multiple keys to be press simultaneously. They studies were inconclusive as to whether the design provided faster data input. Commercial devices available have been the Microwriter, CyKey and the GKOS keyboard intended for wireless tablets. Chorded key devices although considered to improve HEF did not gain widespread popularity.

One type of compact keyboard called Frog Pad by Kaizen FrogPad, Inc. has been said to curb carpal tunnel syndrome. The unique feature about this mobile keyboard is that it has a reduced physical size without reducing the keyboard buttons. The dimensions of the Frog Pad are three inches high, five inches wide, and half an inch thick. The Frog Pad has only 20 keys but provides the same functionality as a standard keyboard. The 20 keys perform multiple functions depending on which shift keys are pressed in combination with the alphabetic keys. The estimated time to learn to type text at 40 words-per-minute is stated as ten hours. The Frog Pad offers Bluetooth wireless and is referred to as a one-handed keyboard. There doesn't appear to be any ergonomic advantage for use of this keyboard and seems limited to mobile use rather than use in a workplace.

Datahand offers a unique design in keyboards as a solution to RSI and CTS. It provides two keyboards each specifically contoured to either the right or left hand. Each keyboard offers 132 keys controlled through five key-switches clustered around the tips of each finger. The Datahand wraps the keys around each finger in a three dimensional array. The thumbs control four modes eliminated the need to move the hand. Very little finger movement or force is required to activate the key controls sparing the fingers from hyperflexion and reducing cumulative trauma. The hands are supported in the contours of each keyboard therefore preventing potentially injurious repetitive and stressful motion of the wrists, forearms, shoulders and neck. Reviews of the Datahand keyboard ranged from very positive with regards to resolving pain associated with RSI to concerns about the complexity of learning how to use the controls. Solutions to RSI must be beneficial in reducing the strain and unnecessary motion but also easy to learn and teach to others. A number of ergonomic keyboarding solutions require time invested in learning a new system. This is true when choosing a redesigned key layout.

The Dvorak key layout is the most well know alternative to QWERTY. It is also known as the Simplified Keyboard and also the American Simplified Keyboard. The Dvorak keyboard was designed by August Dvorak and William Dealey in the 1920s and 1930s. Dvorak and Dealey studied the anatomy and function of the human hand and defined a set of principles that would define efficiency and safety:

- It is easier to type between alternating hands.
- The most common characters should be easiest to reach.
- The least common characters can be placed farthest away from the fingers.
- The right hand should do more of the typing because most people are right handed.
- It is more difficult to type diagraphs using adjacent fingers than non-adjacent.
- Key stroking should generally move from the edges of the keyboard inward.

The Dvorak layout was patented in 1932 and designate by the American National Standards Institute as an alternate standard keyboard layout. Although the science used to develop the key layout was sound scientific studies have remained inconclusive as to whether there are any benefits to using the Dvorak layout. This mainly due to inconsistent studies of its use and nonstandard metrics such as ‘effort’ and ‘relief’ values which account for the use of the alternate hand saving one hand/finger from experiencing 100% of the repetitive stress. One general conclusion with regards to the Dvorak keyboard is that the cost-benefit of converting from QWERTY is marginal due to the time required to learn the new standard layout.

Conversion to the Dvorak key layout has met resistance from QWERTY touch typists apparently from their reluctance to set time aside to learn a new key layout. Another discouraging aspect of changing to a Dvorak key layout is the impact to software applications that share the use of the QWERTY keys. Once the key map is altered, Unix text editors such as vi no longer work as originally designed. For example the H, J. L, K keys do not perform complementary cursor movements as with QWERTY. Short cut keys such as cut /copy / paste are physically distant once the key layout is remapped to Dvorak. Although these examples are sidebar issues, when the focus is directed at implementing a potentially more ergonomic tool it reminds us of how difficult behavior changes are for most individuals. As an additional note, Microsoft operating systems include the option of using the Dvorak key map under the Control Panel menu. User defined key mapping changes are offered on most modern operating systems, allowing each computer user to set up their own unique key mapping choices.

There are several key layouts alternative that are alternates to QWERTY. Lillian Malt also designed a specific key layout that can be ordered with any of the unique Maltron keyboards. The key layout was designed to accommodate the most frequently used patterns of characters and words in the English language and also to decrease transposition errors due to brain and motor miscommunication. On example is the error that occurs with transposition of the characters “e” and “i”. On the QWERTY keyboard these keys are both struck by the middle fingers of the opposing hand. By separating these keys on the Maltron layout the confusion is less likely to occur.

The use of new virtual keyboard has brought up some speculation of its ergonomic potential since it is essentially a light projection of a keyboard without the physical substance. The Canesta Keyboard Perception Chipset publicized in 2003, is made up of three components: an invisible light source, a pattern projector for the keyboard, and a sensor chip. “The chip enables the machine to “see” in real-time by tracking nearby objects.”(Good, February 7. 2003).The keyboard can be projected on any flat surface and can then be typed on. This allows typists to use the same surface for both the keyboard and mouse. An internal laser projects the image of a full size QWERTY keyboard. Typists can achieve 50 words-per-minute with no more errors than a typical keyboard. The chipset works by tracking finger movements optically within a 3-D space and determining the intended keystroke. The feedback from the initial users complained about the lack of tactile feedback and a click was added for user comfort. Typing on a hard, flat surface doesn’t support RSI prevention measures as many of the ergonomically designed keyboards have. But the idea may be that fingers will lightly touch a projected keyboard and eliminate stress and strain. Unfortunately, wrists, forearms and the upper body must also be addressed by good posture and work habits. So the virtual keyboard may provide little or no preventive measure.

The use of alternative keyboards to reduce motion in the effort to reduce repetitive strain has brought up interesting thoughts on whether these alternatives are the right solution for everyone. One concept regarding the use of alternative keyboards is that reducing the movement in various areas of the body may create static positions and repetitive motion may be occurring in a different location of the body that has not become damaged yet. The use of ergonomic alternatives to address specific issues may cause us to overlook the original root cause: repetition and static position.

Reviewing the approach to redesign of keyboards for improved biomechanical use and the prevention of RSI four general principles of control panel design have been followed: sequence of use, frequency of use, importance of use and function. Redesign of keyboards is a major factor in correction and prevention of RSI and Carpal Tunnel Syndrome, but posture, behavior and general fitness also play a role. Advice from Damany and Bellis state the following: when implementing corrective measures for RSI:

- A design that promotes the neutral position is better as long as routine movement occurs.
- A design that allows keystrokes with less force is better.
- If you don't use the keypad consider getting a keyboard without one. This will allow you to bring the mouse closer to the body.
- The most wonderful keyboard in the work is not a solution, only a piece of the puzzle.

The split adjustable Kinesis Maxim Keyboard seems to be the most appealing and practical ergonomic design. Using the Maxim with the standard QWERTY layout would minimize the impact of change and transition to a tilted keyboard. Immediate relief may be experienced once ulnar and radial deviation and forearm pronation have been corrected.

Keyboard accessories such as a pull out keyboard tray can prevent dorsiflexion of the wrist. By ensuring the tray and keyboard have an adjustable negative tilt away from the user will encourage a neutral alignment of the wrist and forearm. The keyboard tray should have an adjustable height so the keyboard can be low enough to allow the elbows to rest easily and freely at the sides close to the body with a slightly greater than 90 degree angle. The keyboard tray should be large enough to accommodate a spilt keyboard as needed. A sliding mouse tray that can move alternately from one to the other side of the keyboard is very good option. The physical arrangement of the keyboard in combination with proper posture is a significant preventive measure against RSI.

The workstation keyboards usually include an external mouse. The mouse can also be a potential source of RSI because they require refined and constant repositioning. Techniques to avoid RSI while using a mouse:

- Use larger muscle groups of the arm to move the mouse,
- Keep your wrist straightened and inline with the forearm,
- Keep your hand relaxed when holding the mouse,
- Create a mouse corral if it continually slides off a negatively tilted keyboard tray.
- Move the mouse in close to you to avoid reaching
- Connect two mice at once to provide an alternate mouse, alternating use of each will allow use of different muscle groups.
- Swap sides when using a mouse

Computer mice do cause overuse of different muscles. No single type of mouse is the best but there are pros and cons to be considered. The trace ball does not require a mouse pad. You can place the track ball anywhere. Use of the track ball uses the upper arm which is stronger. The track ball is a good alternative to the classic mouse.

The use of wrist rests can be controversial. The healthiest posture while keyboarding does not rest the forearms or wrists on anything. Placing the arm in a stationary position removes the arm from work and placing all of the strain and effort solely on the hands. Use of wrist rests can encourage incorrect placement of the wrists so that the wrist becomes bent upward (dorsiflexion) and begin to be moved side-to-side (ulnar, radial deviation). Resting on the wrist will place undue pressure on the carpal tunnel area causing rather than preventing injury.

Even with appropriately designed computer keyboards and work stations repetitive strain injury can occur whenever the work culture promotes an unhealthy work load and attitude. Developing good work habits can combat stress and reduce habitual muscle tension. According to Damany and Bellis (2000) "the most important stress on most computer pros who get RSI is from within, an irrepressible passion for their work." Reducing stress will allow for better body posture and body mechanics.

Taking breaks from work is a significant but perhaps most challenging work habit to develop.

- Quick 2-5 minute breaks for every 15-30 minutes of work may be optimum.
- Mini-breaks every 3-5 minutes, hands leave the keyboard and you move your arms.
- Exercise while sitting in your chair. Stretch your arms and upper body, move your arms and shoulders.
- Move your feet and legs.
- Practice conscious deep breathing exercises.

Develop healthy keyboarding techniques. Learn to use your large muscles to move your hands over the keyboard. Shoulders and arms take on the greater amount of work and fatigue less frequently.

- Keep elbows at your side and don't reach out. Reaching out adds weight to the arms producing tension.
- Avoid single-handed combination keys such as Control-Alt-Delete. If necessary remove the keys to alter your behavior.
- If you experience severe muscle symptoms perform two-finger typing to slow down and allow recovery.
- Keep your wrists as straight as comfortably possible. Avoid bending vertically or laterally.
- Gently touch key with performing key strokes.
- Use fingers to press the spacebar not the thumb.
- Adjust the work station arrangement until the proper fit is found. In many cases photographs of the worker seated at the work station are taken in order to analyze which ergonomic adjustments are necessary.

Promoting good work habits from an employer's perspective is a win-win situation. According to Kromer (2001), employees are the center of the organization. Maintaining happy employees leads to a stable and productive organization. But keeping employees satisfied with their jobs, motivated to perform well, foster good work habits and cope with stress effectively is complex. Understanding hierarchy theories of human need will provide insight of how and what can motivate employees to perform and behave as desired. Equally as important is the need to identify types of organizational determinants of job satisfaction and work performance.

Improving overall health and fitness will help reduce stress levels and improve both posture and biomechanics when at work. The best way to prevent RSI, including Carpal Tunnel Syndrome is to take multiple proactive steps to address work environments that present risk of RSI. Employers and employees must learn to recognize repetitive work activities, long work days, poorly designed equipment, poor posture and work habits. Effort should be made to select ergonomically correct keyboards, use good body mechanics when typing, maintain fitness, posture, work behavior and attitude.

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