COMPUTING WITHOUT PAIN WITH THE MOUSEKEYDO™ SYSTEM:

A New Technique For TheTreatment & Prevention of Computer-Related Repetitive Stress Injuries (RSI)

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INTRODUCTION

As a physiatrist, or Physical Medicine & Rehabilitation specialist, my first goal is to take care of an injured person by evaluating the medical problem and coming up with a diagnosis and treatment plan. However, I also have to make sure the diagnosis and treatment plan help the injured person return to functioning and avoid further injury.

If doing a certain task causes you pain, you need to learn a different way to do it! I'm going to introduce you to a training program that does exactly that: teaches patients precisely how to do things differently. This training program helps people correct their bad working habits by changing their body mechanics so they can maximize function over the long term—a necessity in dealing with repetitive stress injuries (RSI) or overuse syndromes.

Please follow the narrative along with each slide as you read on.

SLIDE 1:

The training program we're discussing today is called the MouseKeyDo® System. It's a new technique to treat and prevent computer-related RSI.

SLIDE 2:

In addition to this slide presentation, you can download a few sample chapters and view video clips of some of the many techniques that make up the MouseKeyDo® System by visiting the "MouseKeyDo® System" section of mousekeydo.com.

The "Research & Development" section of mousekeydo.com contains four articles that prove the system works: a two-part article titled “Technique Addresses Computer-Related RSI, Part One and Part Two” and a two-part outcome study titled “Outcomes of Mouse-Keyboard Training, Part One and Part Two.” In that same section of the website, you can also find a biographical reference list of the journal articles and books I used to develop this lecture.

SLIDE 3:

Your computer is not really out to get you.

The Mouse & Keyboard Training Program Components Mnemonic:

- Diagnosing
- Reduce pain
- Sitting Posture
- Awareness of tension
- Flexibility
- Ergonomics—equipment, lighting, sound
- Keyboard/mouse technique
- Endurance
- Your Practice

SLIDE 4:

Mnemonics are a great way to remember important information. To treat people with computer-related injury, I developed a treatment algorithm and a mnemonic to help remember it. It spells DR SAFEKEY.

D: **Diagnosing** the problem or problems. Often a patient suffers from pain in three or four areas.

R: **Reduce** pain through rest, medication, and/or physical or occupational therapy.

S: **Sitting** posture. This is the first step in the process of keyboard retraining, by which I mean all aspects of computer use, such as sitting; working with a keyboard, mouse, or laptop; or using any hand held device.

A: **Awareness** of muscle tension. This means learning how to relax and move fluidly while still working efficiently.

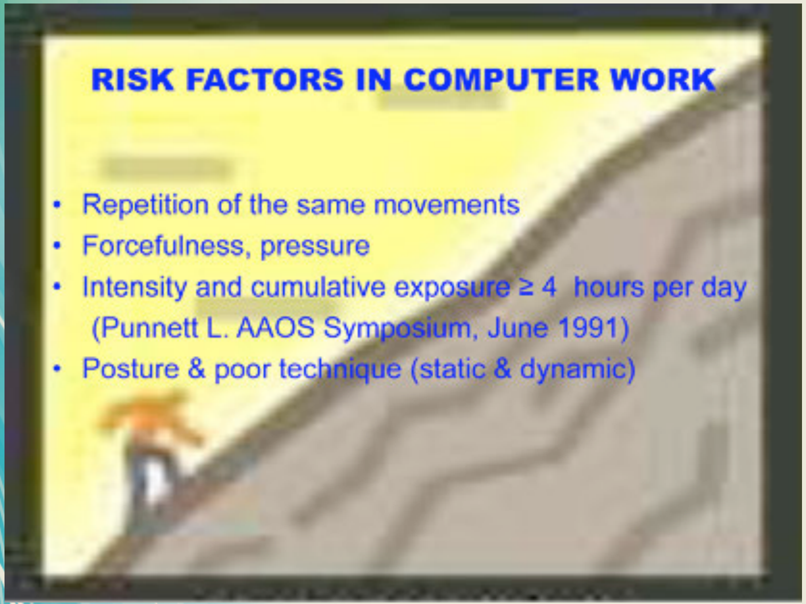
F: **Flexibility** improves posture, comfort, and ease of movement.

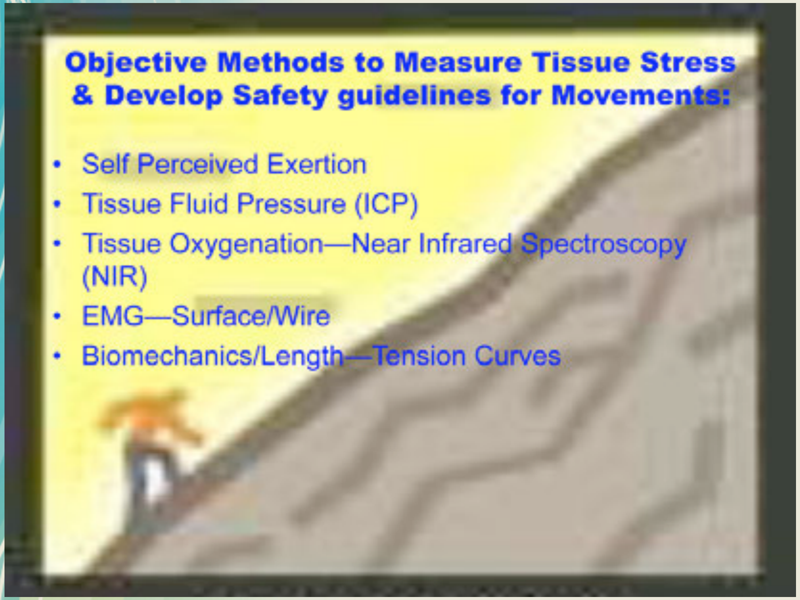
E: **Ergonomics** includes equipment, lighting, vision, and sound.

K: **Keyboard** technique. MouseKeyDo® training teaches a new skill set for computer use to help patients avoid pain and maintain productivity.

E: **Endurance.** Using these new skills will allow patients to use a keyboard without pain for increasingly longer periods of time.

Y: **Your** practice. This takes practice!





SLIDE 5:

Four problems inherent in computer work are associated with repetitive motion injuries: repetition, force, duration of exposure, and awkward posture.

SLIDE 6:

To develop a training program to reduce these problems, we needed to find ways to measure the tissue stress they cause.
When we reviewed the literature, we found that these five measurements were the most reliable ways to quantify tissue stress:

1. Self-perceived exertion - The patient will tell you what's wrong by saying it hurts to do something. That lets us develop a less painful way to accomplish that task. For example, if it hurts a patient to lift the index finger repeatedly to hit a key, we can teach the patient to lift the entire arm from the elbow, shifting the responsibility for the primary movement from the finger to the whole arm.

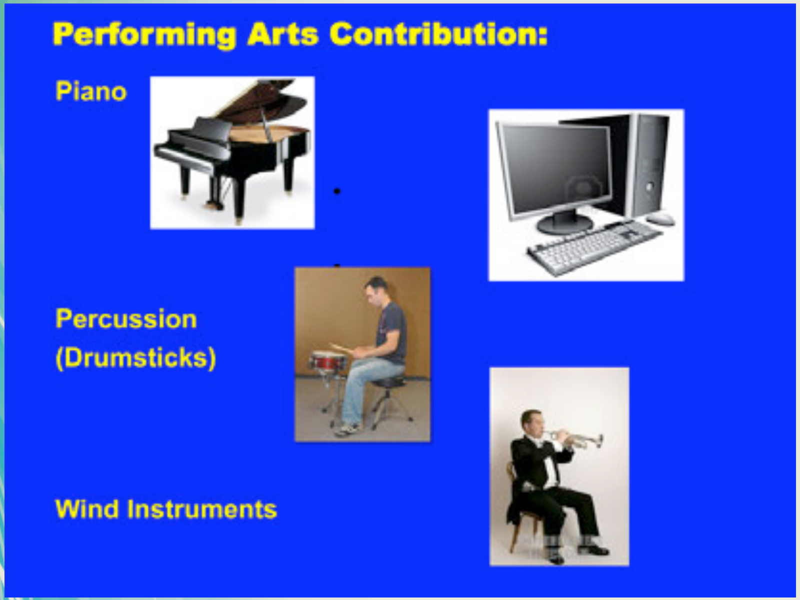
2. Tissue fluid pressure - By using a catheter to measure the disc pressure in the spine when the patient is sitting in various postures (6, 107, 108), we can determine the best posture for maintaining safe spinal disc pressure. By doing catheter studies in muscles and around nerves, we can reveal high tissue fluid pressure in the cubital (18, 98, 112) or carpal tunnel (41, 56, 121). We can then teach patients better angles and positions for the elbow, wrist, and finger, so they can avoid nerve ischemia or oxygen deprivation (56, 92) in the muscles.

3. Tissue oxygenation - Using the Near Infrared Spectroscopy probe allows direct measurement of muscle oxygenation as a function of muscle contraction force (106). Keyboarding techniques that use the least amount of force necessary increase muscle oxygenation.

4. Electromyography (EMG) - Surface or wire electromyography allows us to measure varying levels of muscle contraction forces and recommend techniques that perform tasks with minimal muscle contraction forces (94, 95).

5. Biomechanics - By studying the biomechanics of the upper limb and the length and tension curves of its muscles and tendons, we can determine the most efficient ways for the joints and muscles to work at the computer (14, 22).

All of these factors help us make educated recommendations for safe movement.



SLIDE 7:
Musicians use motions that are qualitatively similar to those involved in working at a computer. For instance, musicians use their whole body while sitting at an instrument, so we studied pianists. We also observed how drummers sit, and how they use their arms and hands, as well as wrists and fingers, to move the drumsticks. In addition, we looked at how players of wind instruments position their shoulders and neck to perform while still breathing comfortably. Then we applied this information to computer users (2, 52, 99, 100).

SLIDE 8:
Repetitive actions and forces of typical keyboard moves cause 12 common problems. Each one requires certain treatment guidelines, which you'll find in the reference article entitled "Technique Addresses Computer-Related RSI, Part One (75)."

We used these guidelines to develop new ways to perform the same tasks without the high-risk actions that caused pain in the first place. To ensure these new actions were effective, we measured them using the objective methods set out in Slide #6, as well as general medical treatment.

SLIDE 9:

It's never too soon to learn safe ergonomic techniques. This is my son, Daniel, at nine months old. See how he already integrates his whole body in using the mouse.

SLIDE 10:

This is an article from the late 1990s in which young children are learning about keyboarding technique. The notion of keyboard training actually began in 1951, with Lundervold's electromyographic investigations of sedentary work, especially typing (6, 47, 93, 94, 95).

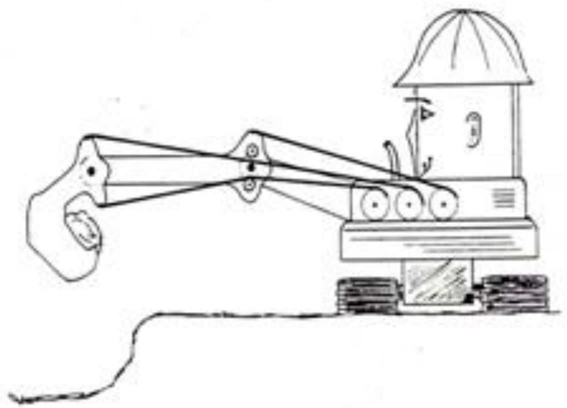


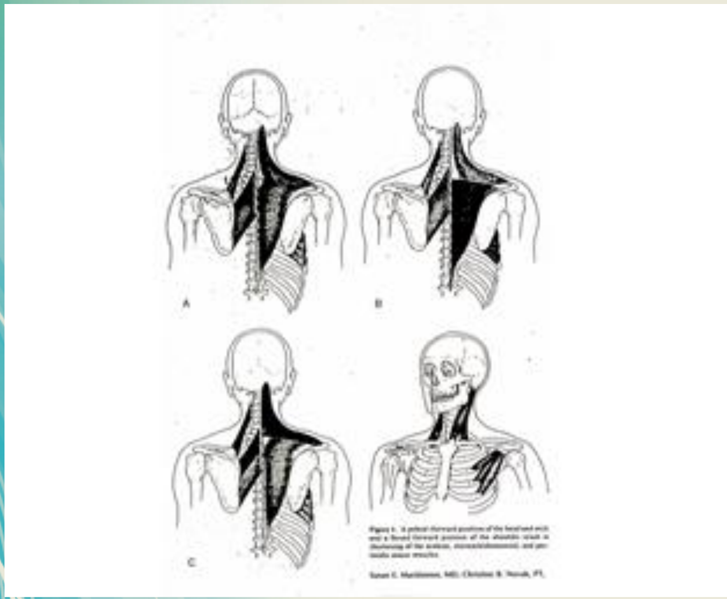
FIG 2–2.
Caricature of old-fashioned cable-operated trench digger.

SLIDE 11:
Let's start to talk about how the body moves. This is a caricature of an old-fashioned cable-operated trench digger. It operates efficiently by coordinating the movements of many pulleys and wires while resting on a solid but mobile foundation. The system of moving parts is designed for maximum efficiency.

Computer workers are like this trench digger. To move the keys and mouse efficiently, they need to coordinate the movements of the shoulder, elbows, wrists, and fingers (pulleys) and muscle and tendons (wires) of the whole upper arm on a solid, but mobile foundation (feet and seat). Just as a trench digger can't move dirt efficiently by only using its bucket, a computer user can't work efficiently by using just the wrist and fingers to work the computer. The idea is to spread the workload across the entire body with coordinated movements.

By integrating these ideas with our experience treating these injuries, we can create a whole new way of working.

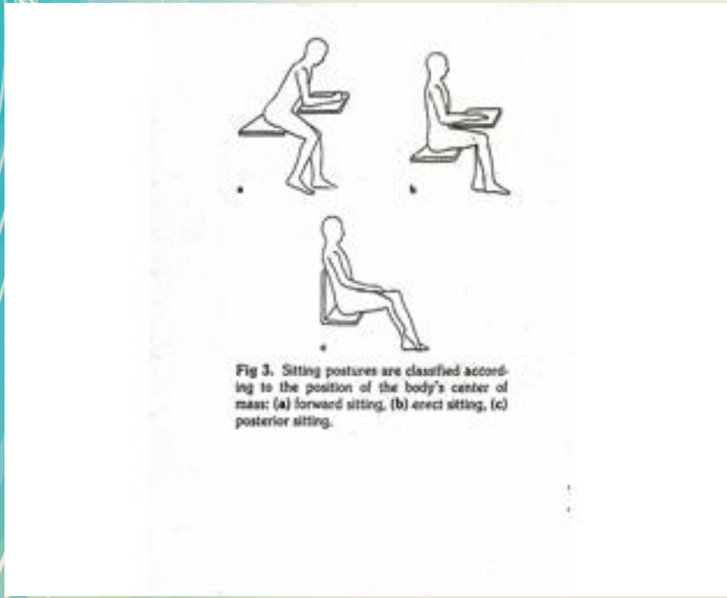
SLIDE 12:
Now we are going to talk about these problems using specific examples of muscle and tendon disorders.



SLIDE 13:

One of the most common patient complaints is neck pain. Neck pain often comes from muscle tension. This slide depicts the typical areas of neck and shoulder muscle tension for computer workers who sit at a desktop.

Examining how a patient sits can help determine what changes would help. See whether or not their arms are reaching, or whether their neck is flexing downward or extending upward excessively.



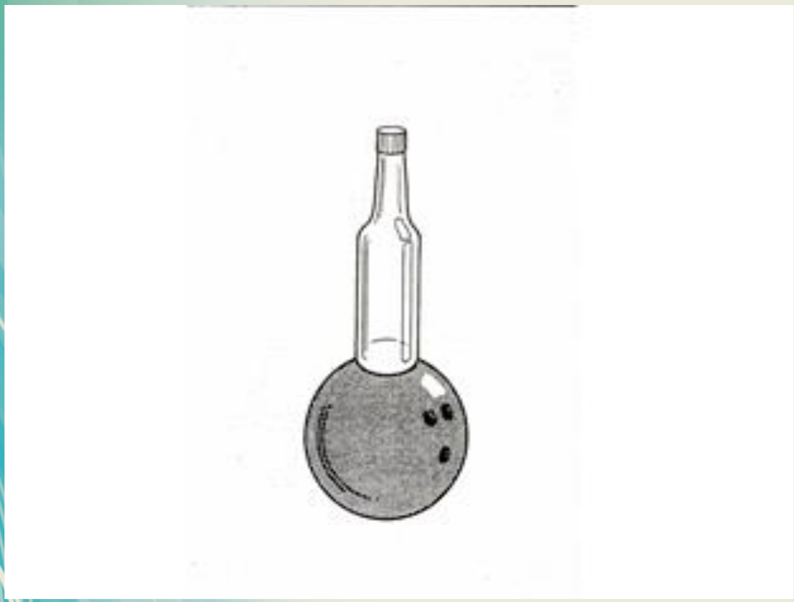
SLIDE 14:

When three famous athletes — a golfer, a football quarterback, and a boxer — were asked which of their body parts seemed to be the most important in their sport, their answers might surprise you. Was it their arms? Their back? Their legs? Their hands? No, all three said it was their feet. Feet were the foundation of their movement. Likewise, when you are sitting at a computer, your feet and your seat become the foundation of your movement. So just as athletes need to learn to stand properly, it is important for you to learn how to sit at a computer properly.

Sitting can be supported (that is, with a lumbar support) or unsupported, and it will fall into three categories (22):
a) Forward sitting.
b) Erect sitting.
c) Posterior sitting.

No one position is best. In fact, sitting requires a series of continual adjustments and weight shifts for comfort, balance, and for the safety of the work task. For example, if you need to reach with your arms, sitting in the posterior or reclined position will make your neck and shoulders fatigue quickly. For computer work, we recommend either erect or forward sitting depending on the intensity and duration of your work.

For a more detailed look at proper sitting, please download chapter 3 of the MouseKeyDo® training manual. You'll find it at mousekeydo.com. Just click on “The MouseKeyDo® System” link at the top of the page and select chapter 3 from the training manual table of contents.



SLIDE 15:

This image of a bottle balanced on a ball depicts the goal of balanced sitting and comfort while working.

SLIDE 16:

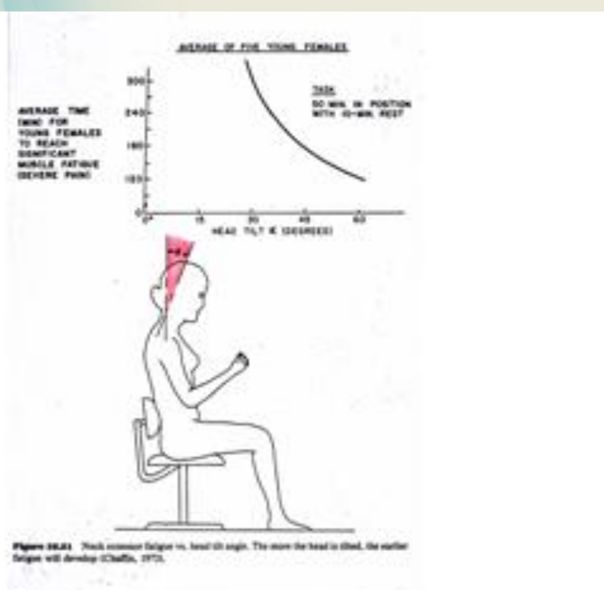
This is a group training class on sitting. At a computer, your posture needs to meet several criteria.

a). You are comfortable both at rest and while using the computer.
b). You can move your head, arms, and legs easily.
c). You can see comfortably.
d). You can breathe freely.

Let's now travel up the neck, then down to the shoulders, elbows, and hands. We'll conclude by discussing how our hands and fingers touch and work with your keyboard and mouse. The core of this program is a new approach to typing and mousing in an ergonomic setup. For typing, you will learn how to "Drop," "Beat," and "Roll." For mousing, you will learn how to "Drop," "Drape," and "Skate." For Laptops and Handhelds, it's just combinations of the two.

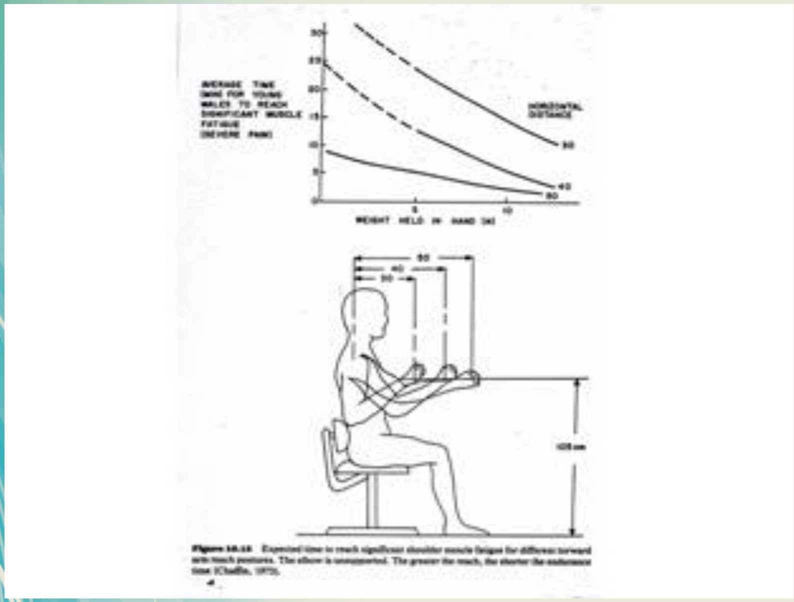
SLIDE 17:

This slide shows the axis of the neck's rotation in bending forward (flexion) and backwards (extension). Your head weighs approximately 22 pounds. When the neck is tilted forward in flexion, the neck muscles must work with an equal, but opposite direction of tension to support the weight of the head when gravity acts upon it.



SLIDE 18:

In a study by Chaffin (22) on neck angle and fatigue at the University of Michigan, researchers asked a group of healthy subjects to flex their heads forward, then measured the onset of fatigue as a function of time and neck angle in flexion. The vertical axis in the graph above the diagram represents the time, while the horizontal axis reflects the flexion or forward angle of the head from neutral position. As the graph shows, the farther forward subjects flexed their neck, the faster they became fatigued. They became least fatigued when their necks were flexed forward 0-15 degrees.



SLIDE 19:

Chaffin conducted a second study (22) asking the same healthy subjects to reach with their arms forward from the shoulder joints, then measured neck and shoulder muscle fatigue as a function of time and shoulder angle. As a reference, a shoulder angle of 90 degrees would be the arm extended in front of you reaching forward and parallel to the ground for flexion, or extended to the side and parallel to the ground for abduction, and an angle of 0 degrees would be the arm dangling neutrally from the shoulder, perpendicular to the ground. Here the vertical axis in the top graph is time and the horizontal axis represents increasing shoulder angle.

SLIDE 20:

The farther the subjects' arms were from 0 degrees shoulder flexion or abduction, the faster their neck and shoulder muscles became fatigued. A shoulder flexion angle of 0-25 degrees and a shoulder abduction angle of 0-20 degrees caused the least fatigue.

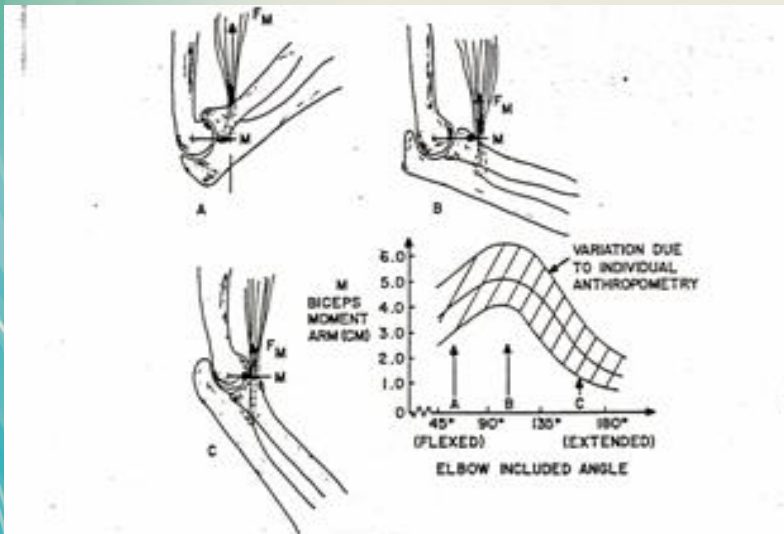
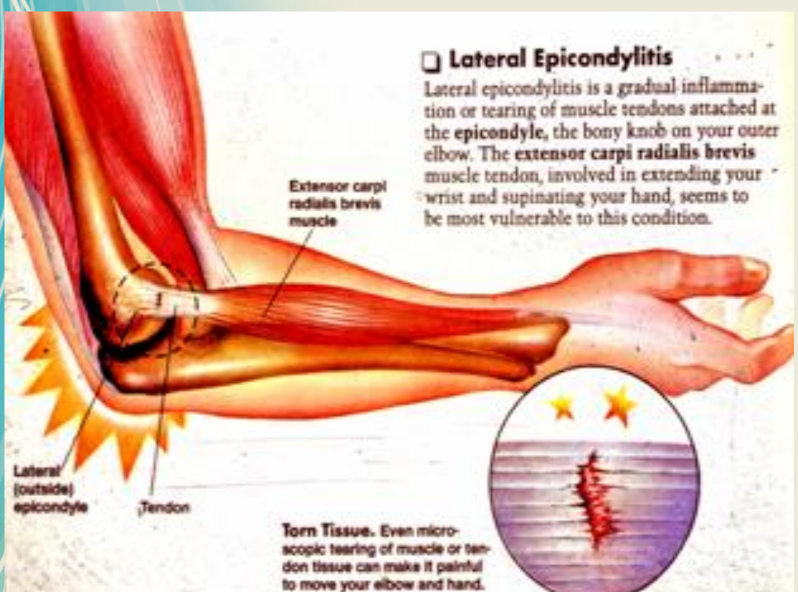


Figure 4.7 Length variation in the moment arm of the biceps brachii at different elbow flexion angles.

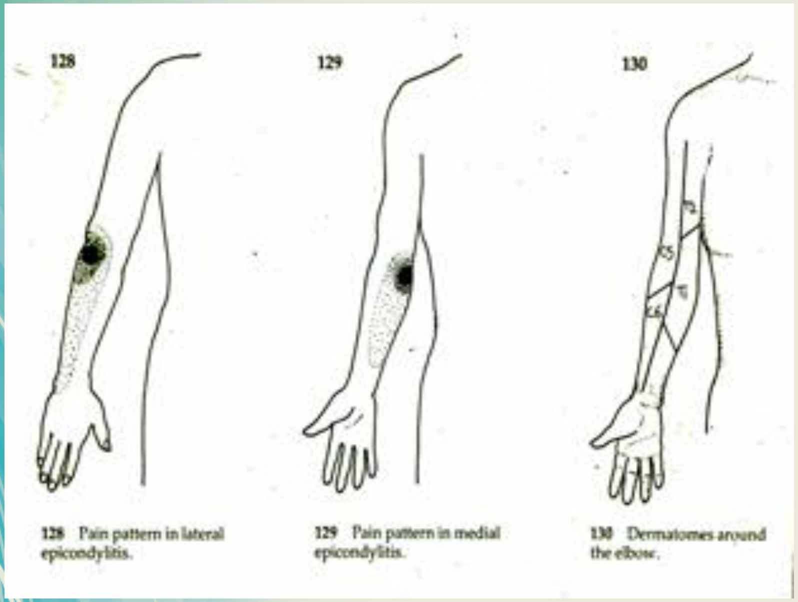
SLIDE 21:

This slide helps us understand at what angle the elbow has its greatest capacity for work endurance (22). Many computer ergonomic diagrams of the elbow recommend working at the computer with elbows flexed to 90 degrees. This figure graphs the biceps moment arm on the vertical axis and the elbow flexion angle (fully extended would be 180 degrees) on the horizontal axis. Notice the top right elbow flexion angle at “B” is approximately 105 degrees. This same angle represented in the graph bottom right corresponds to the greatest biceps moment arm or the greatest mechanical advantage in lifting a weighted object. This elbow angle is most likely to be the most comfortable position for the extended period of time typically involved in computer work. The take-home message: Keep the elbow between 90-105 degrees, which is slightly more open than a 90-degree angle.



SLIDE 22:

This is a side view of the right elbow/arm and muscle attachments. Lateral epicondylitis causes pain at the elbow due to the repetitive forces of finger and wrist work. It results in a gradual inflammation, fatigue, and possible tear of the extensor carpi radialis brevis or longus muscles. Computer users may also have pain over the entire extensor surface of the forearm and wrist caused by the excessive amount of finger and wrist movement under force when using the mouse and keys.



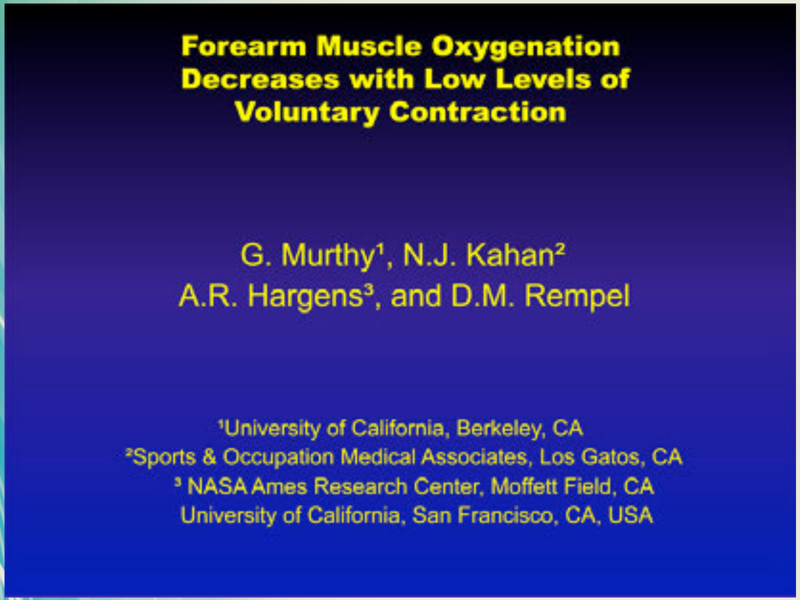
SLIDE 23:

The left figure on this slide depicts the pain pattern of lateral epicondylitis, caused by overuse of the extensor muscles. You may already know lateral epicondylitis as "tennis elbow." The middle diagram shows the pain distribution of medial epicondylitis, also known as "golfer's elbow," caused by overuse of the forearm flexors, as in gripping and pinching motions.

SLIDE 24:

Problems can also come from body parts that aren't directly in contact with the keyboard. In this example, it's true that the model may experience pain in the left elbow and arm from resting the heel of her hand on the wrist rest and extending the wrist and fingers. However, as she depresses the space bar with her right thumb, look at what happens to the remaining fingers of her right hand. As she depresses the thumb forcefully, she pops her fingers equally forcefully into the air.

A lot of isometric contractions are occurring here in the extensor muscles of the right hand. All the muscles in her right arm as well as the index, long, ring, and pinky fingers of her right hand are under an isometric load after her thumb hits the space bar. The prolonged exertion and excessive contraction of these muscles over time puts them at risk for developing epicondylar or arm pain. In other words, while the right thumb works, the remaining four fingers contribute to their own fatigue with no work to show for it.

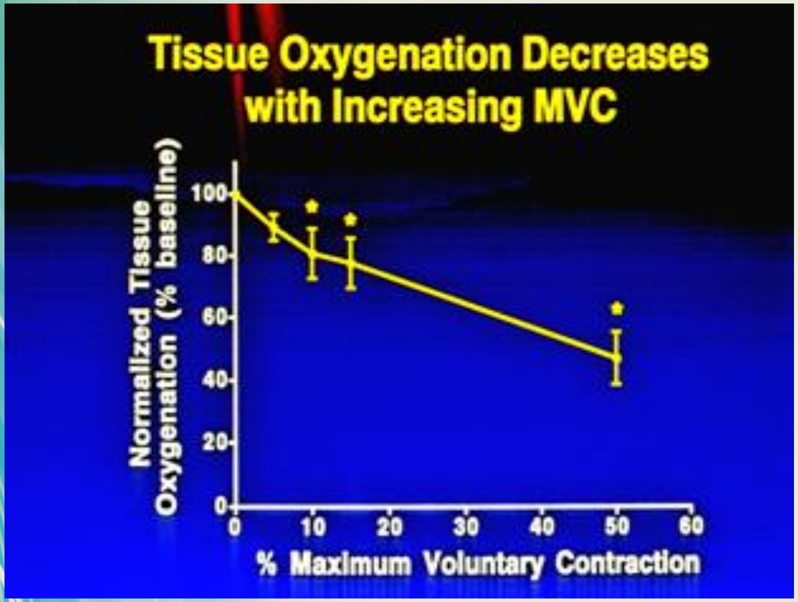


SLIDE 25:

This was a study we did in conjunction with the University of California, Berkeley, the University of California, San Francisco, and the NASA Ames Research Center, Division of Life Sciences (106).

SLIDE 26:

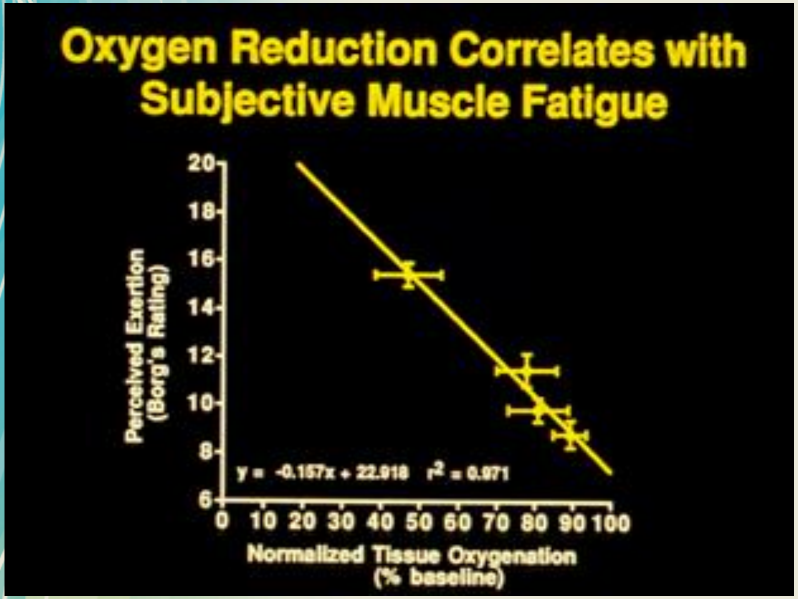
This slide shows the experimental setup, illustrating the subject's sitting posture during randomized isometric contractions of the extensor carpi radialis (ECR) muscle. (An isometric muscle contraction subjects a muscle to tension without a change in its length). The probe over the muscle at the elbow is the Near Infrared Spectroscopy (NIR) device, which uses a light transmitter to detect different tissue oxygenation levels in the muscle.



SLIDE 27:

In this study, we determined that "Tissue Oxygenation Decreases with Increasing Maximum Voluntary Contraction (MVC)." MVC is defined as the maximum ability to voluntarily contract a muscle and proportions of that would be a percentage of the maximum. Keep in mind that computer work is estimated at just 10-15% of maximum.

The vertical axis represents the tissue oxygenation in the ECR muscle. The horizontal axis represents the percent MVC. These results show that increasing the isometric contraction loads decreased the amount of oxygen in the muscle, even at low MVCs.



SLIDE 28:

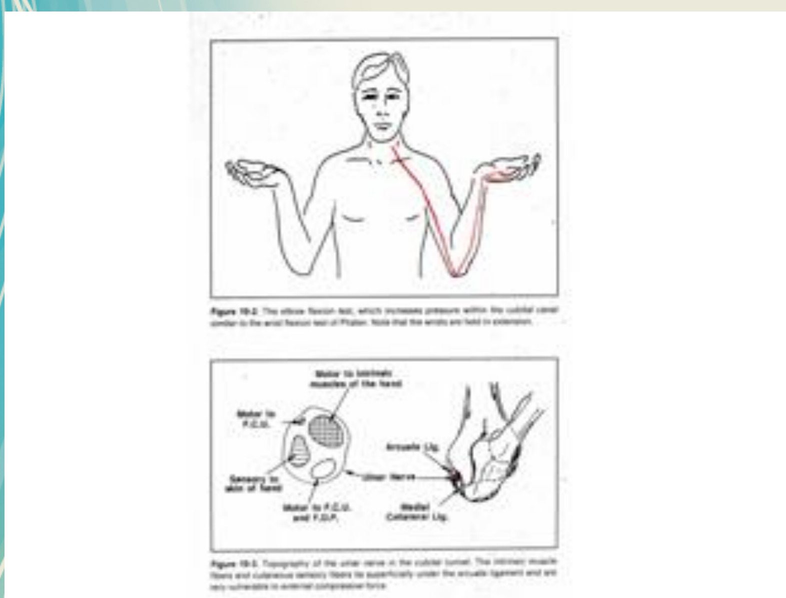
As the slide states, "Oxygen Reduction Correlates with Subjective Muscle Fatigue." In this slide the perceived exertion, meaning the sensation of fatigue, is on the vertical axis and muscle tissue oxygenation is on the horizontal axis. We can see that as the amount of oxygen decreases in the muscle, as a result of increasing MVC, the subjects feel more fatigued.

Taken as a whole, this study suggests that the sensation of fatigue alone in a contracting muscle is linked to low oxygenation levels, which may be a precursor to fatigue and repetitive stress injuries. I encourage you to review this study to improve both your understanding of the probable basis of muscle fatigue and your insight into the treatment and management of repetitive stress injuries.

Feeling discomfort in a muscle group during a repetitive task is a signal to think about how to achieve the same task in a different way. The idea is to vary the work load of individual muscles by allowing other muscle groups to do the same job. In this way no one muscle gets overused. This is the foundation of the MouseKeyDo® system.

SLIDE 29:
Let’s look at how examples of nerve problems can teach us to move smarter and avoid pain.

SLIDE 30:
This slide shows the pattern of numbness/pain in a person who might suffer from cubital tunnel syndrome, which is a problem involving the ulnar nerve.



SLIDE 31:

In 1973, Apfelberg's work (7) showed the dynamic anatomy of the ulnar nerve at the elbow. He injected an acrylic mold into the cubital tunnel of a cadaver when the elbow was flexed (seen in the top diagram) and extended (as seen in the bottom diagram). He found that the acrylic mold was flattened and deformed in the flexed position. This flattening is what we believe happens to the small arterials that feed the nerve, thus starving the nerve of oxygen. The patient then feels electrical changes, such as numbness and tingling, or even weakness if left untreated. These symptoms are caused by ischemic changes in the nerve.

In the bottom, extended position, the acrylic mold has a normal cylinder pattern implying no deformation of the nerve would have occurred in this position. This is a very nice demonstration of what can happen to the ulnar nerve just by bending the elbow excessively.

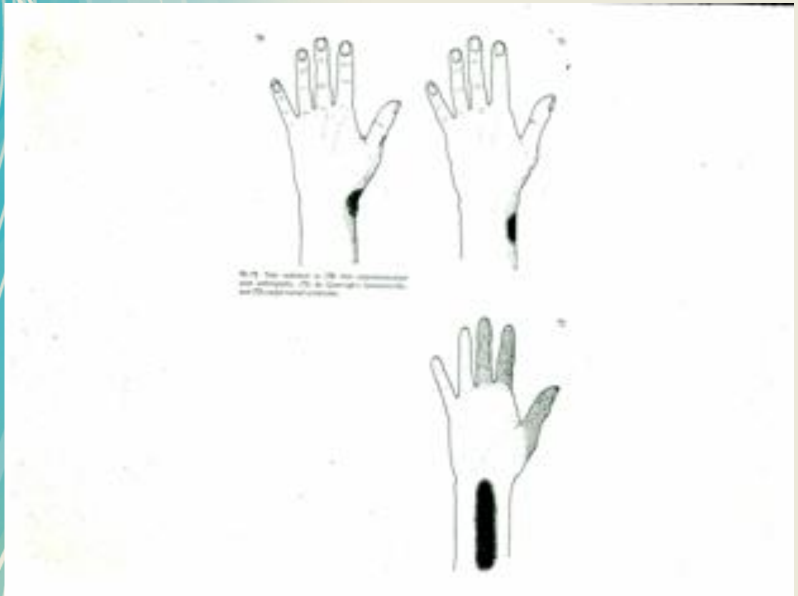
In another study, not shown here, MacNicol (98) has demonstrated that the ulnar nerve can also be compressed at the elbow by wrist extension, wrist ulnar deviation, shoulder abduction, and direct pressure on the elbow when there is a slight bend at the elbow to begin with. Each of these additional moves in an already flexed elbow put traction on the ulnar nerve at the elbow, which can increase cubital tunnel pressure and subsequent symptoms.

SLIDE 32:

At the top of this slide, we see a subject doing the "elbow flexion test" to provoke cubital tunnel symptoms. It is done by asking the patient to flex their elbow and extend their wrist simultaneously as seen in the top figure. Can you think of a typical position a computer worker might normally and unknowingly do that resembles the elbow flexion test? Remember the left arm of the person with the striped T-shirt in slide #24. People often take this position while waiting for information to appear on the computer screen. They flex their elbow, rest their forearm or wrist on the wrist rest, and extend their hand and fingers in preparation for their next action.

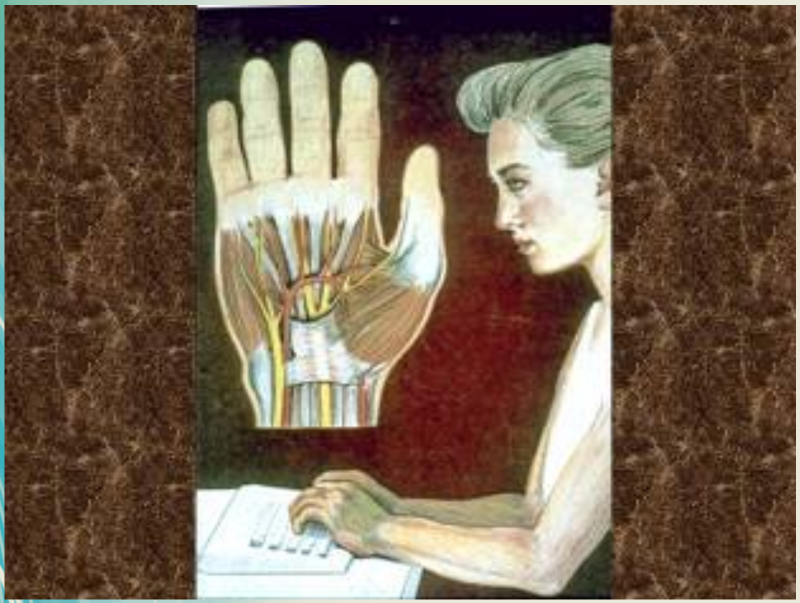
SLIDE 33:

Here I am with my son, reading newspapers on a couch. I'm demonstrating what not to do. To avoid cubital-tunnel-like symptoms in this position, keep your left elbow straight, like the kid on the left, and not flexed, like me on the right.



SLIDE 34:

The last nerve problem I would like to talk about is carpal tunnel syndrome. Typically, you will see a pain pattern like the bottom right figure in this slide. There would be numbness and tingling involving the thumb, index, long, and half of the ring finger, as well as potential for wrist pain on the volar aspect of the forearm. The other two pictures on slide 34 are the typical pain patterns for de Quervain tenosynovitis, on the top right, and carpometacarpal joint arthritis on the top left.



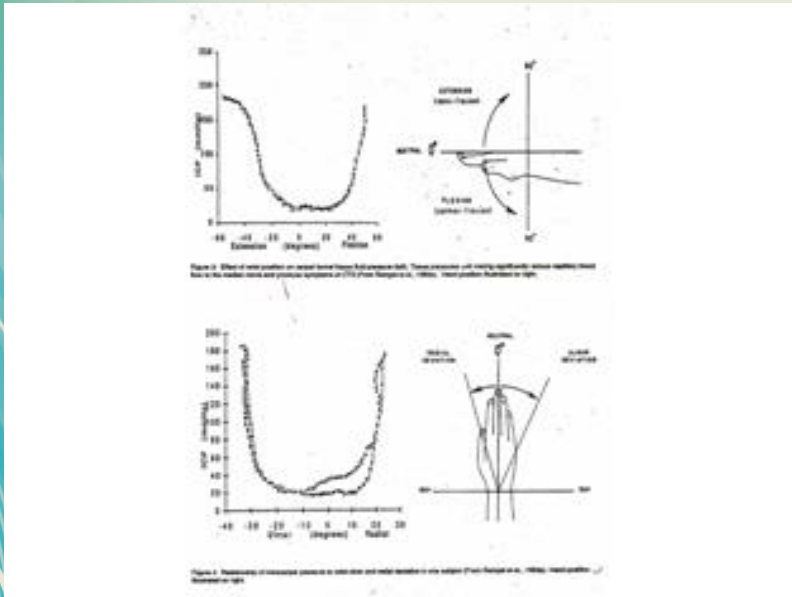
SLIDE 35:

The general consensus on carpal tunnel syndrome (CTS) is that it's caused by an ischemic problem, in other words, lack of oxygen, caused by high pressures of approximately 30mmHg or more around the nerve that collapse the arterials feeding the nerve. The work-related risk factors include repeated exposure to extreme wrist angles, prolonged grip force, vibration, and/or cold temperatures.

SLIDE 36:

Researchers at the University of California, San Diego developed a technique in 1981 that uses a catheter to measure carpal tunnel pressures (41). They actually put a catheter into the carpal canal to measure the pressure in the wrist (see the catheter tip in the wrist in slide #36). In people with carpal tunnel syndrome, the pressures were elevated to approximately 30 mmHg. People without carpal tunnel syndrome have pressures in the 5-8 mmHg range.

After the subjects with diagnosed carpal tunnel syndrome had surgery for it, their pressures were again measured and they had dropped significantly. This work established a technique of measuring pressure in a compartment using a catheter. Physicians then used this technique while people performed different tasks to see what would cause pressures to exceed 30 mm. This is important, because the number 30 mmHg represents the significant pressure required to cause tissue ischemic changes. Therefore, in order to develop safety guidelines for movement, we try to keep tissue fluid pressures under 30 mmHg for any highly repetitive tasks done over a long period of time.



SLIDE 37:

This slide shows the results of studies by Rempel, at the University of California, Berkeley, where subjects with catheters in the carpal tunnel performed various keyboard functions (118, 124). On the left top and bottom, you see graphs in which the vertical axis represents mmHg of pressure in the carpal canal. On the horizontal axis of each graph you see wrist angle. At top right are the wrist flexion and extension angles superimposed over a flexion and extension wrist angle diagram. At bottom right are the wrist radial-ulnar angles superimposed over a radial ulnar angle diagram.

In summary, the wrist angles can move approximately 15 degrees in any direction of flexion, extension, ulnar or radial deviation, before they reach the critical pressure of 30 mmHg. Put another way, to avoid carpal tunnel syndrome, keep your wrist angles within 15 degrees from neutral.

Some professionals recommend wearing a wrist splint while typing to keep the wrist straight, but I recommend against it. The wrists do not need to be straight while typing, and a splint may in fact create more pressure by limiting movement. You will learn to keep your wrists in the acceptable ranges when you learn the “Drop”.

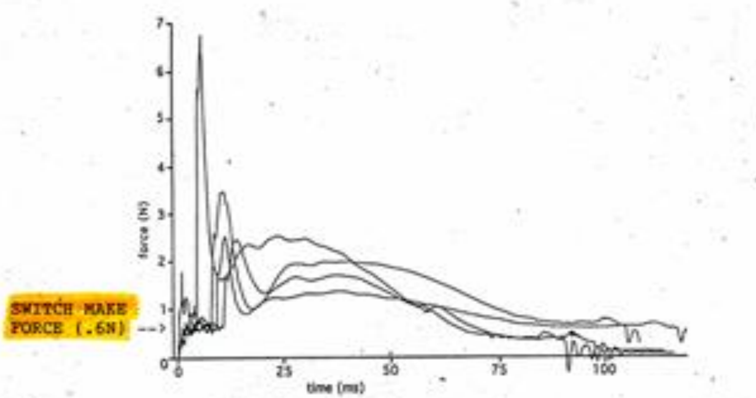


Fig. 3. Four typical fingertip force histories during an 'h' keystroke; each is from a different subject. The shapes of the curves are similar although different force magnitudes and event times are apparent between subjects. The force measured during phase I converges on the switch make force of 0.6 N. These curves are more descriptive than under the keyboard force measurements.

SLIDE 38:

This graph measures the force and time profile of a fingertip hitting a keyboard key. The vertical line on the graph represents the force in Newton’s (N). The horizontal line represents time in milliseconds. The setup of the study involves putting a force transducer under the keycap and then measuring the force a fingertip exerts on the key, as well as the length of time the fingertip makes contact with the key during a normal keystroke (119).

At time 0, the force is 0, since the finger has not contacted the key.

As the finger hits the key a force is recorded. The switch make force occurs at 0.6 N. This is the force needed for the input of data and occurs at approximately 10 milliseconds. Any more force or time spent on the key is wasted energy and time. As you can see, some of the key strokes bottom out and reach 6 or 7 N. Also some of the key strokes last over 100 milliseconds on the key. This represents 10 times more force than necessary, over 10 times the needed amount of time, an excess of risk for pointless effort.

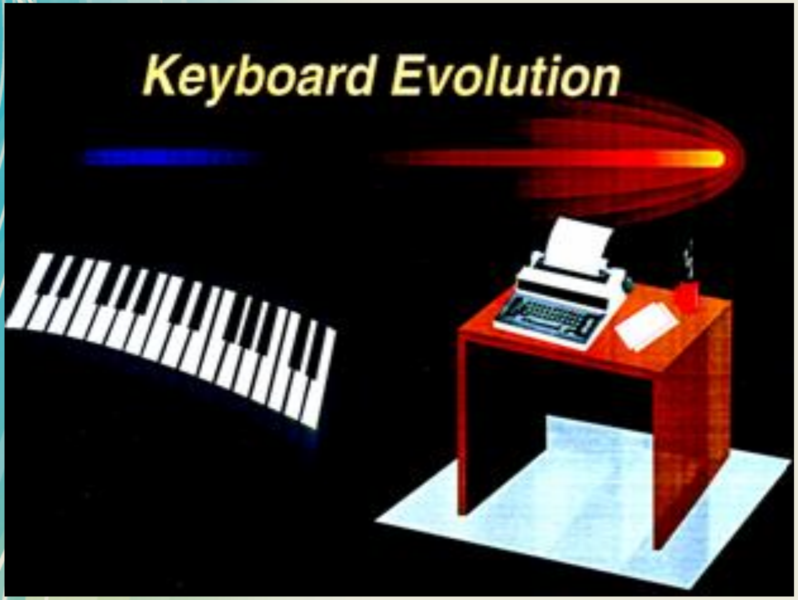
The MouseKeyDo® System avoids this inefficiency through the “Roll,” a way of hitting multiple keys with the minimal necessary force and time by using a rolling motion of the arm and hand. You can find out more about the "Roll" and its companion motions, the "Drop" and the "Beat," in the article entitled “Technique Addresses Computer - Related RSI, Part Two (76).”

SLIDE 39:

This is an example of someone who has gone through training. He is sitting without a backrest, so we consider this unsupported erect sitting. The angles of his shoulders are under 25 degrees of flexion and under 20 degrees of abduction.

His neck angle is slightly tilted at the mastoid, and is less than 15 degrees of flexion. His elbow angles are at a bit more than 90 degrees, in fact probably about 100 degrees as we talked about earlier. The wrist angles are slightly extended (considered the "position of function"). The fingers over the keyboard are curved to conform to the natural position of the hand. Lastly, the fingers do not line up to the traditional keyboard "home row.". The reason that the fingers do not line up is because they are not all the same length. As the middle two fingers are longer than the index and pinky, they should not have to be on the same row as the index and pinky fingers. We will talk about this more when you learn the “New Home Row.”

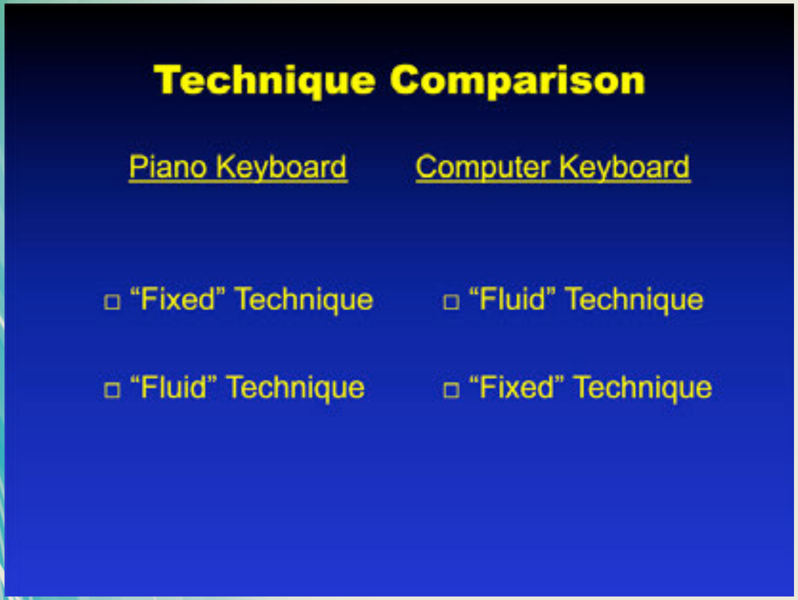
Since this is a still shot, the angles appear fixed. When typing, however, we are moving within a range of safe angles for each joint. For more on this, please review Chapters 11 and 12 of the MouseKeyDo® training manual, which you can view on the mousekeydo.com home page under the “MouseKeyDo® Systems” link.



SLIDE 40:

Pianos used to have very small, rigid keyboards, requiring pianists to play with static arms and forceful, busy fingers. Over time, the keyboard grew to be longer with more keys. This required piano players to use more whole body movements, rotational moves of the arms and shoulders, and weight shifts at the hips, seat, and feet in order to reach all the keys.

By comparison, typists once had to use their whole arms to move their hands up and down several tiers of keys, press stiff keys, turn knobs, and push the return lever. As computer keyboards became flat surfaces with a separate keystroke for every function, typists began to sit rigidly, with stiff arms and busy fingers.



SLIDE 41:
As you can see, the two kinds of keyboards switched techniques! The pianist went from a rigid, fixed posture with static arms and busy fingers to a more fluid technique that used whole-body motion. The typist shifted from a fluid technique of upper body moves to a more static "touch typing" method of static arms and busy fingers.

Although pianists aren't immune to RSI, some of their evolved techniques are valuable in order to make keyboard use more comfortable and fluid without losing efficiency (99, 142). The MouseKeyDo training program incorporates lessons learned from pianists and earlier typewriter users, as well as percussion concepts like the "Drop" and the "Beat."

SLIDE 42:
This is Mountain Sky in Montana, where we were taking a break from our horse ride.

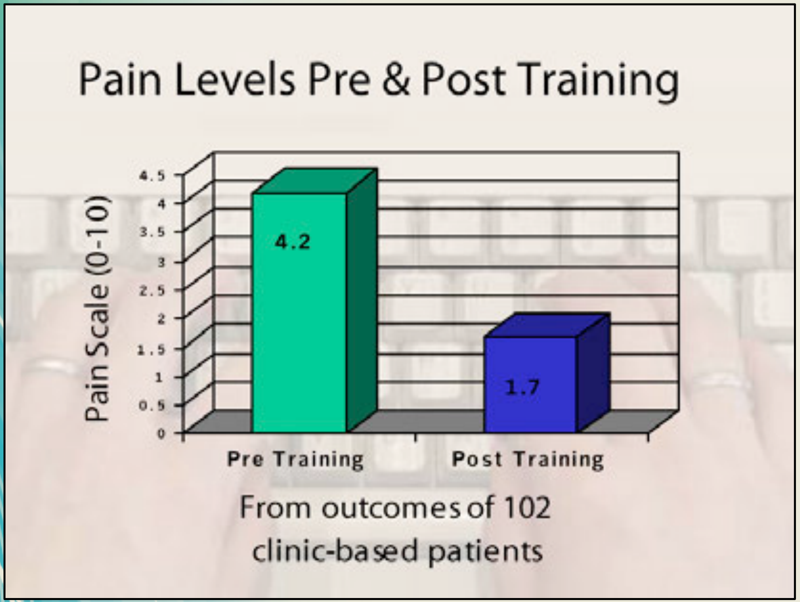
Let's take a quick break ourselves to talk about reference materials. If you visit the Research & Development link at mousekeydo.com, you'll find several outcome studies of the training program. I'm going to summarize some of the important findings for you.

Our group at Sports & Occupation Medical Associates conducted a three phase investigation.

PHASE I: Evaluated the outcome of 102 worker's compensation patients who underwent individual MouseKeyDo® training in a clinic-based setting.

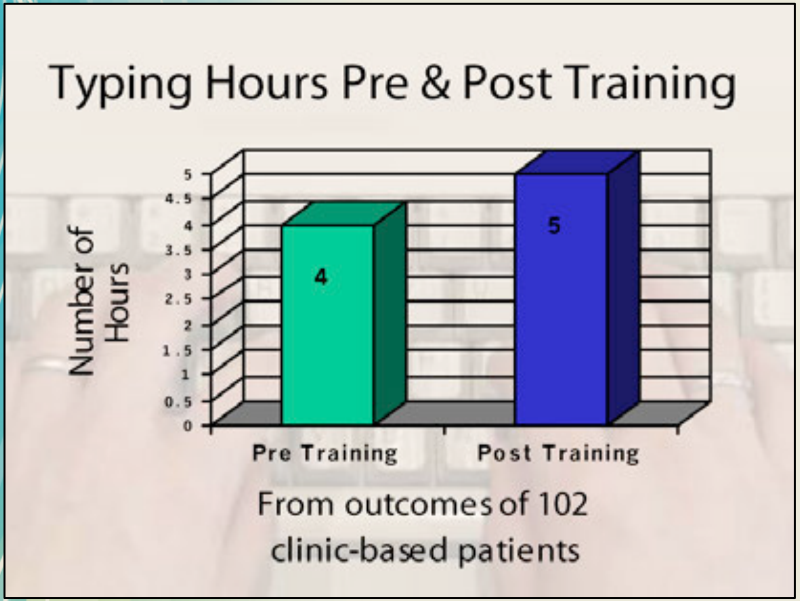
PHASE II: Evaluated 81 injured employees in a group worksite-based training program. Subjects were evaluated before, immediately after, and 1.3 years after training.

PHASE III: Evaluated 7 subjects using surface-electromyography (S-EMG) and joint range of motion (ROM) of the right upper limb both before and after mouse and keyboard training.



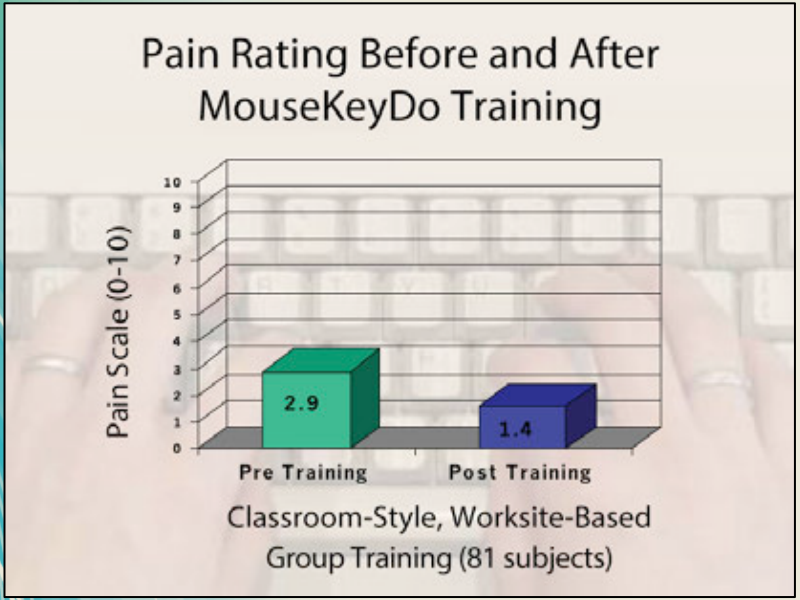
SLIDE 43:

Looking at the 102 workmen's compensation patients in phase I, and using a scale of 0-10, where 10 is the worst pain and zero is no pain, the average pain ratings went from 4.2 before MouseKeyDo (MKD) training to 1.7 after training.



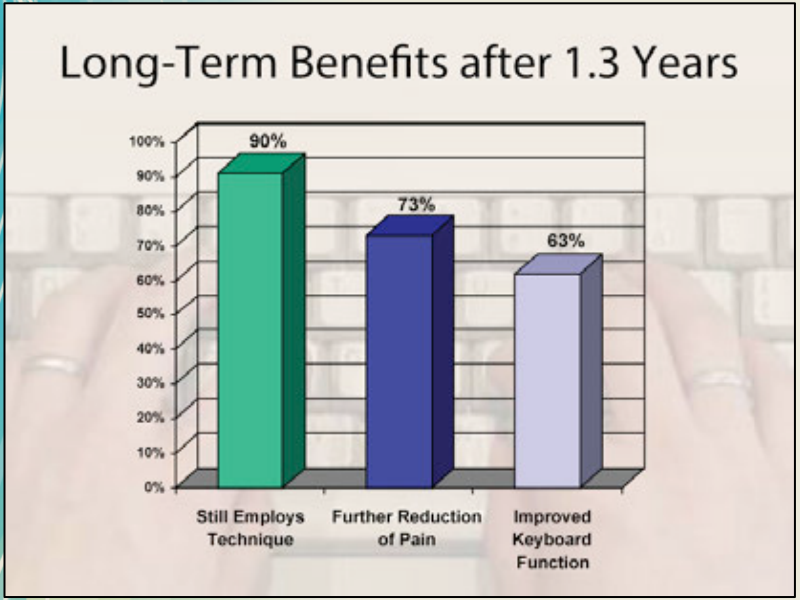
SLIDE 44:

On average, our population of worker's compensation patients typed 4.2 hours per day. We also found their cumulative typing hours increased by one hour per day. It took approximately 4.8 to 6 months to reach maximum medical improvement, a term referred to in workers compensation terminology as permanent and stationary. 85% of patients reported a minimal category of pain, considered an annoyance. Patients who could not type at all before training because of severe pain were able to type 3.6 hours per day after training.



SLIDE 45:

As part of phase II, and after refining a system of training individual patients, we developed a model of training groups of individuals in a classroom-style, worksite-based training program. Group sizes ranged from 8-12 individuals. The pain levels in the 81 subjects who participated dropped from 2.9 down to 1.4 on a scale of 0-10.



SLIDE 46:

1.3 years after completing the group training program of phase II, we evaluated how much improvement each of the subjects continued to experience. They were all using their self-guided training manual to reinforce their new skill set. Findings were as follows:

- 90% continued to use the MouseKeyDo® technique for their keyboarding and mousing work.
- 73% felt that their pain continued to diminish with time.
- 63% felt that they were functioning better at their computer.

The take home message is: Teach people how to help themselves by teaching them a new set of keyboarding and mousing skills, and they will continue to practice, especially if it makes them feel better physically.

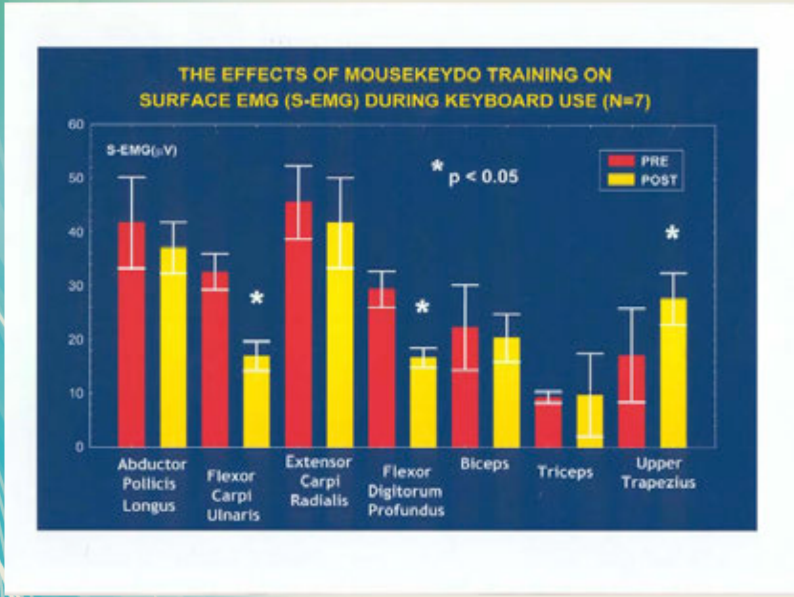
SLIDE 47:

This slide shows a phase III subject fitted with surface EMG recording electrodes. Each strap secures two surface electrodes on the skin surface of the right arm and over the trapezius. We looked at 7 muscle groups in the right upper limb of each of our subjects. Underneath each of the Velcro straps is a surface electrode, which records group muscle activity, very much like biofeedback. We studied the muscle groups to the thumb, to the little finger, to the wrist extensors and flexors, the elbow extensors and flexors, and the trapezius.

So for instance, the arm extensor muscles are the muscles in charge of lifting the wrist and fingers. The arm flexor muscles are in charge of depressing the keys. The biceps muscle lifts the forearm. The triceps group drops the forearm along with gravity and the trapezius muscle lifts and stabilizes the whole shoulder girdle and arm. We studied each of these muscle groups both before and after mouse and keyboard retraining.

SLIDE 48:

In phase III, two certified hand therapists measured the changes in the range of motion of each joint in the shoulder, elbow, and the wrist of the right upper limb during mousing and keyboarding. In this image, one of them is using a handheld goniometer to measure the side-to-side angle such as shoulder internal and external rotation, as well as wrist ulnar and radial deviation. Not shown is a hand therapist viewing the subject from the side in order to measure the shoulder flexion and extension angle, the elbow flexion and extension angle, and the wrist flexion and extension angles.



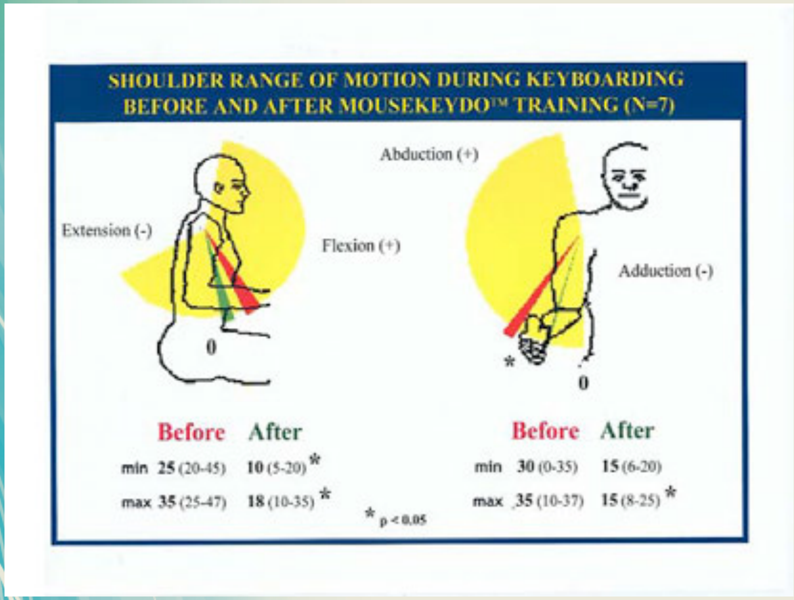
Slide 49: Surface EMG during keyboard work. *Surface EMG root mean square recordings during two minutes of keyboarding on seven muscles of the right upper limb and neck before (red bars) and after (yellow bars) MouseKeyDo™ training. Dependent T tests were used to determine statistical significance with P <.05 indicated by asterisk(*).*

SLIDE 49:

This slide illustrates the effects of MouseKeyDo® training by comparing surface EMG during keyboard use before and after training. The red or darker color bar graphs denote the amplitudes prior to training, and the yellow or lighter color amplitude bar graphs are post training for each of the muscle groups labeled on the horizontal axis. On the vertical axis on the left are the surface EMG amplitudes. On the horizontal axis are the different muscles groups labeled from left to right, representing distal to proximal right upper limb muscles.

For example, the most distal muscle studied was the abductor pollicis group, then the flexor carpi ulnaris, the extensor carpi radialis, the flexor digitorum profundus, the biceps, triceps, and, most proximally, the upper trapezius muscle.

In each case you see that the amplitude is decreasing in each muscle group after training, except in the neck where you see an increase in activity. I believe the workload is being transferred from the fingers and wrists to the forearms, elbows, and shoulder girdle. We believe that the increased activity in the neck and shoulder represents the musculature now navigating the arms and fingers. That is, the fingers follow where the arms go rather than the reverse. The “arms do the walking” not the fingers. The movements are more kinetic than isometric throughout the whole upper limb. The fingers and wrists are now resting more, because the more proximal limb musculature is taking over for some of the work. Instead of the fingers flexing and extending to depress the keys, some of the work is accomplished by the arm moving up and down from the elbow, powered by the biceps and triceps. Instead of the fingers curling and reaching to go forward and backward across the keyboard (towards or away from the monitor), the shoulder is now flexing forward and extending backward, moving the whole arm across the keyboard.



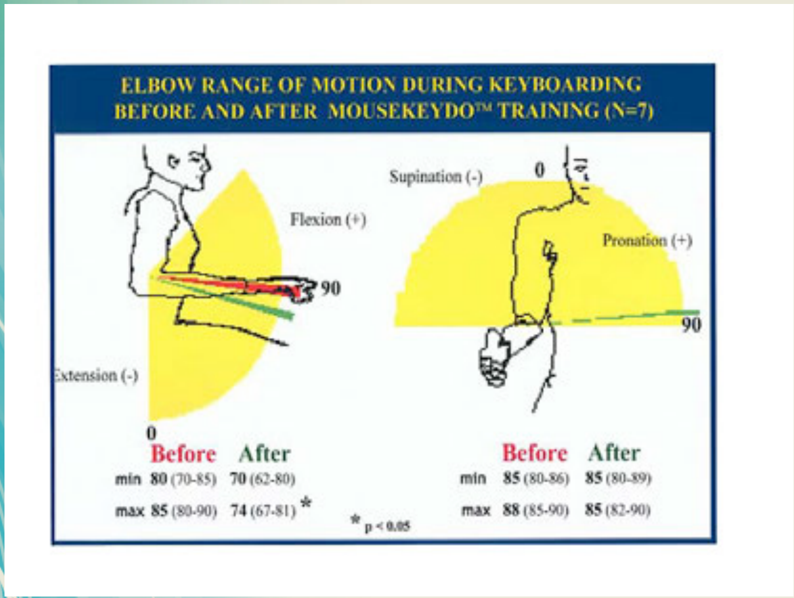
Slides 50–52: Changes in range of motion for the shoulder, elbow, and wrist. *Changes are denoted during two minutes of keyboarding before and after MouseKeyDo™ training in seven subjects. Joint position is expressed as a median followed by the minimum and maximum values of the data sample in parentheses. An (*) denotes statistical significance with p < 0.05. Yellow is the full range of motion, which the selected joint is capable of performing; red is the before- training range of motion for the selected joint; green is the after-training range of motion for the selected joint.*

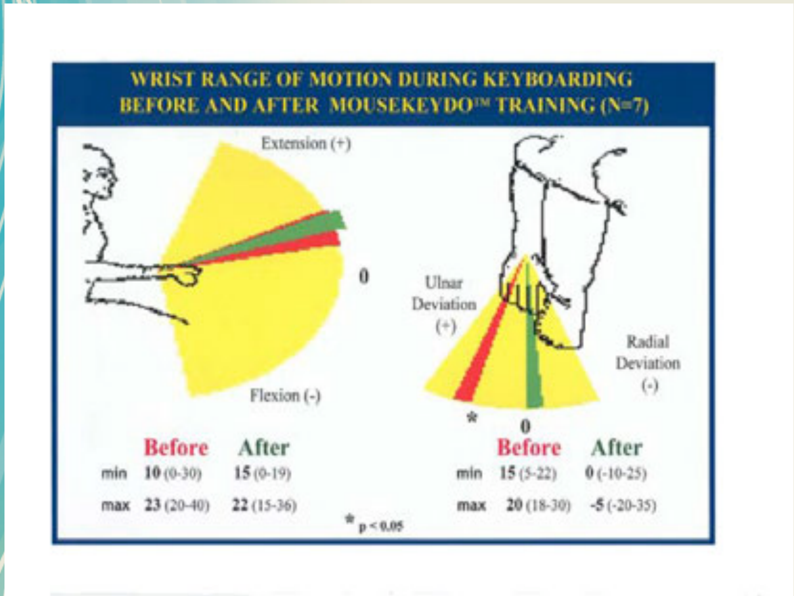
SLIDE 50:

In this slide, we see shoulder range of motion changes before and after MouseKeyDo® keyboard retraining. The yellow arcs represent maximum range of motion, the red the arc of movement before training, and the green the arc of movement after training. On the left, the range of motion is between 25 to 35 degrees of shoulder flexion, outside the safety range of 25 degrees. After training, the subjects sit more erect or upright, with the keyboard closer to their body so they need not reach out at the shoulders. The green arc of shoulder flexion is 10 to 18 degrees, well within the recommended guidelines.

On the right side, you see the shoulder abduction and adduction ranges. Prior to training, subjects typed with arms held at between 30 to 35 degrees. This is outside the safety range of less than 20 degrees. After training the shoulder angle drops to 15 degrees.

This is typically what happens in the training program. As you start to learn the technique, you begin to bring the keyboard and mouse closer to the body to make them extensions of your body, and you straighten your spine and neck, eliminating a lot of neck, arm, and shoulder tension.





SLIDE 51:

This is the elbow range of motion before and after MKD keyboard retraining. In the left figure, the elbow angle is slightly more open at 90 degrees. In slide #21, we used a different reference system in which full extension was 180 degrees. Here full extension is labeled as 0 degrees, so do not be confused.

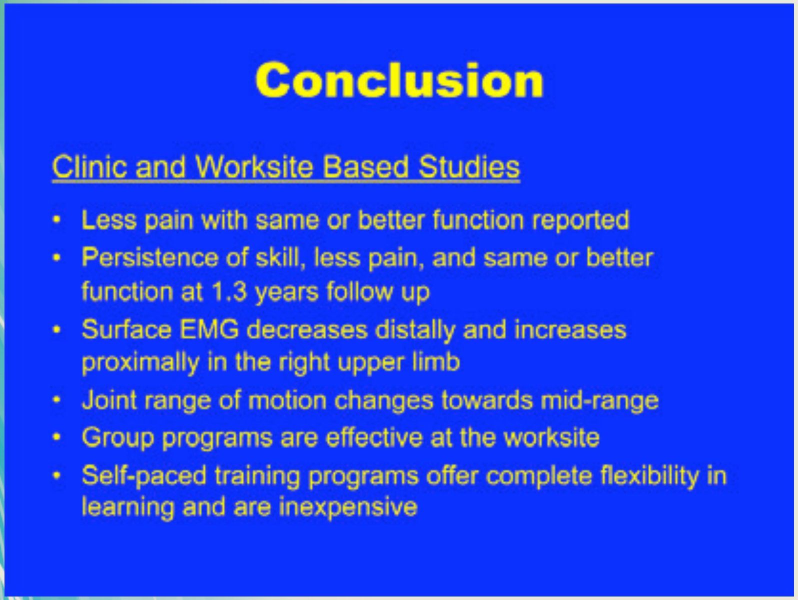
We did not see much change in absolute measurements for supination and pronation angles, but as you will see when you learn the “Roll,” a small pronation or supination move at the elbow allows the hands and fingers to move effortlessly with great efficiency across many keys (76).

SLIDE 52:

This slide depicts pre and post-training range of motion in the wrist. The left figure shows flexion and extension, while the right shows ulnar and radial deviation. On the left, the range of motion is greater before training. After training, the up and down moves of the fingers and the hand minimize. The forearm augments the up and down movements by moving the whole arm as a single unit from the elbow, using the biceps and triceps rather than the wrist flexors and extensors of the arm. This is known as the “Drop.” It helps treat lateral and medial epicondylitis by decreasing the repetitious use of the wrist and fingers for flexion and extension, which the forearm now does by moving at the elbow axis powered by the biceps and triceps. Imagine a hammer moving up and down from the elbow as you tap on a nail.

The ulnar/radial range of motion changes dramatically. Before training, the subjects type and mouse with a 15 to 20 degree angle of ulnar deviation. This can contribute to pain at the wrist, the elbow, and the back of the shoulder or scapular region. After training, subjects held their wrists in a more neutral position, replacing many side-to-side moves with the shoulder’s external and internal rotation to alleviate the wrist and finger workload. This technique has been effective in relieving wrist pain from de Quervain tenosynovitis, lateral epicondylitis (tennis elbow), and medial epicondylitis (golfer's elbow), as well as nonspecific tendinitises which occur in the thumb and pinky sides of the wrists. We have not seen it cause shoulder or neck pain, even with greatly increased use of the shoulder girdle.

MouseKeyDo® training for the mouse had similar before and after range of motion (ROM) and surface electromyographic (S-EMG) results. Skills to learn here will be the "Drop," "Drape," and "Skate" techniques.



SLIDE 53:

In conclusion:

- 90% of users report less pain with same or better function during keyboard and mouse work after the MouseKeyDo(R) training program.
- Patients unable to type due to pain before training were able to type 3.6 hours per day after retraining.
- Persistence of skill, less pain, and same or better function were seen at 1.3 years follow-up.
- Surface EMG decreases distally and increases proximally without an increase in neck or shoulder pain.
- Joint range of motion changes toward mid-range, with wrist, elbow, and shoulder joints working collectively, achieving motion at the lowest level of joint stress and muscle tension.
- Group programs are effective at the worksite.
- A self-guided training program – the MouseKeyDo® system CD-ROM and training manual -- offers complete flexibility in learning and serves as a tool to facilitate the retraining process up to 75% faster than without it.

SLIDE 54:

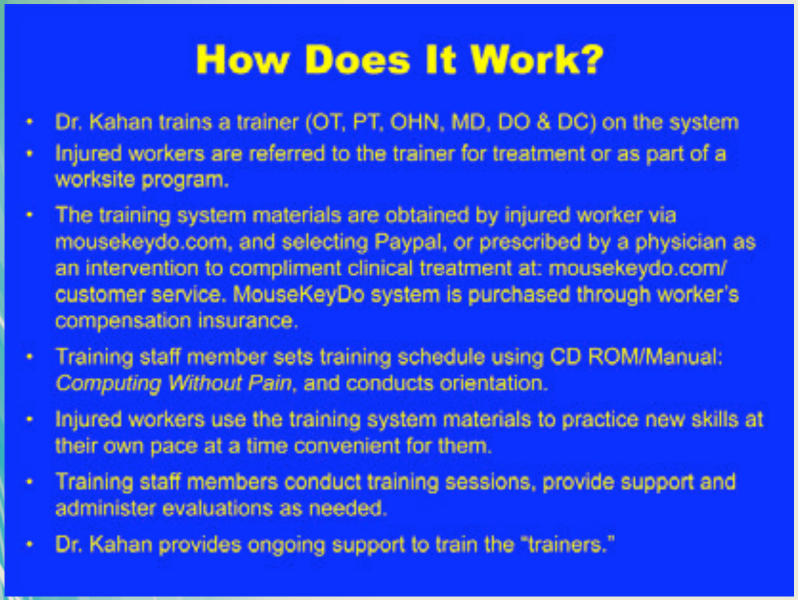
This slide shows a typical training session. I'm in the red shirt. The patient is wearing an elbow splint. MouseKeyDo training involves a lot of hands-on work and one-on-one training with your patient. Based on my experience, you should take 4 to 6 visits to train the patient, spending approximately 45 minutes per visit.

Encourage patients to review the workbook and CD-ROM before starting supervised training, and urge them to practice at least 20 minutes a day on their own. The training system also includes logs and references to use as tools to ensure your patient has reviewed the material.

SLIDE 55 & 56:

Again, here I am training a patient. You can see we are both having fun. Hands-on work helps people learn this new skill set, which includes learning to use gravity and relaxing their shoulders, hands, elbows, and fingertips as they type.
As you can see, training requires very little equipment:a computer with keyboard and mouse, a simple chair, a desktop surface that is about level with the patient's elbows when the arm is fully relaxed from the shoulder.

It's your job to zero in on the places where your patient feels pain and help them change their typing mechanics to eliminate the causes of that pain. It's also critical that your patient associates the pain with using a computer. This may sound simple — but a patient who doesn't believe computer use is part of the problem is unlikely to see keyboard retraining as part of the solution.



SLIDE 57:

How does the training program work?

FOR THE COMPUTER USER WITH PAIN:
If you are experiencing wrist, arm, or neck pain which is aggravated by computer use, and you want to begin training, just order the MouseKeyDo® System Training Manual/CD-ROM. It has been designed as a self-guided learning tool.

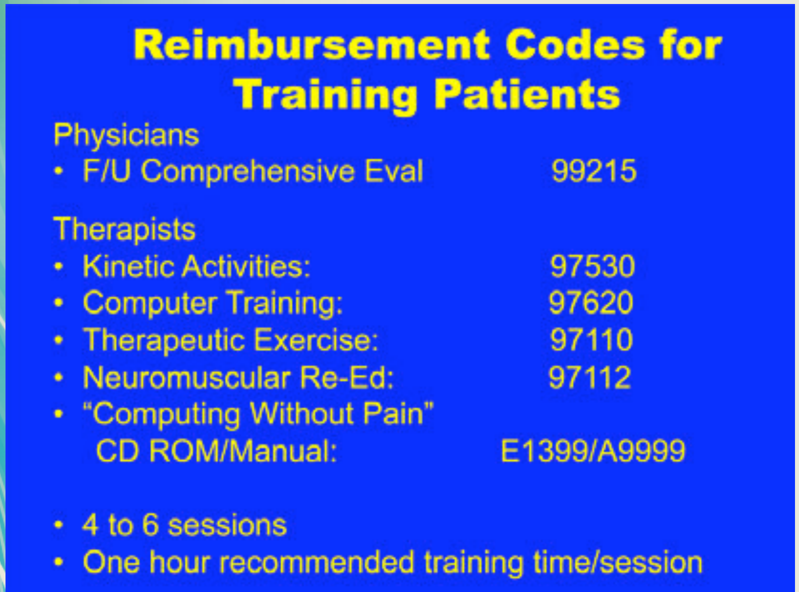
If you need any additional training or have questions, just contact Dr. Norman Kahan or a MouseKeyDo® provider near you.

In many cases and with preapproval, your Worker's Compensation or Private Health Insurance will pay for the training materials (meaning the training manual/CD) and supervised training by a licensed physical or occupational therapist. To start the process, visit mousekeydo.com, go to the "Customer Service" page, choose "purchase the MouseKeyDo System," and click on "through Worker's Compensation or Private Health Insurance." Download a prescription form and ask your M.D., D.O., or D.C. to sign it. Then place an order as directed.

IF YOU WANT TO BE A MOUSEKEYDO® PROVIDER TO HELP COMPUTER USERS WITH PAIN:
To become a MouseKeyDo® trainer and provide this service to your employees or patients as part of your ergonomic program or therapy treatment plan, just contact Dr. Kahan or another MouseKeyDo® provider near you. Once you learn the techniques, it is easy to incorporate the program into your existing ergonomic program or practice. Begin by using the self-guided MouseKeyDo® CD and training manual on your own, then contact Dr. Kahan or another provider for further training.

A typical model when dealing with Worker's Compensation or Private Health Insurance works like this.

- Dr. Kahan or a MouseKeyDo® provider trains a trainer (an OT, PT, occupational health nurse, M.D., D.O., D.C., ergonomist, or PT assistant) to become a provider.
- Injured workers who need supervised training are referred to a MouseKeyDo® Provider for treatment or as part of a worksite-based program.
- The training provider sets the schedule and conducts the orientation.
- Injured workers use the training materials to practice and reinforce their new skills, at their own pace, at times which are convenient for them. Providers conduct training sessions, provide support, and administer evaluations as needed.
- Dr. Kahan provides ongoing support to the trainers.
- We're looking forward to helping you get started!



SLIDE 58:

These are the current procedural training codes necessary for healthcare providers (OT, PT, OHN, MD, DO, DC) to submit for maximum reimbursement for services, which include the following:

Kinetic activities:	#97530
Computer Training:	#97620
Therapeutic Exercise:	#97110
Neuromuscular Re-education:	#97112

"Computing Without Pain with the MouseKeyDo System" CD ROM/Manual: #'s E1399/A9999.

To learn more about this system and the evidence on which it is based, please review the reference articles in the Research and Development section of the mousekeydo.com website. You may also contact me directly.

Thank you,

Norman J. Kahan, MD