What You Never Knew

About Mousing!

or

Some Possible

Physiological Implications

of

Gripping & Clicking Computer Mice.

By

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Introduction:

"A Ring a ring of, roses; a pocket full of poses; atishoo, atishoo; we all fall down." This "nurse rhyme noir' is a grime reminder of another rodent mediated plaque that befell a 14th century European/Asian society that constructed an ill considered infrastructure based on good intent, though in ignorance. While the cause of the Black Death is now obvious the agent a bacteria called Yersinina Pestis was not as back then bacteria were undiscovered. That fleas on rats could carry such a thing would have been beyond the realms of what we now call science fiction. While Yersinina Pestis must had been around a long time its success, which is what an epidemic represents for any species of bug, can be attributed to a change in our social infrastructure with inadequate technology that didn't know or anticipate its existence or mechanism of "infection propagation". This alone should be a cautionary tale for any new human endeavor that is likely to impact millions of people. Recovery from the Black Death, in Europe at least, took 150 years or more of infrastructure redevelopment and changes in perceptions, habit and so practice. Presumably, in the absence of knowledge of bacteria, on the basis of experimentation, common sense and what was seen to work. Ironically, though coincidentally, Yersinina pestis is an anaerobe and the issue in this 20th Century technology plague once again appears to involve the consequences of aerobic verses anaerobic conditions and ironically the Rat, the propagator of that old plague could be lending a hand, quite literally, in starting to find a clinical basis for this problem.

The problem, Repetitive Strain Injury, or Repetitive Stress Injury, we'll call RSI, is an assumptive name used as a catchall and by most as an explanation of a medical condition. As such it is wholly unsatisfactory, like calling a fractured fibula or tibia "falling over injury". Unfortunately medicine has been drawn into this debacle on a "needs" basis as always, in the absence of clear understanding and best practice, good medicine is called upon as a last resort.

RSI is zoned on the basis of "body parts" and categorized by the discipline of the clinician that deals with each zone. Consequently we have Work Related Upper Limb Disorders (WRULD) and all the other acronyms that depict anatomy and not physiology and finally we hone in and reach medical descriptors such as carpal tunnel syndrome (CTS) that provide authority to the consensus that we are dealing with a disease not an unviable method of working. Such conditions have never been seen at these levels before so it is obvious that focusing on disease is looking at consequence and not at cause.

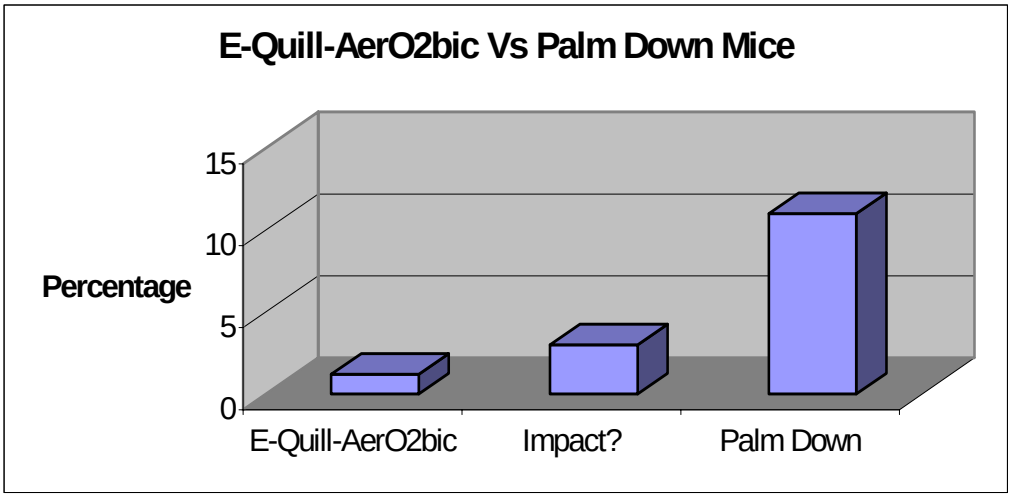
Background:

The science of "ergonomics" has evolved out of what were the time and motion studies of the sixties. It is now cited as the science of man's interaction with his work, but as a science it is considerably soft in terms of specific objectives and measurement tools [one man's opinion]. The science of biomechanics however is more numerate and seeks to measure so compare the load and impact of different human tasks and rule out opinion and "individuality". Developments in dynamic techniques for analyzing load while performing tasks have to some extent revolutionized sporting performance by improving technique and also the tools that are employed. Two Biomechanists in private practice in the UK, advisors to UK national sports teams, top athletes and celebrities, also performed

research at UK Teaching Hospital. Their research (extract below) designed an experiment to look at "muscle tone" development in computer mouse users.

While muscle tone per se is not a specific indicator of anything but physiological change, it can be used as a benchmark of expectation of consequence. That is to say that any task that invokes a muscle tone response greater than 3% is considered to have physiological consequences. If you are a body builder and you work to a program they are likely positive. If seeking weight loss or simply cardio exercise then a 20 minute "burn" three times a week will invoke responses that are beneficial. What is not known however are the consequences of working for 8 hours, or more, a day in a posture that continuously invokes muscles tone in small muscle groups under sedentary conditions? All other forms of exercise and manual labor require a rest and recovery period and are also performed under elevated respiratory (breathing and heart rate) circumstance, which is stimulated when the larger muscles of the body are employed.

The study that precipitated the design of the computer mouse now known as the E-Quill-AirO_2bic Mouse employed three subject groups, a resting or control group, a group that used a pronated [palm down] mouse and a third group using a prototype device (not the actual mouse of today) that placed the hand in a mid pronated [handshake"] posture. Both mousing groups followed a predetermined path across a mousing surface for a period of 45 minutes per subject. Under the analysis conditions described the average hand to shoulder muscles tone development in the pronated [palm down] subject group was 11%. For the mid pronated [handshake] group it was 1.4% or half that considered to have a physiological impact.



This initial evidence was compelling enough to suggest it was now possible to manage some consequence even if we could not find or yet model cause.

Posture and Working Practices (Cause and Consequence).

Most other breakthroughs in disease diagnosis, recognizing that the consequence of "this cause" results in disease, have come about through the development of new analytical

tools developed following the study of available damaged tissue, usually cadaver, and the study of a statistically viable population. More difficult in this case is the fact that we are dealing with a "phantom" causal agent that we postulate is a posture that makes the ordinary metabolic processes of some cells do ordinary things, but likely at an accelerated rate with the ultimate consequence being their, relative to the rest of use, premature death. So there is no physically determinable agent that we can excise or titre, subjects would likely be retired and so "non acute" before post mortem, so damaged tissue, data would be available and a medical history of RSI problems would not be considered as relevant enough to "cause of death" to merit such investigation at that time.

With a rapidly growing incidence of injury occurrence that tracks entirely with an increase in the application and the extent of use of computers and in the absence of a tangible cause or specific medical marker we are in a position in which speculation is popular, fact diverse and remedy seemingly not on the horizon. But, if as we anticipate, it is a localized consumption of the capabilities of "life" at an accelerated rate then we are inevitably seeking a cure for death, be it partial and or premature. With no expectation of finding a cure for (localized tissue) death we have resorted to an old adage that has kept us in good stead in the past; "If it hurts don't do it". What may seem a very trite statement is actually very relevant as the reality is that if you don't do work that makes you ache then you are less likely to go on to injury. The challenge is in knowing what is ache? In this model defined as when your metabolism has become exhausted and is an indication of fatigue, and what is pain? The result of an injury and the sensation, call it ache or pain, does not go away after resting or stopping whatever it was that was done to caused the aches. Injuries in this case would therefore be a consequence of being in the realms of ache too often and for too long! But for this model and process of unnoticed aches going on to become injury to be true it must assume that reasonably intelligent people, as the use of computers implies, do not notice when they aching?

We refer to them as "end of day wrist massagers". Look around the office about 4:30 in the afternoon and they'll show themselves. The paradox is that it maybe the gift of intelligence that is masking the aches so facilitating the risk and opportunity for injury. This is discussed in the section called Cognitive Distraction below.

Posture Impacts Molecules.

I wrote not too long ago, in response to another "ergonomic guru's" protestations that you can treat your knee bone in isolation to your toe bone.

"Biochemistry is the consequence of biomechanics, subject to the laws of physics, mediated by gravity, vectored by geometry and, if done with all those things in mind, may be managed by ergonomics".

In my opinion the term "ergonomics" would be best forgotten due to its misuse and abuse that has parted many people from millions of dollars of their painfully earned cash for products that do not work in the long term. Case in point; despite millions of dollars and almost ten years presence in the market ergonomic keyboards have not stemmed the RSI

tide. It has also cost employers, State, Government and insurance companies, billions more in false hope by turning short term medical intervention into long term care. I'll get to the politics later! Ergonomics could be better called The Science of Postural Physiology, but lets wage one battle at a time!

As a clinical biochemistry major (when I had a real job) this concept "Posture Manages Molecules" inspired my publication called Molecular Ergonomics (manuscript versions Parts 1 & II are available on the www.aerobicmouse.com website, under In House Publications.) These publications, like most of my other work in this area are intended for a lay readership and seek to inform rather than educate or opine qualified opinion. The premise behind all of these publications is that "work" is not the lowest common denominator, that because certain muscles or joints that do different work develop the same problem, even though medically they are zoned and so called different things, they are of a common cause. So if the anatomy and work is different and so the physiology is variable what factor, common to all, is not? The answer, I postulate, is Biochemistry.

When we are looking at complex systems and we cannot model an interaction between them we must work backwards to find the lowest level of decision making that any component of the matrix can make. At the molecular level; physics on this planet predetermines all chemical inter-action and so all outcomes. Therefore the only decision is to "react or not", which is governed by the availability of the substrate and reagent. Therefore this physic at this intracellular level is managed by what we will call supply chain issues and administration of this is at an individual cellular level. This is relatively important because ergonomics seems to miss the fact that individual cells can make their own decisions even though as a collective, a muscle, they act as one in response to neurological stimuli. By various means the cell will put out calls to the "supply side" system, which in turn makes demands on the "procurement" system. If we consider the circulatory system as supply side and the lungs as procurement, then we have a model that we can work with. The digestive system is not included as hunger if a supply side issue impacts all cells so tires all tissues. It therefore can be discounted as a short term impact with long term consequences. The primary issue we deal with here as the one that can have short term, transient and critical impact upon individual cells is the need for Oxygen! We should include the removal of the toxins, byproducts of our metabolism, but we won't for simplicities sake.

If the design of our bodies had been given a model number with a date stamp that date would likely be some 10,000 years ago. The model reference number would relate to "Pampas Living", hunter gathers near the top, but not at the top, of the food chain. The significance of that being that the physical effort nature designed us for would be to catch food or avoid becoming it! If you are at the top, catching is your only worry. While to develop the idea behind this might be interesting it is too involved to elaborate further.

There are three points; firstly there can be two motivations behind any physical (work) activity, fight or flight; secondly we have two mechanisms that suppress pain, one at the site of the injury as a result of extensive and traumatic cellular damage and the our suppression of pain awareness in the brain. The reason is simple; if we engage in battle

and get hurt, the damage means that we are more likely to loose and so maybe we should exit, but without these suppression mechanisms we might immediately react to that hurt and fall over in pain, in which case we're lunch! The third and most easily assimilated point in these allegedly more civilized times is that our "Pampas Design" never anticipated us using small muscles at limb extremities for hours at a time, day in day out, at or near fatigue activity levels while the larger muscles of our body's were at inactive or at rest.

As a result overworking some tissues while in a sedentary posture we suspect can create localized tissue oxygen depletion that could easily be satisfied if "procurement" were made aware of the need. But because the supply side, local blood circulation, is delivering all that it can under what is a centrally managed system, localized depletion has no impact upon the "sensory" system so as to increase respiration (procurement). The volume of oxygen depleted blood returning from the hands into the main venous system is too small, volumetrically, to dilute and so lower blood oxygen levels sufficiently to a level at which the brain's oxygen sensor can detect it and so initiate a response. If larger muscles are being worked oxygen levels fall sufficiently to increase breathing and heart rate and so muscles at limb extremities are supplied as at and only under those circumstances. The design of man is at total odds with man's design in regards to applying that extensive small muscle activity that computer input can require. We speculate that "metabolically out of bound" conditions can occur in aerobically active and insufficiently provided for tissues. There is one particular posture that probably exacerbates this lack of design update and it is that posture applied in gripping computer mice. You read about it below.

Speculating further and looking at one specific toxin and another back up system with a likely evolutionary benefit, the lactic acid cycle (LAC). If you cannot get enough air (so oxygen) via your, lungs, which is what tissue cells assume is the problem if oxygen levels fall, then any one cell can and will make a "last ditch" decision to go into LAC. The healthy body can't even anticipate that we can have localized oxygen depletion due to poor circulation, which is why gangrene is a problem. So the concept that we can adopt an activity in which we overuse small muscles without employing larger ones is totally alien to it. LAC is the only way a cell can produce energy in the absence of oxygen and the reason it is last ditch is because the toxin it produces, lactic acid, will damage the cell within a few minutes if adequate circulation and a return to normal aerobic biochemistry is not achieved. But a few extra minutes of energy could easily have been the difference between eating lunch and being lunch in our Pampas days.

It is not suggested that a catastrophic event or even an immediate single cellular death event takes place or that lactic chemistries are brought into play over large areas of tissue. We know when extensive tissue involvement occurs such as when we get a Charlie horse or the pain that is experienced during a heart attack as both are due to lactic acid build up. What is envisaged in RSI onset is that some cells cycle in and out of LAC, which may precipitate changes, possibly membrane related, that create cellular fragility so premature death. We now know due to research discussed below that repetitive negligible force work can cause micro-fractures at muscle bone joints that causes swelling and damage.

The fact that cells have a unique decision making capability in that they can and will migrate between aerobic and anaerobic chemistry at their own behest is an issue that ergonomics has not yet appreciated and is why muscles are very often treated as unified organelles. Localized tissue damage could then contribute to further disruption of the circulatory efficiency in muscle or soft tissue, which may impact other structures, such as nerves in their vicinity. Sometimes the obvious is obscure: many RSI sufferers complain of tingling sensations after they stop work. This is viewed as something bad is happening though when looked at another way it may indicate that something bad already happened and that something better is now occurring. If you fall asleep on your hand (or just tie a tourniquet around it, an alternative way of cutting off the blood supply) then when you awake and move and the circulation returns the same tingling sensations are typically experienced. Consequently tingling likely indicates a resumption of better circulation follow a period, which obviously correlates with the work performed, of poor circulation.

Circulation suppression as a process could explain a long term covert process with a multiplicity of impacts upon joints, nerves and connective tissues that are typically only noticed when some sort of "systemic crash" occurs. This is when a prevailing chronic ache condition develops into an acute pain one. As already mentioned the difference between aches and pains being that if you notice ache and rest it goes away, pain, as a result of injury, does not. So a primeval design benefit, in our more technological times, could now be the flaw that partly explains why we fail to recognize the ache stage and circulation suppression, in our opinion, is a reasonable model for the pathogenesis of the multitude of ailments that present as RSI. So we have a theoretical model, can we tie it into any facts?

External References to RSI:

Until now we have dealt with building a model for a physiological basis for RSI in general. In order to demonstrate efficacy for our solution, the computer mouse, we must distil any data available without adding any bias, which may indicate our premise that computer mice contribute to (we maintain are the primary causal agent) some of the injury circumstances seen. We suggest that the reason is because the design of existing mice, during the sixties was when computers were in their infancy and so the extent of their use was never anticipated and any potential impact thereof studied. Add to this the ergonomic consensus of the nineties that cited repetition and so keyboards as the culprit (and launched billions of dollars of ergonomic keyboard sales) and the conclusion that we might now draw is that the industry firmly grabbed both ends of the wrong stick. We also now know that grabbing anything, so as to maintain a grip, is a bad Static Posture.

After 4 years of working with public domain information from such bodies as OSHA I do not believe that any desktop study can be done conclusively. But then if it had been we would not need to be postulating new theory and trying to correlate it to known fact. Also most published injury data is skewed in that it only catches the (clinical) outcome and does not look at a normal "in population" distribution.

Population study data (looking at those with no problem, problems and in clinical) is far less abundant and that which there is can be subjective, subject to critique of construction and analysis technique and so with whatever bias it may induce several believed relevant will be pointed to, but by no means all. What is also interesting is that we have yet to find the name of any major mouse or computer manufacturer referenced, associated with, or overtly funding RSI research publications. I apologize in advance if it is simply because I haven't come across one. But then only 120 million mice a year are sold typically. It is also of interest to note that "ergonomic" as a descriptor on products has been pretty much abandoned or at least detuned it. I also find it amusing that one large mouse manufacturer boldly takes credit (on their website) for the fact that they invented the (thumb manipulated) trackball. In our Pampas design the thumb evolved as a counter opposing digit for the fingers so as to be able to form a "vice" by which to grip and not as a dexterous digit. It would be interesting to see any research undertaken ahead of such a products launch in regards to any impact on the CMC joint (base joint of the thumb) and opinions as to the recent incidence of thousands (possibly millions globally) of cases of De Quervain's disease, a problem with tendon lubrication in the thumb.

As I have mentioned it I will start with De Quervain's and refer to and thank the Canadian COHS. http://www.ccohs.ca/oshanswers/diseases/dequervain.html

What is De Quervain's disease?

De Quervain's disease is a term used to describe a painful disorder affecting the tendons at the base of the thumb. This is one of the most common kinds of tendon lining inflammatory diseases or tenosynovitis. These tendons are encased in sheaths, or sleeves, through which the tendons slide. The inner wall of the sheaths contains cells that produce a slippery fluid to lubricate the tendons. With repetitive or excessive movements such as hand twisting and forceful gripping, the lubrication system may malfunction. Failure of the lubricating system allows friction to develop between the tendons of the thumb and their common sheath. The repetitive friction accounts for the abnormal thickening and the constriction of the sheath which interferes with the smooth gliding motion of the tendons.

How can we prevent De Quervain's disease?

The prevention of De Quervain's disease consists of avoiding excessive movements such as hand and wrist twisting and forceful gripping. Thumb pressure in pushing controls or while typing should also be avoided.

The American Assoc. of Orthopaedic Surgeons:
This synopsis is taken from this link at Newswise.
http://www.newswise.com/articles/view/31441/

It provides general RSI injury "apocalypse" information 6M cases per year $60 Bn etc, and a section on computing and, by the inference that repetition provides, that the mouse has a high priority in terms of their consideration to injury. It is also interesting to note that now two independent bodies, the AAOS and ourselves, have, based upon their own medical consideration, advised against gripping a mouse and advocate using the whole arm to manipulate it. We also agree that Wrist Rests, talked about in more detail in "A Practical Guide To Mouse Keeping", are tourniquets for the wrist cutting off blood supply where vessels are closet to the surface. I am still amazed that these products are still on sale and more amazed that so many ergonomic suppliers, supposedly those who should know better, have them in their catalogue. The AAOS and we both advocate

taking regular "prompted" breaks, even more important if we consider we cannot trust our own senses, as Cognitive Distraction (below) suggests and a feature that is built into our software. For PC users we even provide the option to disable the mouse and keyboard so a rest break must be taken.

As part of the Prevent Injuries America!(r) Program, the American Academy of Orthopaedic Surgeons offers these tips to preventing workplace injuries:

Computer users:

*Take frequent short breaks from your activity; stand up, walk around, stretch.

*Learn to use the computer mouse sensibly. Choose a mouse that allows you to work with an open relaxed hand posture. Don't squeeze or grip the mouse between your thumb and little finger. Don't twist the mouse side-to-side; move the mouse with the entire arm. Don't use a wrist rest; this doubles the pressure inside the carpal tunnel. Keep the mouse close to the keyboard; don't stretch out to the side of the desk.

*Make sure your computer workstation is properly set-up. Choose a chair with a backrest that supports the curve of your lower (lumbar) back. Sit back in the chair when you work at a computer. It is important to position your thighs horizontal with your knees at about the same level as your hips. Rest your feet comfortably on the floor (or a footrest if you need one). Make sure there is enough room below the work surface to comfortably fit your knees and thighs. Consider having the height of the surface holding your keyboard and mouse or trackball about 1-2 inches above your thighs. Center the keyboard in front of your body. Correct placement of your monitor may help some individuals prevent eye strain, neck pain and shoulder fatigue by keeping your head and neck as straight as possible.

*Additional workstation considerations: locate your workstation away from sources of glare such as windows, organize your workstation so the objects you need most often are within easy reach, and some find it helpful to use a head set if you talk on the phone and type at the same time.

Danish Study: (via Reuters) at
http://www.abc.net.au/cgi-bin/common/printfriendly.pl?/science/news/stories/s797354.htm

In a study on 3,500 Danish workers at 11 companies over 18 months it concluded that, as a percentage of computer use time, those who used a mouse for 50% of the time had a four fold higher incidence of problems compared to those who use a mouse 25% of the time. Another study referenced in this article states "In a second study, researchers from the Odense University Hospital in Denmark found that those who used the mouse for more than 30 hours per week had as much as an eight-fold higher risk of developing forearm pain, double the risk of moderate to severe neck pain and triple the risk of right shoulder pain."

"The problem is not only the mouse, but performing repetitive tasks," Jensen told reporters attending the 27th International Congress of Occupational Health in Foz do Iguaçu, Brazil."

[In closing] "My impression is that it does not really matter so much which device you use," Jensen said. "I do not believe that you can invent a device capable of solving these problems, you could try some preventive exercises instead, but I think the best thing ... is that they keep you away from the mouse or the keyboard while doing them."

"End of summary and quotes"

I love to quote James A. Baldwin who said; "Those who say it can't be done are usually interrupted by others doing it."…excuse me Dr. Jensen, check out AirO_2bic Mouse!

A Study by the American Journal of Industrial Medicine
Volume 41, Issue 4 , Pages 221 – 235 (Wiley Interscience)

This was a study on 632 new hires, assumedly, out of school as there appears to be an inference of "no prior" computer work experience, so kids with student loans looking to take a grip on the corporate ladder. Excuse the "perspective" placed in this way but for every painful statistic there is a miserable life behind it. While very abbreviated in reporting these findings are seemingly un-contentious, bearing in mind the US government vetoed and so killed off an office ergonomic policy the year before this report came out. It concludes: "Hand/Arm and Neck/Shoulder MSS and MSD [RSI'S] were common among computer users. More than 50% of computer users reported MSS during the first year after starting a new job. Am. J. Ind. Med. 41:221-235, 2002. © 2002 Wiley-Liss, Inc."

So it seems that an individuals grip on the corporate ladder is under RSI threat too!

RR 045 - Ergonomics of using a mouse or other non-keyboard input device UK Health & Safety Executive (2002).

This is a 180 page pdf document available from this link:
http://www.hse.gov.uk/research/rrhtm/rr045.htm

NKID refers to Non Keyboard Input Devices.

As this is an extensive report (it actually contains as much "how to design a questionnaire as it does data) I wanted to extract and paste some contiguous text from the original. I requested reproduction permission for this, but was declined. So I have whittled a summary into my own words and the huge download required will be needed for the original document.

PREVALENCE OF MUSCULOSKELETAL COMPLAINTS ASSOCIATED WITH NKID

Stats:

20% of organizations reported neck, shoulder or arm pain or discomfort related to the use of NKID's.

Of those who did report (59% of respondents) some 20% noted employee leave that was related to neck, shoulder or arm pain in the 12 months prior to responding.

67% of organization respondents and 37% of their users surveyed reported aches and pains they attributed to methods and tools used for work. 17% cited the mouse as the source of their problems. 2% cited the use of other NKID's.

9% had been off work in previous 12 months due to aches and pains.

Taken out of its original context; computer use has increased significantly with the increasing use of email and the internet. One part in whole: "Given the current limited understanding of injury mechanisms, dose-injury relationships and the latency period for symptoms to develop, a precautionary approach to reducing risk seems advisable."

Under a Section called "Patterns of Pain or Discomfort"
Primary areas of pain and/or discomfort were the lower back, neck, right shoulder, right wrist and hand. [editorial comments in these brackets]. They further report that the observation of right handed problems is statistically valid and conclude it is a function of the equipment used. [The mouse is the most abundant dexterity specific tool used. Dexterity specific observations do not mention as to if left handed users where factored in. They represent some 15 to 25% of populations, though many left handed users mouse write handed and vice versa.] Observations made alongside of these stats are of: neck flexion, static postures and deviated wrist postures. [2 out of 3 of these observations we consider problematic and are issues of mouse use.] Time spent on the computer correlated with perceptions of pain and discomfort. Karlqvist et. al. are also cited as reporting relationship between neck and upper extremity symptoms and hours per week of mouse use. More than 5.6 hours of mouse time per week being correlated with and increased likelihood of upper limb symptoms. [Attention is drawn to the section on Postural compensation below.]

NKID position.
Studies are referred to suggesting that a mouse positioned too far from the body's midline results arms being unsupported, shoulders abducted and externally rotated and arm in forward flexion (Franzblau et. al., 1993; Karlqvist et. al.,1994 & 1996; Cooper and Straker, 1998; Aaras et. al., 1997; Fernstrom and Ericson, 1997; Harvey and Peper, 1997; Cook and Kothiyal, 1998). One study reported to us indicated that loss of flexibility in the wrist lead to elbow abduction and other consequences, see posture compensation below.

Placing NKID's too far from the keyboard resulted in arm extension when they were used. Commentary as to mouse position quoted Karlqvist et. al., 1996; Karlqvist, 1997, "placement allowing a near neutral posture is preferable". Keyboards with built in numeric keypads likely impede right-handed mouse users as they require extra lateral reach away from the body midline (Cook and Kothiyal, 1996; Cook et. al., 2000).
End of NKID synopsis.

One final and compelling piece of recent research into the pathology of RSI.

Repetitive, Negligible Force Reaching in Rats Induces Pathological Overloading of Upper Extremity Bones*

Link to abstract and location for paper purchase:
http://www.jbmr-online.org/toc/toc01811.html.

However there is Synopsis Link http://www.eurekalert.org/pub_releases/2003-11/tu-rwt110703.php, with thanks to Eureka Alert for permission to reproduce it.

Repetitive work tasks linked to bone damage

While experts disagree on whether work tasks alone can be the exact cause of work-related musculoskeletal disorders (WMSD) such as carpal tunnel syndrome, a new study by researchers at Temple University proves that a highly repetitive work task, a risk factor for WMSD, does in fact cause bone damage.

"Because multiple factors play a role in the development of WMSD, including work tasks, home activities, and medical conditions such as diabetes or heart disease, we studied work tasks alone to isolate their impact," said Ann Barr, P.T., Ph.D., associate professor of physical therapy at Temple University and the study's lead author. "This information is critical in helping industry and medicine establish workplace guidelines to prevent WMSD."

The study, "Repetitive, Negligible Force Reaching in Rats Induces Pathological Overloading of Upper Extremity Bones," published in the November 11 [2003] issue of the Journal of Bone and Mineral Research, is the third in a series conducted by a group of researchers at Temple University's College of Health Professions and School of Medicine. "Our studies have shown a direct relationship between repetitive, low force movement and the inflammation of muscles, bone, nerves and connective tissue typical of WMSD," said Barr.

Work-related musculoskeletal disorders, including carpal tunnel syndrome, osteoarthritis and tendonitis, make up the majority (65 percent) of all occupational illnesses and cost industry tens of billions of dollars each year.

To show how the tissue damage caused symptoms of WMSDs, the researchers analyzed behaviors in rats such as decreased movement performance and task avoidance. "These behaviors increased according to the rate of repetition. The higher the repetition, the more severe the symptoms," said Barr.

While the researchers were not surprised by the nature of the tissue damage or the resulting behaviors, they were surprised by how early it began. "Carpal tunnel syndrome usually takes a long time to develop, yet we started seeing evidence of tissue damage within 3-6 weeks. This finding suggests that we may be able to intervene earlier in the development of the disorder and prevent further, more severe damage," said Barr.

Currently, the group is studying the effects of increasing or decreasing repetitive tasks on both tissue and behavior. They have also begun to determine markers of inflammation in patients with known WMSD.

"Future work will examine the long term effects of repetitive motion and the power of ergonomics or medication in preventing or lessening tissue damage," said Barr.

This research is supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIH), the National Institute of Occupational Safety and Health (CDC), the Foundation for Physical Therapy and Temple University.

In addition to Barr, the research team includes faculty members at Temple University's College of Health Professions and School of Medicine: Mary Barbe, Ph.D., associate professor of physical therapy; Brian Clark, Ph.D., assistant professor of physical therapy; Steven Popoff, Ph.D., professor and chair of anatomy and cell biology; and Fayez Safadi, Ph.D., assistant professor of anatomy and cell biology.

This work at last starts to explore what is happening to "the meat on the bone!" It contains histological and immunological results that, within the model provided, rats reaching for things, indicate the pathogenesis of seemingly insignificant work.

The import from these studies and our own theories is that until there is a defined pathology and from it diagnostic marker the conclusion must be that if you can avoid the activity that correlates with the occurrence of injury then you are more likely to minimize its occurrence. We also recognize that reduction and not total eradication can only be the objective for now as the normal diversity of humankind means that there will be a Gaussian distribution in regards to genetic propensity to the damage itself and that other clinically underlying conditions will likely be exacerbated under this pathology as we begin to understand it. Likewise both of these vectors have a third and inescapable component that for some will be a vector in its own right; Aging!

We now have an aging Baby Boomer, a "computer savvy", Internet friendly generation who in the absence of other factors may simply be accelerating a normal aging process that mankind has never been subject to before, and way beyond issues created by "knitting and whittling". The computer is as important a communication tool today for Diaspora cultures and families as once was the letter and the telephone. Consequently the impact of the design of this tool in particular, the mouse, has far reaching and societal impact.

Designing a better mouse appliance.

More detail is found in "A Practical Guide To Mouse Keeping". Our overall objective is to avoid the employment of activity that is now known to be associated with injury. To that end we have designed and developed a Gripless Mouse and by developing software a Gripless & Clickless mousing system that we call the Virtually Hands Free™ mousing system. The simple objective is that if you do not grip and click you are less likely to fatigue muscles and so ache, which unchecked can go on to cause injury and pain!

The design objects are based upon a priority of posture objectives.

Functional Neutral:
Is a posture in which "at risk" muscles are maintained at rest and the load is redistributed to other larger muscle groups, which are also managed on the basis of their posture and activity? Functional Neutral Mousing simply means working at finger/hand/wrist muscles at or near metabolic rest.

Dynamic Posture:
Is the short term contraction/relaxation of muscles that is less likely to disrupt and so impact blood flow. Muscles under any degree of contraction use more oxygen, produce more toxins and have a lesser blood volume and greater resistance to flow. However the act of contraction itself, squeezing blood out of the tissue and replenishing it upon relaxation, acts to pump blood through tissue as long as there is sufficient blood supply to that tissue or extremity. Dynamic Posture can be beneficial and in isolation need not be a factor in injury.

Dynamic Posture is that employed when typing and clicking mouse buttons! We speculate that typing with an injury to the wrist due to mousing is likely to correlate more closely with input work injury than just typing work on its own. This is borne out by the correlation of injury in the dominant or mouse hand first. However the Rat study suggests that tensile load itself on tendon attachments might create potential pathological scenarios. Fortunately, if there is cause for concern in the future in regards to Dynamic Posture while under a Static Posture, as it applies to mousing, we have removed the need to apply both postures with the addition of Clickless software.

Static Posture:
This is a posture under which muscles are held and kept tense for extended periods, which in biochemical terms can be just a few minutes. If repeated often and for long a duration it can likely explain many of the symptoms that are seen.

Functional Neutral is our primary design objective with Dynamic Posture a secondary and back up technique used under a well managed break regime. Static Posture should, in our opinion, be avoided. I will mention three other "Posture" containing expressions:

Postural Compensation:
This is a mechanism under which different muscles groups are used to cover for damaged muscles, e.g. a limp. It is anticipated as being a temporary measure while the body repairs itself. However and one of the causes of extensive [opinion] injury migration of computer related problems is because at the onset of damage postural compensation takes over and involves other muscles to compensate for the damaged ones. Because the primary injured muscles do not heal what should be a temporary compensatory posture becomes a new working posture. As these secondary muscles injure Postural Compensation moves damage along to yet another set of muscles.

Neck injuries are often overlooked as symptoms of mouse injury. A Workers Compensation Board in Canada performed a limited study on 2 Thoracic Outlet Syndrome patients. This was following an ergonomic assessment of the subjects with different mice to see what if anything might help. They noticed that the TOS subjects abducted (stuck out) their elbows with ordinary mice and even trackballs and on further investigation it was realized that they were unaware that they did. They did this due to wrist injury that reduced their capacity to pronate (twist) their wrists so as to be able to lay them flat in a palm down position. Elbow abduction, biomechanically, allows for the

hand to be placed flatter when the wrist cannot twist as far as it once could and appears to be a postural compensation response to the wrist damage and continuing palm down posture use. As the subjects studied continued to work palm down the wrist did not heal and so the elbow abduction became an established and not temporary working posture. Over time this posture placed strain on the rotator cuff and damaged it. Postural Compensation kicked in again leading to what is believed to be the cause of their TOS.

In a different example my wife, a retired ballerina developed a fluid sac in the arch of one foot. After various foot diagnoses from local doctors it was discovered, when seen by one of the biomechanist's that developed our mouse products, that she had a one inch vertical hip displacement on one side. As a result it caused her to raise one leg to compensate, which invoked an arched foot to compensate for that. This then caused the fluid sac to form to help support the arch so formed. The knee bone is connected etc!

New Posture Syndrome!

This as a concept is one that I have developed myself. It was stimulated by the "disappointment" and now suspicion of anything labeled "ergonomic". A web survey we conduct suggests that on average our customers have spent over $400 on searching for a "technology cure" and some in excess of $1,200. This survey also indicates that over 80% who have problems for which they are looking for solutions do not attend a physician! 86% plus have dominant side problems and that switching mousing hand, as many are advised to do when dominant hand problems develop, discover problems in that hand typically develop in 40% of the time it took to injure the dominant side. This is a limited population and not a typical population sample as by the fact that they visit our website (180,000 visitors a month approx) they are having problems.

New Posture Syndrome seeks to explain why, when a new "ergonomic" product is purchased that after any initial relief experienced and some weeks to months later they resume their search for a yet another and hopefully better product. The issue seems simply due to the fact that any new product that addresses issues for one muscle group, so alleviating the stress upon it and so providing immediate experiences of relief, moves and so places the burden onto other muscles, which over time begin to demonstrate their dissatisfaction so baulk at the new posture that they are now in. It is a form of technology postural compensation if you will. Recent influxes of so called vertical mice demonstrate this phenomenon. They do untwist the wrist and provide that relief, but they now and typically require more grip, either claw grip or pinch grip, to provide control. Consequently we see an increasing number of vertical mice users having to spend more money as to be able to switch to Gripless mousing. One of our main testimonies to working Gripless is when an occasional warranty situation occurs. Users are on the phone the same day, having typically had to switch back to their previous device, pleading (and we have had customers actually crying) on the phone with us to get a replacement out that day.

Posture or Autonomic Reflex & Postural Anticipation:

When we first developed our mouse product and I started using it (with a history of wrist aches and tingling) for the first hour or so for almost two weeks my hand would sweat

profusely, not as bad as hurting though. It seemed that we were about to launch "sweaty mouse" on an unsuspecting world. I was obviously concerned and so it peaked my interest at the process behind the process and I started to look at things in physiological/ biochemical terms.

I monitored what was happening and there actually was a perceived increase in hand temperature shortly after I placed my hand into the AirO_2bic mouse, which at that time was called the Quill mouse.

In terms of background; work (activity) by the muscles of the hand is not sufficient to heat (a metabolic byproduct) them. Warmth in the hand is supplied as if by a central heating system, carried out from the body cavity to the hands via the circulatory system.

The conclusion was that when adopting this specific working posture that anticipated using any mouse and not specifically AirO_2bic mouse, the body automatically responds and increases circulation to the hands. As heart rate did not change it was not due to an elevation in blood flow. The conclusion was that a vaso-dilation process (increasing the diameter of blood vessels) was taking place. Vaso-dilation is a control mechanism that increases (or decreases) the diameter of blood vessels subject to certain stimuli.

Static Posture, as is used when gripping objects, tenses muscles and keeps them tense. Muscles that are tensed use more oxygen and have less blood volume as they constrict their own blood vessels so making it more difficult for blood to flow through them. We know that the low oxygen levels in the hands do not impact the oxygen sensor in the brain sufficiently to increase heart rate and so the only "local" explanation is that of a vaso-dilatory process at work in an attempt to open the “bore” of blood vessels so as to increase blood flow that way. This process is known to be stimulated amongst other things by elevated levels of carbon dioxide.

“Postural Anticipation” is a known phenomenon, a conditioned physiological response in anticipation of adopting a work habit which physiologically translates into “adapting to a working posture”. It would appear that Computer Mouse Work Anticipation recognizes a reduction in blood flow (as higher Carbon Dioxide levels) due to Static Posture so has become a part of the autonomic system that adopts a new set of physiological conditions when assuming a mousing posture, precipitating a vaso-dilatory response.

The reason for “New User Sweats” was concluded as being the body recognizing the consequences of working with grip and palm down posture and the only local response it can provide is vaso-dilation. Based upon RSI prevalence it is insufficient to compensate.

Once a different tool is used that eliminates Static Posture then the autonomic response, being autonomic, still kicks in, even though it is now not needed. As hand/wrist blood vessels are no longer constricted blood flow is not impeded and so dilating blood vessels in this Gripless posture actually delivers more blood, so heat, than is required. After an hour or so the sweating ceases as the [opinion] "conditioned" response system detects that the extra blood flow is not required.

After a few days this posture reflex (sweating) disappears tending to suggest that the autonomic system has been recalibrated for this new Gripless working posture. This phenomenon is so prevalent in new users that it prompted the inclusion of an explanation of its occurrence in the instruction manual. In all cases it disappears in a week or two.

Cognitive Distraction (Sensors and Sirens)
A fire sensor, actuated in the basement, sets a siren off on the roof. Alarm detection and alert notification are a two stage and separate process. Cognitive distraction, a phenomenon discovered during investigation into migraine management and now used to control pain by keeping the higher orders of the brain busy, indicates that when we are doing "thinking work" the brain is able to some extent suppress pain signals. It is considered a part of a primeval survival strategy so that you do not fall over due to nagging pain that might distract your thoughts from actions that may be critical to your survival. Effectively (task) reward centers appear to be able to dampen pain perception (siren volume) in the brain. This process is separate to the endorphin release, feel good chemicals that damaged tissue release, which can suppress signals from pain sensors (the trigger or fire sensors in our basement analogy) for, usually, about 20 minutes or so. Cognitive distraction, in the sensors and sirens analogy, is the brain turning down the volume on the siren so as to ignore it, even though the sensor in the basement might detect a raging fire. This correlates in our opinion with the observation that most people do not notice aches until after they stop work (in early and pre-clinical stages more typically). This further suggests that we cannot depend upon our own perception to warn of ache at the time of fatigue. Fatigue aches, messages that our biochemistry is flagging, will subside if we stop doing what we are doing. If we miss those messages they can turn into pains (which don't stop when we rest) as a result of developing injury. A brief link is at http://brain.oupjournals.org/cgi/content/abstract/125/2/310

Other Clinical Correlations:
Scientists in Japan believe that they have correlated extensive computer use with Glaucoma, a disease that causes peripheral vision problems and is associated with pressure on the optic nerve (BBC News Article on Glaucoma.
http://news.bbc.co.uk/1/hi/health/4008185.stm).

It is already well known that "static focusing", eyes (eye muscles) fixed on one point for extended periods, causes difficulty in focusing at other distance after working on a computer. We compare this to the issue of constant grip, the static muscular posture required to hold computer mice. Because gripping and clicking computer mice (and looking at things) is perceived as small muscular effort the consequences of doing such task for hours a day, many days a week, year after year have been overlooked.

European Union Press Release
In a press release (link below) dated 11/12/04 and entitled "Commission asks workers and employers what action should be taken to combat musculoskeletal disorders" the European Union (EU) are seeking input as to dealing with injuries and state; "The European Commission is seeking the views of workers' and employers' representatives on

how best to tackle the growing problem of musculoskeletal disorders (MSD). These ailments, which include back pain and repetitive strain injury, are the biggest health and safety problem facing European workers today. Studies show that they affect over 40 million workers in all sectors across the EU and account for 40 to 50 per cent of all work-related ill-health. They are costing employers across the EU billions of euros. The problem is eroding Europe's competitiveness and leading to losses of 0.5 to 2 per cent of GNP each year."

We believe the EU's release to be of significance because it provides "EU authority" to the extent of injuries in Europe and is an "acknowledgement" that current theory and practice are not working. This awareness some years ago, in relation to computer input technology, initiated the development of this company's products. The announcement indicates that despite the billions of dollars (euros) spent on ergonomic products and programs the injury problem is still growing. The release goes on to state: "The highest increases are being seen amongst professionals (up from 18 per cent to 24 per cent) and technicians (up from 23 per cent to 31 per cent)", which we interpret as correlating with office computer type of work and in light of references to workstation design and mousing activity.

EU Press Release.
http://europa.eu.int/rapid/pressReleasesAction.do?reference=IP/04/1358&f

Conclusion:
Are there any physiological implications associated with the use of computer mice? The answer is most definitely yes and for all effort there is consequence. Knowing that; is there a probability that current working practice and the use of current mouse design represents a greater risk of injury than could reasonably be anticipated if there was an alteration in working practice and or a change in the design of the computer mouse? I suggest based at least upon the evidence herein provided that there is.

If change is therefore required what is the best and easier to change, the working practice or the mouse? While it is obvious that education in workstation set up, the taking of regular breaks etc will have impact, but there is no change in working practice that will compensate for the physiological burdens that are placed upon the hands of current design computer mouse users. If mouse design is not changed then we will need to reduce mouse "hand on time" even though the outcome is not predictable? Yes though it will result in a significant loss of productivity and increase costs on the basis of the redeployment of work by way of the introduction of task rotation between on and off computer work. The expertise and resource may not even be available to make this a practicable scenario.

Consequently there is a compelling argument, on the basis of best practice that if knowing, beyond a reasonable doubt, that an activity will likely cause an injurious outcome and alternative technology that removes the majority of that injurious activity is

available, then prudence and a duty of care can be seen to be strong argument for the introduction of such technology into, at least, the workplace.

In a circumstance in which the only absolute fact is that muscles get injured, using a system that allows you to mouse conventionally and avoid using those muscles most at risk seems somewhat logical. AirO_2bic mouse is the only mouse to date to have been independently tested and commended for ease of use by the Arthritis Foundation, is recognized by the Microsoft Assistive tech team who approached us and made us an Assistive Tech Partner and (as of writing) the only conventional mouse found on the US Government's Accessible tech site, www.section508.gov as we assert that it meets their specification of not twisting wrists, requiring excessive grip or causing pinching.

Please note this is not an endorsement by the US Government, but we as a manufacturer assert that we do meet the standards required under Section 508 Law and so have registered ourselves on the website so that government purchasing officers can find the products and the information they need to comply with Section 508 law. Following a review by Dept of Justice group that set the standards, called the Access board and the GSA, computer mice have now been positively confirmed as being required to meet the Section 508 standards. The intent of Section 508 Law is to try and ensure that the US Government purchases IT products that are accessible to people with disabilities or can accommodate Assistive Tech devices. As RSI's are now considered as a disability, even to the point that lawsuits have been won under the ADA act wherein the argument of how the disability (RSI in this case) developed was ignored in favor of the argument that however it occurred an employee has to be provided technology that accommodates it. In one case a secretary walked in a court with RSI and, as a result of the ADA legislation, walked out with several million dollars. So the object of the Section 508 standards is to accommodate disability by providing accessible technology and we assert that our products do meet totally meet the design standards. Your can draw you own conclusions, after such a review and confirmation has just taken place as to why other ergonomic mouse manufacturer's don't post their products there and so try to compete for US Government business under Section 508.

Other arguments equally apply to the school environment and we have concerns that an increased dependency on computers and the Internet as part of the school curriculum may have as yet unforeseen consequences. In pre-pubescent children especially bones are not fully formed so fully calcified and a concern is that even a Dynamic Posture such as clicking mouse buttons, under conditions of constant tension or Static Posture, such as when gripping a mouse to surf the web, could create conditions for deformity in wrist bones and possibly impact or deviate the heads of the ulna and radial bones. The potential for a form of computer rickets, if you will!

I mentioned politics previously and there are many. There are those of the computer industry that is likely mindful of the tobacco settlement so call injury impairment and talk of comfort and not risk. No one set out to harm anyone, but ignoring what is now known or suspected, downstream, could result in litigious threats and culpability. Current mitigation of risk extends to "use this too much and it hurts" type "on product"

disclaimers. Thoughts of bringing out a product of a better design would likely be under the "jeopardy of due process" insofar as an "on the day decision" to make a better mouse could require, from one legal perspective or even precedent, the announcement of such concerns to users (and shareholders) and possibly the need for re-labeling or even withdrawal of old products. This is willful speculation on the part of a company who genuinely believe they have got it right!

Employers and Insurance Companies, who bear the direct costs, have no "authority" that they can refer to, the computer industry denies any knowledge (quote from a UK Government IT individual who asked the largest mouse manufacturer if there was a link between mice and RSI) and government that asks industry to solve its own problems. Ergonomic opinion and standards vary from perceptions based on old data, a focus on repetition and keyboards while people walk around nursing their mousing hands. This is against a back drop of increasing time lost, health costs and workers compensation claims (to say nothing of the pain and misery people have to endure). In the absence of a change in practice or tools will continue to pay for therapy that never provides the opportunity for such healing delivered to take a hold. Short term therapy becomes long term care as like Christian's sufferers are patched up and thrown back to the same "mouse lion"; the exact same "physiological" circumstance, the same tools and practice that precipitated the need for their treatment.

In one irony, while the US Government cancelled an office ergonomics bill they did pass another under amendments to the 1998 Rehabilitation Act, the previously mentioned Section 508 Law. In making IT Accessible to all "definitive" standards were set by which the Government must purchase IT products, one section of which relates to Controls on Desktop and Portable Computers.

(2) Controls and keys shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls and keys shall be 5 lbs. (22.2 N) maximum.

If the US Government applies this Standard as it was intended and provide everyone with products made to designs that the standard depicts, it will for the very positive reasons of trying to help those people with injury or disability help to save many from developing the same themselves.

There is also irony in that rats provide the technology analogy at the start of this epic and may provided the insight needed to close the chapter on the RSI story.

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