Ergonomics 101

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"The New Economy is fundamentally about sitting on your ass. The Digital Revolution means sitting with a devout intensity that has never been equaled by sitters before. It means staring rigidly into a single screen and moving your fingers up and down. It means a generation, hunched forward tensely, groping for cybernetic interaction, typing and clicking. Forget those little breaks that used to come with traditional pink-collar office work, like changing a typewriter ribbon, pulling open a file cabinet, or fainting. Now everything's right in front of you, and you perch there staring and clicking for years on end."

Bruce Sterling, *Wired*, July 2000

Notice the date of that comment – over 10 years ago. It is no longer just knowledge workers who are subjected to extended periods in front of their computer. The impact of technology has meant that more of us are spending more time in front of our computer. Facebook had 100,000,000 subscribers in August 2008. Seven months later, by March 2009, they had 200,000,000. At the beginning of 2015, there are over 1.441 billion active Facebook users.

In 2000, there were fifty million people on the Internet and there were zero smartphones. Today, there are three billion Internet users and two billion smartphones.

We are spending more time in sedentary postures, which is producing higher rates of injury. In 2001, U.S. companies experience 1.5 million lost workdays associated with ergonomic issues, with

50% of those days attributed to musculoskeletal disorders (MSD). According to the Journal of the AMA, these impacts had a direct cost of $20 billion and an indirect cost of $60 billion annually.

To understand postural mechanisms, we must understand the muscles and spine. The workings of our muscles are intricate and complex and we need to understand certain significant properties. When stretched, muscle contracts in proportion to the degree of stretch applied. Like a piece of elastic, the further it is stretched, the more it tenses. If you tie one end of a piece of elastic to a door handle and the other end to the door frame next to it and then open the door to stretch the elastic, the harder you pull the door, the harder the tension in the elastic will pull the door back towards its original position. That is basically how a muscle works.

It is this characteristic activity of skeletal muscle that holds us together. African women walking with heavy pitchers on their heads not only maintain their height, but their bodies actually lengthen in response to the extra weight. In the same way, the force of gravity weights us against the resistance of the earth. The skeletal musculature as a whole responds reflexively to this stimulus with a complex interplay of tension and release, constantly adapting to buoy us up. Astronauts living in space for any length of time lose muscle tone and can hardly walk when they get back to earth. Without gravity to stimulate the stretch reflexes, their skeletal muscles atrophy. It is the stretch reflexes which keep earthbound humans buoyant and elegantly supported all the time.

The supporting core of the skeleton, the spine, is a flexible column of intricately linked vertebrae bones. We are able to hold ourselves erect because of the spine's unique structure and the myriad of muscles interacting with and upon it, like guy ropes or rigging on the mast of a sailing ship. Also, the human spine contains four curves which, when healthy, give it its amazing flexibility, strength and buoyancy, thereby contributing to our anti-gravity capacity. An essential stimulus for the spine to maintain its length is the heavy human head. Its 12 pounds of solid weight, when balanced atop the spinal column, stimulate the spinal curves to resist upward against it.

The relationship of the head with the well-sprung backbone, the way the head is carried, decides for better or worse, the overall state of poise of the human body and whether or not, right now, you are shortening yourself by holding those spinal curves in a compressed state, putting undue pressure on your ribcage and joints, or, poised in the fully upright and gracefully expanding stature that is your natural inheritance.

When we slump while sitting and try to prop ourselves up with our arms leaning on the front of the seat or wait in a line, shifting our weight from one leg to the other to relieve the strain of standing,

we are co-opting our fast-twitch muscle into performing the role of slow-twitch muscle. The rapid onset of tiredness demonstrates the inappropriate engagement of fatigable muscle for these tasks. At the same time, the stabilizing and supportive slow-twitch muscles of our trunks, which should be holding us up, are weakened through lack of use because their work has been taken over by the wrong muscles.

Their function is also to supply the central nervous system with sensory input to provide it with information about our orientation in the gravitational field. The feedback they provide in their weakened state becomes distorted. The central nervous system, responding on the basis of their distorted feedback, 'thinks' they need help to hold us up and a vicious cycle is set up in which our tired mover and strength muscles try even harder to do just that. Gravity wins, our postural mechanisms lose and we end up with muscles in some parts doing too much work and muscles in other parts doing too little. In other words, our bodies no longer have a balanced distribution of muscle tonus. The excessive tension in the musculature as a whole then exerts undue pressure on ligaments and joints. And we become achy and tired.

One of the legacies of the Age of Enlightenment is the mind-set introduced by philosopher Rene Descartes : "I think, therefore I am." The resultant 'Cartesian split' led to the valuing of 'mind' (the left brain,) over 'body' emphasizing mental development and regarding the body as irrelevant. Under the subtle influence of this mind-set, we prefer to live 'in our heads'. Among the catalogue of liabilities such an attitude generates is radical loss of body awareness. The operation of our postural mechanisms happens 'in the dark'.

We do things on automatic pilot without registering how we are doing them, remaining unaware of muscular activity until something starts to hurt. Repetitive strain injury of the wrist, arm and shoulder incurred by computer operators using a mouse for hours at a time is a prime example. Their attention is absorbed by what is happening on the screen while they make repeated demands on the fine mover muscles of the hand, forearm, upper arm and shoulder, without being aware of the feedback the fatiguing muscles are sending them. They just keep staring at the screen and manipulating the mouse, unaware that their muscles are protesting. A mouse weighs next to nothing, yet it only takes a few hours of this 'careless' activity for the muscles of the hand, arm and shoulder to become strained.

This can happen because most muscle activity goes on outside our awareness. In the average person the conscious activity of the brain constitutes about one millionth of all brain activity. When our minds are busy in the virtual world of the computer screen or the television, we pay even less

attention to what is happening in the rest of us.

The application of basic ergonomic criteria in constructing and furnishing effective workplace environments allows us to apply science to maximize worker productivity while reducing worker fatigue. There are a number of misconceptions that inhibit clarity among design professionals and end users:

1. **Sitting up straight is not good for you.** The proper alignment of the vertebrae with adequate support and key points is essential for comfort and management of the weight of the human torso in a seated position. Reclining does not mitigate disc pressure.
2. **More adjustability in chairs equates to better ergonomics.** Too many features if not properly engaged can induce bad postures. The almost mad rush to sell the market on adjustable arms in the past decade has created an army of chairs whose arms, if not regularly adjusted to different postures, do not support the fleshy part of the forearm and, in fact, push the arm up to place the wrist articulation to an inappropriate elevation and articulation, inducing carpal tunnel stresses.
3. **All products labeled "ergonomic" are good for you.** There is no qualification for the application of this marketing term. Ergonomics has become its own marketing hype. When Taco Bell introduced an "ergonomically shaped" quesadilla which was supposedly "easier to eat," you could tell that merchandising was racing far past the zone of meaningful credibility.

Instead, there are five essential concepts that will keep an application of ergonomic principles to seating solutions between the rails:

1. **Environment affects behavior:** Our environments either encourage or discourage safe working postures. And it is not just the chair. The physical context is where things are – horizontal and vertical surfaces, where "work" and visual display that is accessed for processing occurs. There is the visual field that is where the eyes go. There are postures, awkward and acceptable. The postures of hands and wrists translate up the body, often in awkward ways. Static muscle contraction occurs. Extra muscle activity is required to maintain position of the head and neck whose forces translate down the body.

2. **Minimize extreme pressures:** These are awkward postures that require extra muscle activity to maintain position. Carpal tunnel syndrome (CTS) is often misdiagnosed as ulnar nerve entrapment at the elbow. A typical computer posture from smaller screen sizes and laptops

involves the neck being extended forward, which places the average 8-bound head (bowling ball) off the axis of the spine and the vertebrae that support it.

3. **Movement is essential for health:** Movement nourishes the spine and keeps joints lubricated. It also improves circulation and removes metabolic waste from muscles. A footrest typically encourages movement in the lower extremedies. Mini-breaks are to be encouraged, which get muscle strength back up, reduce fatigue and improve productivity. It is not practical to require people to take breaks, raise their arms and perform short exercises or stretches, but there is significant therapeutic value in such activities. I prefer active ergonomic chairs with a forward silt seat pan and a floating synchronized seat-back pressure articulation, which responds more effectively to body movement that the passive membrane products so popular today because they remove moving parts and mechanisms, making seating products less costly with their diminished performance attributes.

4. **Avoid contact stress:** Forced pressures can cause nerve damage and circulation problems. Armrests are a huge liability of introduced improperly. In many chairs, they are mounted at the rear of the seat pan or off of the chair's back, so the only way to get them out of the way is to position them too low. Many professionals argue that the safest application is no arm rests for the bad an improper or inappropriately adjusted armrest can do is more serious that the comfort benefit when properly designed and located. A seat pan that is flat or at an upward tilt will cut off circulation to the legs. A waterfall front edge reduces pressure under the thighs so circulation is not restricted. Keyboard trays are also controversial. Kevin Butler, Ergonomist for seating manufacturer Humanscale says, "Without a job analysis, the cornerstone of a healthy workstation is one with no armrest for keying and mousing because arm support equates to contact stress which is bad." He hastens to add that arms are typically 12% of bodyweight and that armrests have value for telephone use of no headset is used, as well as for reading and documentation. This issue has prompted some including Alan Hedge at Cornell to recommend negative tilkt for keyboards. For the mouse, the palm should support the wrist.

5. **Educate employees;** Knowledgable employees will understand. Manufacturers are using counterbalance technology to reduce and eliminate potential exposure for user adjustability errors. A seat position that is too low likely placing wrists and arms in risky positions. A seat too high cuts off circulation to the lower body. In the 980's and 1990's, manufacturers introduced many, many adjustments.

The preparation of a Functional Analysis of user work tasks by a qualified professional is an added value. There are no many Design firms capable of providing such a service. Kleeman and Prunier's studies (1980) found that most people do not use all of the features of their chairs. Martin Helander (1995, 2003) identified that back tension, perhaps the most critical adjustment, is rarely adjusted by users. This information and stiff price competition congealed after Herman Miller introduced its successful passive Aeron chair in 1994, which has been the most copied seating product since the tree trunk. Miller's marketing storyboard is that the Aeron "adapts naturally and adjusts precisely to fit people of all sizes and postures doing all kinds of activities, all day long." The stretch Pellicle membrane fabric over its plastic frame "distributes weight evenly over the seat and back" and allows the body to dissipate heat.

Today's chairs should facilitate movement. Recline is healthy as it temporarily redistributes the load of the body off of the spine. CTS, numbness in the hand and pain in the wrist, can be avoided with basic preventative measures. As a work habit, one should "float over the keys. If you rest, put your palm down!" When moving the rest, extend the wrist upwards, flexing downwards. Side-to-side movement is to be avoided because it represents ulnar and radial deviation of the wrist.

Visual Field Issues:

The placement of the monitor screen and documents is important. The monitor should be located in-line with the eyes to minimize neck and trunk location. Previously, scientists recommended a viewing plane with an 11 degree downward viewing angle. Now, a 17.5 degree viewing angle is recommended so that the top of the text or monitor should be at or slightly below eye level and at arm's reach (not closer than 24"). With flat screen monitors way up, the neutral reach zone is opened up. With many people, including us, using large dual monitors, the primary work area is moving to the side.

One residual issue is that the deeper 30" work surfaces from the 1970's – 1990's to accommodate tube monitors now have the potential to place the monitor too far away from the user, causing forward lean and neck pain.

The impacts of lighting and glare are issues. OSHA studies indicate that 90% of computer user experience Computer Vision syndrome, which is a temporary condition resulting from focusing the eyes on a **computer** display for protracted period of time. For users age 61 – 70, a contrast value 350% more than that required at age 20 – 30 is needed to see effectively. A key factor in lighting is adjustability, particularly as multi-tasking increases. The trick is to keep the lighting low enough that there is no glare on the screen, while placing sources at the non-dominant hand so it dos not cast a shadow when it broadcasts across the surface.

Fashion and Emotion

The Aeron chair's styling got it in Hollywood quickly and conspicuously, appearing in Disclosure and wall Street and becoming the fashionable seating choice of the chic and wannabees.

Martin Helander (2003) encouraged us to "forget about ergonomics and let aesthetic and comfort be our guide." Reijneveld, deLooze, Krause and Dessmet (2003) observe that office chair designers have traditionally focused their design efforts on optimizing the so-called 'ergonomic fit.' Although the effort to design chairs that support physical comfort is commendable, the focus on ergonomics neglects the possible impact of emotional responses on the general experience of comfort. The general experience of comfort experienced when using a chair is not only influenced by the ergonomic fit but also by the 'emotional fit,' i.e. an emotional response that is desired by the user.

Their study was measured emotional responses evoked by office chair appearance as part of a bigger project concerning attractive and comfortable office chairs. The emotional responses evoked by 15 chairs were measured with the Emocard method, a non-verbal self-report instrument. Some differences were found in the results obtained with the Emocards and those obtained with a standard verbal evaluation method. Although discriminative to some extent, the non-verbal method was found to be less discriminative than the verbal method.

Helander and deLooze have proposed a model of seated comfort in which *comfort* and *discomfort* are conceptually separate. They argue that ergonomic chairs tend to be overdesigned with insufficient attention paid to aesthetics. This argument is critiqued on both methodological and

conceptual grounds. The methodological critique is based on psychometric criteria. Their conceptual critique is based on the need for an integrated (ecological) approach in which work context and user characteristics are explicitly considered.

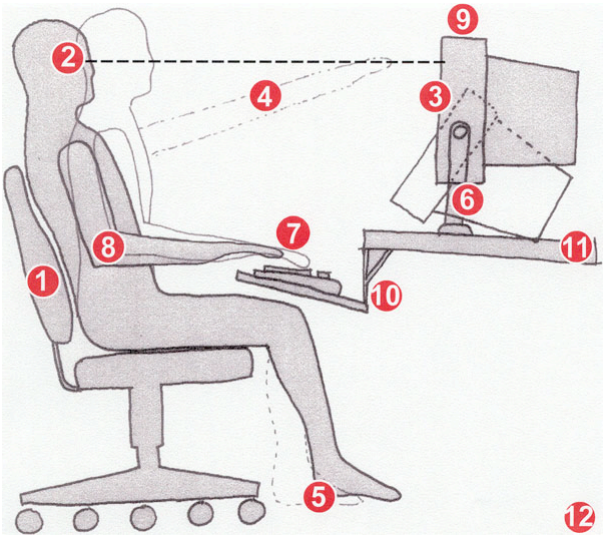
Microprocessors were first introduced on a large scale in the 1970's. The IMP PC came out in 1981. The Apple II was introduced in 1977. In 1997, only 37% of families with incomes of $15k - $25k used computers at home or work. By 2001, that percentage had increased to 47%. with over 80% in families with incomes in excess of $75k.

Trends:

The exploding sales of notebook PC's is a concern as they promote poor static upper body postures when used at a desk. The hunched over postures equal contact stress at wrists, downward neck flexing and static working pressure due to smaller keyboards and less movement. Ergonomic experts recommend raising the monitor up and using separate peripheral keyboard. Compaq has five detachables on the market.

At American Express, a concerted application of ergonomics and appropriate tools saw claims drop 400% in four years.

Passive ergonomic chairs have gained strong market penetration because of their aggressive marketing with ergonomic storyboards and lower price points. But few provide critical lumbar support for the lower number 3 – 5 vertebrae other than a tensioning of fabric or membrane when the torso comes in contact. While the Aeron chair now has an optional shaped horizontal lumbar 'bar' that moves up and down, it must be questioned if it is effective and used since it is quite challenging to adjust when seated.



The latest thinking makes achieving a "dynamic neutral posture" the goal. Professor Alan Hedge's 12 tips for an ergonomic workstation for computer use include:

1. Use a good chair with a dynamic chair back and sit back in this
2. Locate top of monitor casing 2-3" (5-8 cm) above eye level
3. No glare on screen, use an optical glass anti-glare filter where needed
4. Sit at arms length from monitor
5. Have feet on floor or stable footrest; knees level with hips
6. Use a document holder, preferably in-line with the computer screen
7. Wrists flat and straight in relation to forearms to use keyboard/mouse/input device
8. Arms and elbows relaxed close to body
9. Center monitor and keyboard in front of you
10. Use a negative tilt keyboard tray with an upper mouse platform or downward tiltable platform adjacent to keyboard
11. Use a stable work surface and stable (no bounce) keyboard tray
12. Take frequent short breaks (microbreaks)

The international standard for work surface height is 28″. But many desks are 29″ – 30″ high which immediately place a user with a conventional keyboard and mouse at risk for tension on the medial nerve and transverse carpal ligaments. The top 10 mouse tips to minimize ergonimc problems include:

1. **Mouse Grip** - don't throttle your mouse (it's already dead)! Hold the mouse gently to move it over a mousing surface.
2. **Mouse from the Elbow** - don't skate or flick the mouse with your wrist. Make controlled mouse movements using your elbow as the pivot point and keep your wrist straight and neutral.
3. **Optimal Mouse position**- sit back in your chair, relax your arms then lift your mousing hand up, pivoting at the elbow, until your hand is just above elbow level. Your mouse should be positioned somewhere around this point. Don't use a mouse by stretching to the desk or out to the side of a keyboard. With a **flat mouse platform**, position this 1-2" above the keyboard and over the numeric keypad if you are right handed - you can easily move it out of the way if you need to access these keys. With a **downward sloping mouse platform**, position this close to the side of the keyboard so that you can use the mouse in a neutral wrist position. Position adjustable mouse platforms are commercially available (e.g. Humanscale, Proformix, Flexrest, 3M etc.).
4. **Protect your wrist** - if you look at the anatomy of the wrist it is curved away from any contact surface (you can easily see this by resting your hand/arm on a flat surface - you'll see light under the wrist and can probably even pass a thin pen under this). The forearm is

shaped liked this for the wrist to remain free of surface pressure contact.

5. **Avoid restricting circulation** - For may people there are exposed blood vessels near the skin at the wrist, which is where the pulse is often taken. Any pressure in this region will disrupt circulation into the hand and this will increase the risks of injury.

6. **Don't use a Wrist Rest** - research has shown that using a wrist rest doubles the pressure inside the carpal tunnel, because the floor of the tunnel is a more flexible ligament that transmits external pressure changes directly into the carpal tunnel (the roof of the tunnel is bone so the pressure doesn't get transmitted on through the hand). Indeed, one test for carpal tunnel syndrome (CTS), know as Tinel's sign, simply involves tapping on the palmar surface of the wrist, which is enough to cause tingling and numbness in someone developing CTS.

7. **Avoid Restricting Arm Movement** - with a softly padded wrist rest, especially one that is rounded, or a soft chair arm rest the forearm becomes "locked" into position and this encourages people to make mouse movements by flicking the wrist, which also increases intracarpal pressure.

8. **Keep the Mouse Free Moving** - The base of the palm of the hand is the part of the body designed to support the hand when resting on a surface. For keyboard use a broad palm support is best. However, mouse use is different from keyboard use. With a keyboard the best posture is for users to float their hands over the keyboard when typing and then to rest on the palm support in microbreaks between typing bursts. You can use rest-breaking software (e.g. Magnitude ErgoManager, Break reminder etc) to help track and advise on your mouse use. With mousing this doesn't happen. A mouse is used by moving its position over a surface, and resting usually occurs when mouse movements stop but with the mouse still being held in the hand. Mouse movements should be made using the elbow as the pivot point, not the wrist. Anything that impairs free movement of the forearm/hand and mouse will increase injury risks.

9. **Mouse shape** - choose a mouse design that fits your hand but is as flat as possible to reduce wrist extension. Don't use a curved mouse. Use a symmetrically shaped mouse. Consider a larger mouse and there are several new interesting products on the market , such as the Whale mouse or the Perfit mouse, that encourage arm rather than wrist movements or that encourage postural variety and one or two-handed use. Pen-based mice designs also allow a more comfortable grip. Some types of mouse palm support can be attached to the mouse, such as the Mouse Bean.

10. **Load sharing** - if you want to load share between your right and left hands, that is using the mouse for some of the time with each hand. For this you need to choose a mouse platform that can easily be configured to the left or/and right, and a symmetrical shaped mouse that can be used by either hand.

Products:

In the interest of full disclosure and revealing any biases, in our office, we sit in the following:

Task Chairs:	Herman Miller “Aeron”
	Humanscale “Freedom”

	AllSteel “Sum”
	Steelcase “Sensor”
Conference Chairs:	Steelcase “Think”
	Vitra “Axiom”

In 2008, Steelcase introduced the Amia, “an innovative and ergonomic task chair.” Its “innovative active back mechanism automatically adapts itself to the body position to provide optimum comfort and full support throughout the working day.” In the backrest is “LiveLumbar” – a system of flexors that contour to fit the spine for continuous lower back support. A sliding support allows the flexors to move up and down, assuming that users know where they want to feel extra support. Steelcase also says the Amia helps take pressure off the body through innovative seat foam, with a cored out middle section with softer foam. “Narrower people naturally sink a bit into the chair. Enough so that when they get into that oft middle, they feel the cushion of the chair naturally comes around them providing some bolstering.” Conceptually, this implies more contact with the sides that can restrict circulation. Widebodies “stretch out over the cushion so they do not feel the softer middle, and they take advantage of the natural bolstering of the cushions.”