Designing Healthy Work Environments

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Workplace Trends

17%
reduction in square footage per worker has occurred since 1994

90%
of computer users experience computer vision syndrome

64
average number of hours spent sitting per week

90%
decline in the production of enzymes that burn fat after 1 hour sitting

Costs of Lost Productivity

Of 28,902 working US adults surveyed:

52.7%
reported discomfort

5.2
hrs/week lost

34
days/year lost

$61.2
billion lost annually

Stewart, W., *et al.* 'Lost productive time and cost due to common pain conditions in the US workforce', Journal of the American Medical Association, 290(18), 2003

Office of the Future?

This workstation looks good, but does not accommodate individual differences

What is likely to happen next?

Discomfort Indicators

Reduces
the seat pan depth and alters the effectiveness of the backrest

Doubles
intra-carpal tunnel pressure

Promotes
neck extension for most users

How Does This Happen?

Employees redesign their workstations to compensate for poor design

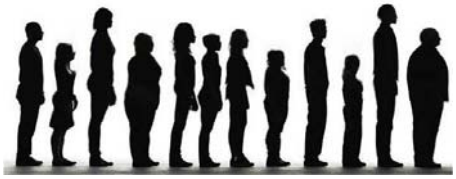
What kind of work experience is this organization providing to this employee?

Design

to accommodate individual differences

- Health, comfort and performance are moderated by design
- The job is not complete until individual differences are considered
- Workstations can be aesthetically pleasing *and* functional at the same time

Ergonomics Defined



Ergonomics is the science of **fitting the task to the worker** to maximize productivity while **reducing discomfort**, fatigue and injury

Injury Risk Factors

Minimize Awkward Postures

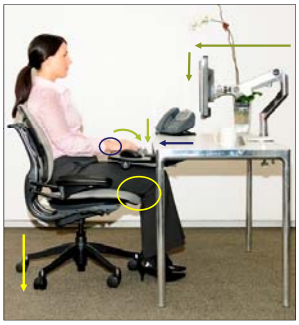
Minimize postures that require excessive muscle activity to maintain and tax the musculoskeletal system

1. Trunk Flexion
2. Neck extension
3. Shoulder shrugging
4. Contact stress at forearm
5. Wrist extension
6. Contact stress behind knee
7. Unsupported feet

Maximize Neutral Postures

Maximize your time spent in neutral postures that require minimal muscle activity to maintain

1. Chair lowered
2. Corrected seat pan depth
3. Lowered keyboard height
4. Keyboard sloped negatively
5. Keyboard closer to body
6. Arms supported at palm
7. Corrected monitor height & depth



Provide Adequate Training

- Lack of training often yields disappointing results
- Equipment is only one component of the solution
- Very few will change their behavior unless they understand ***why*** a change is necessary

Research on Training Benefits

TELUS

- **76%** reduction in incidence of upper extremity MSD's
- Decreased lost workdays from **540** before training to **240** and **330** in the 2 years following the training
- Reduction of **$97,266** in workers compensation claims
- Total direct cost savings of **$163,000** over three year period

Dow Chemical

- Offered a one-hour office ergonomics training course for all new hires
- Developed a website that provided ergonomic information and detailed computer workstations guidelines
- **82%** reduction in cumulative trauma-related OSHA recordables
- **84%** reduction in cumulative trauma-related workers compensation costs

A Simple Cost Benefit Analysis for an Ergonomics "Train-the-Trainer" Program: Kim Baxter, MSc (Erg) and Deanna Harrison, CPE

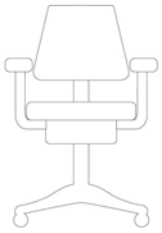
Key Elements
of an ergonomic workstation

1. The Chair
2. The Work Surface
3. Monitor and Document Placement
4. Proper Lighting

Seating Discussion

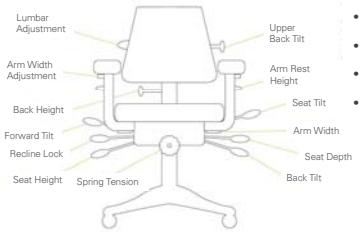
1. Evolution of Task Seating
2. Essential Task Chair Adjustments
3. Passive Ergonomics and Task Chair Design

The Evolution of Seating
70s chairs



- Few controls
- Insufficient adjustability
- Individual differences not accommodated

The Evolution of Seating
80s and 90s chairs



- Too many manual controls
- Adjustability not used
- Poor usability
- Inadequate adjustment ranges

Design Challenges

People do not make manual adjustments.

"Studies of people sitting at work indicate that they tend not to use manual adjustments on their chairs."

–Kleeman & Prunier 1980, Stewart 1980

Back tension is rarely adjusted.

Less than 2% of the subjects in a laboratory setting were able to identify the purpose of .he back tension adjustment knob on a variety of chairs.

–Helander, 1995

Training is required.

"There is a consensus in the literature that users must be trained to use chair adjustability controls..."

–Helander, 1995

Essential Chair Adjustments

Ergonomic chairs should offer adjustable:

- Seat Height
- Seat Depth
- Backrest / Lumbar Height
- Armrest Height
- Backrest Tension

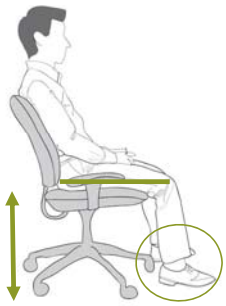
Essential Chair Adjustments

seat height

Adjust height such that feet are flat on the floor and thighs parallel to the floor

Risk Factor

unsupported feet



Essential Chair Adjustments

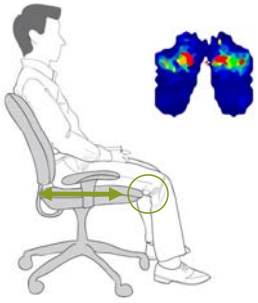
seat pan depth

Allow at least 2 inches of clearance behind the knees

Proper length will improve pressure distribution

Risk Factor

contact stress at seat edge

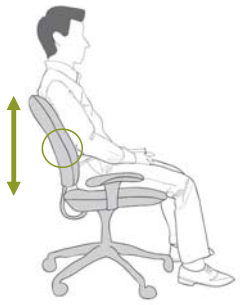


Essential Chair Adjustments
lumbar height

Fit the backrest curvature to the small of the lower back

Risk Factor

trunk flexion



Essential Chair Adjustments
armrest height

Position the armrests such that they are no higher than seated elbow height

Risk Factor

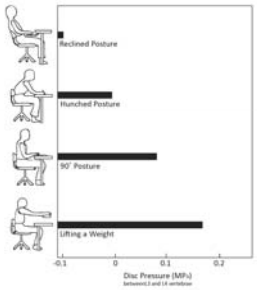
shoulder shrugging

Essential Chair Adjustments
recline tension

- Unlock backrest and adjust the recline tension to support body weight
- The backrest should move freely and support user throughout the recline range
- Movement nourishes the spine, lubricates the joints, removes muscle toxins and improves circulation

Benefits of Reclining

Reclining distributes the load of the body to the back rest of the chair and minimizes spinal loading



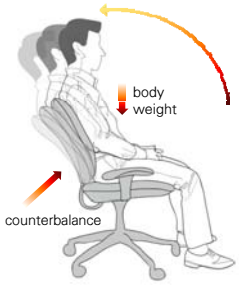
Anderson, B. & Ortengren, R. (1974) Lumbar disc pressure and myoelectric back muscle activity during sitting, *Scandinavian Journal of Rehabilitation Medicine*, 3.

Passive Ergonomics

> *The process by which the fit between the environment and the human operator is improved automatically, without the need for manual adjustment or user input.*

Passive Ergonomics

self adjusting recline mechanisms



- Traditional recline mechanisms require the user to unlock and then tension the backrest.
- Lack of movement impacts spinal nutrition, muscle activity and oxygen delivery.
- Self-adjusting recline mechanisms automatically adjust backrest tension based on the users body weight without the need for manual adjustment.

Passive Ergonomics
mesh backrest design

Single panel stretch mesh

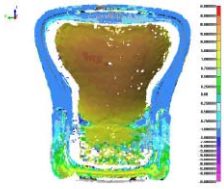
Traditional mesh backrests utilize a single, high-stretch panel of mesh. When stretched over a frame, single panel mesh loses curvature and requires an external lumber support.

Multi-panel non stretch mesh

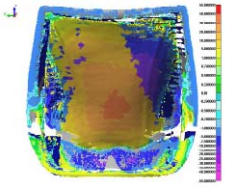
Multi-panel, low-stretch mesh backrests provide a better fit without the need for an adjustable external lumbar support.

Passive Ergonomics
research validation

Research shows that lumbar support improves by as much as 46%



Single Panel Mesh Design
268.7 cm



Three Panel Mesh Design
393.3 cm

Agarwal, A., Hedge 'A 3D body scan method to measure postural deformation in flexible material chair backs' HFES Proceedings, 2006.

Passive Ergonomics
synchronous armrests

Traditional armrests

Synchronous armrests

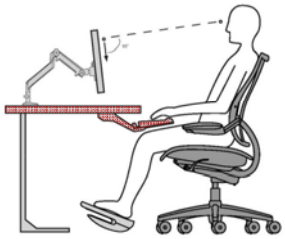
- Users unknowingly adjust armrests at different heights
- Synchronous armrests move together and are always at the same height, greatly reducing potential postural problems

Passive Ergonomics
armrest design

- Armrests attached to the seat pan remain fixed during recline, providing inconsistent support throughout the range of recline.
- Armrests mounted to the chair backrest are designed to move with the body, offering improved support.

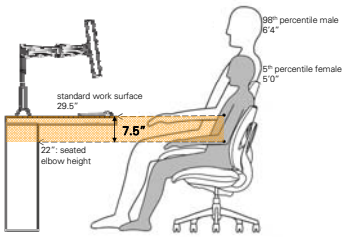
Key Elements
of an ergonomic workstation

1. The Chair
2. The Work Surface
3. Monitor and Document Placement
4. Proper Lighting



Fixed Work Surfaces:
a fundamental design challenge

The standard 29.5" work surface correlates to the seated elbow height of a 6'4" male, less than 2% of our working population.



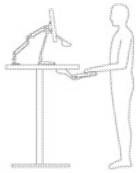
Improvement Strategies

Articulating keyboard supports

- Validated work tool for improving hand, wrist and seated posture
- Appropriate for both seated or standing applications

Sit to stand workstations

- Allows for greatest amount of postural variation
- Shown to significantly reduce discomfort and health risks

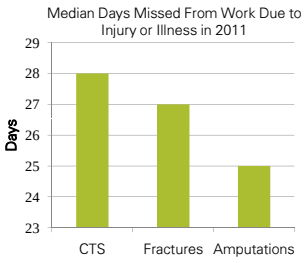


Articulating Keyboard Supports
fundamentals

A 'hands in lap' keyboard position:

- Reduces upper body muscle activity
- Promotes natural elbow and shoulder position
- Eliminates contact stress and reduces wrist extension angle

Carpal Tunnel Syndrome (CTS)

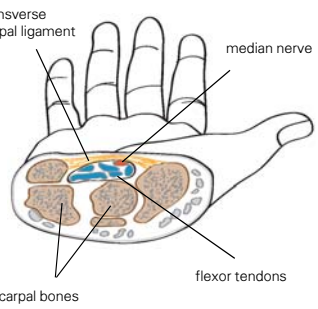


Most cases of CTS can be avoided with some basic preventative measures.

Wrist Basics

Awkward wrist postures elevate carpal tunnel pressure

Tendon inflammation leads to median nerve compression

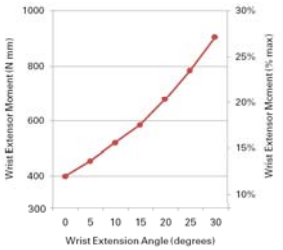


Fixed Work Surfaces

keyboarding posture

30
of wrist extension results in:

2x
intracarpal tunnel pressure

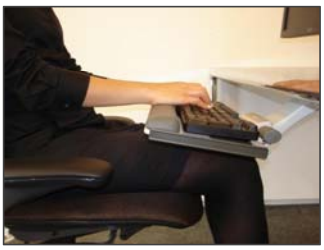


27.5%
increase in forearm muscle activity

Weir, P. Wells, R. 'The effect of typing posture on wrist extensor muscle loading'. Human Factors, 44(3), 2002.

Research Findings

According to Cornell University, a negative tilt keyboard position affords several benefits when compared to a traditional on desk keyboard position:



62% v.s. 42%
Time spent in a neutral posture

82% v.s. 48%
Time spent below the critical carpal tunnel pressure threshold

40%
Reduction in upper body discomfort

91%
Prefer a negative tilting keyboard position over the traditional desk position

Hedge A, Morimoto, S., McCrobie, D. (1999) Effects of keyboard tray geometry on upper body posture and comfort. Ergonomics, 42 (10).

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Sit to stand workstations

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Health Implications
of prolonged sitting

"A study of 73,000 women found that the risk of dying from heart disease was nearly 3x higher among those who sat the most compared with those that sat the least." (Levine, 2009)

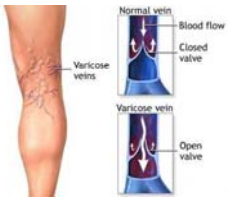
Prolonged sitting:

- Elevates spinal disc pressure and can contribute to premature spinal disc degeneration
- Causes the enzymes (LPL) responsible for burning fat to shut down resulting in weight gain, lowered metabolism and lower levels of good cholesterol (HDL)
- Lowers demands of the circulatory system and results in a slow down of heart activity and blood flow, which accelerates fatigue (NIOSH 1997)

Health Implications
of prolonged standing

Prolonged standing:

- Is more tiring and requires 20% more energy
- Causes pooling of the lower extremities and vein inflammation. After 90 minutes seated the feet can swell to nearly 2% of their starting volume (Chester, 2002)
- Is linked to foot pain, varicose veins, and static muscle fatigue
- Causes the joints in the spine, hips, knees and feet to become temporarily immobilized. This can result in degenerative damage to the tendons and ligaments



Sit to Stand:
a better compromise

- There is increasing evidence to support the notion that varying your posture throughout the workday has significant health benefits
- The same adjustment guidelines for the keyboard and monitor apply
- Studies suggest that for sit-to-stand application to succeed, it must require minimal time and effort to adjust.

Sit to Stand:
health & performance benefits

Weight Control:
A 2009 Mayo Clinic study found that it was possible to burn an additional 340 calories per day by spending two hours of the day standing instead of sitting. (Levine, 2009)

Cardiovascular:
The same study found that physically active work protects against heart disease. Those who sat for prolonged periods suffered three times the rate of the coronary artery blockage and more than twice the rate of death after a cardiovascular event than those who were physically active during work. (Levine, 2009)

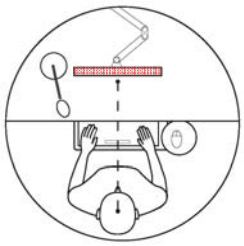
Productivity:
Participants who do not alter their positions during the day take an average of 47% more work breaks. The average duration of their work break is 56% longer. (Dainoff, 2003)

Sit to Stand
design considerations

Crank-Adjust	Electric-Adjust	Counterbalanced
		
Average time to adjust: 2-3 minutes	**Average time to adjust:** 25-30 seconds	**Average time to adjust:** 2-3 seconds
Slow to adjust and require considerable manual effort resulting in infrequent adjustment and poor compliance	An improvement in speed over crank adjustable tables but still too slow for most users and they require a power source	Changes occur quickly and with less effort resulting in more frequent adjustments and greater health benefits

Key Elements
of an ergonomic workstation

1. The Chair
2. The Work Surface
3. **Monitor and Document Placement**
4. Proper Lighting



Monitor & Document Placement

Improper monitor position can lead to a variety of postural problems

Risk Factors

neck extension

neck rotation

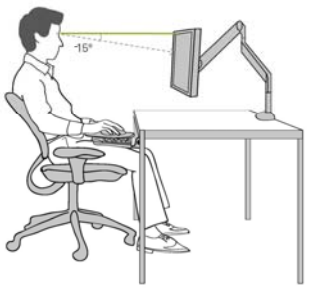
trunk flexion

Monitor Height

Align the top of the monitor at, or slightly below, eye level

Risk Factor

neck extension



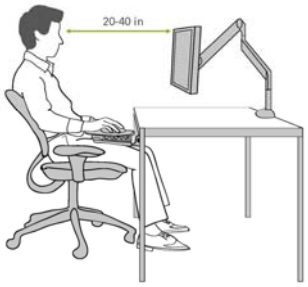
Monitor Depth and Angle

Place the monitor at least an arm's length away while reclining

OSHA recommends 20"-40", no less than 15" from eyes

Risk Factor

trunk flexion



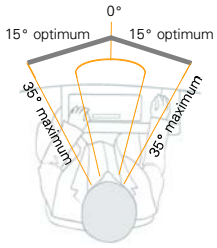
Monitor Alignment

Center keyboard spacebar and monitor with the midline of the body

Risk Factor

trunk rotation

Multiple Monitor Dilemma



- As monitor width increases, our viewing envelope is compromised
- As a result, monitors must be positioned further away, which can negatively effect our ability to view the screen
- Users prefer a viewing distance of 75-83cm; minimum distance is 40cm

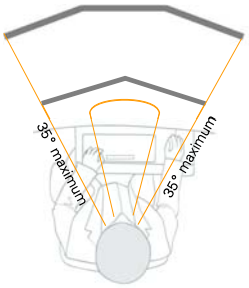
Alignment – Multiple Monitors

Align monitors at the same height, side by side and angle inwards

As monitor size increases, position screens farther from body

Risk Factor

neck rotation



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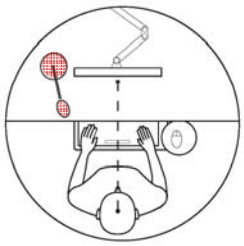


Lighting Challenges

When light is only delivered to a worksurface from the ceiling, there are two major issues:

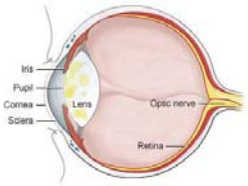
1. Monitors and documents have completely different lighting requirements.
2. Individuals have completely different lighting requirements.

Monitor and Document Conflict

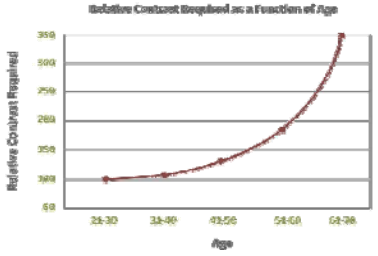
- Monitors generate light, while documents require light
- Reading paper-based documents requires 10-20 times more light than does viewing a monitor

With Age, Our Eyes Change

- The corneal lens hardens and develops opacities
- The ciliary muscles that control the lens atrophy with age
- The process of accommodation becomes increasingly difficult
- Near field viewing requires correction; condition is called presbyopbia (farsightedness)



Contrast Requirements



Persons ages 61-70 require more than **250%** more contrast than persons ages 20-30

Contrast Requirements

Task visibility is the primary aspect of lighting that affects performance

20 years 60 years 75 years

Dual-Source Lighting

Single Source:

- Too much light above eyes
- High energy waste

Dual Source:

- Light level determined by user
- 30-40% less energy required

Benefits of Individual Control

A laboratory study at RPI's Lighting Research Center found that subjects who had controllable lighting:

- Felt more comfortable in the room
- Rated the tasks as being less difficult
- Rated the lighting quality as higher than subjects who did not have control
- Produced a **35%** to **42%** decrease in energy consumption

Veitch, J., "Individual control can be energy efficient" International Association for Energy Efficient Lighting, 8(22), 1999

Economics of Ergonomics

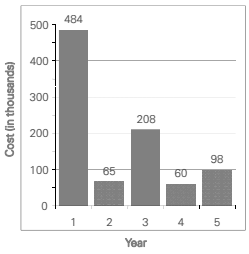
success stories of ergonomic implementations

American Express

- Within four years claims dropped **80%** from **$484,000** in year 1 to **$98,000** in year 5

AT&T Global

- Decline in lost workdays from **298** before implementation to **0** in the first two years
- Claims dropped **75%** from $400,000 to $94,000 in first year
- Savings of **$1.48** million



GAO/HEHS-97-163 'Private Sector Ergonomics Programs Yield Positive Results'

Key Points to Remember

1. Ergonomics is a preventative, design based discipline
2. Ergonomic interventions can benefit the masses, not just those that are injured
3. Product interventions alone are not enough – training is an integral part of an ergonomic program's success
4. See ergonomics as a benefit to an organization, not as a burden!

Ergonomic Resources

CUErgo http://ergo.human.cornell.edu

http://ehs.virginia.edu/ergo/stretch.html

Humanscale www.humanscale.com

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