Workstation Design

Reduce Static Loads & Fixed Work Postures

- Human body is designed for movement. Movement helps blood circulation, which provides oxygen and nutrients to body tissue. Static pressure impedes blood flow:
  - External pressure: supporting surfaces to body limbs
  - Internal pressure: static muscle tension
- Static muscle contraction increases both systolic and diastolic Blood Pressure, thus heart has to do more work.
- Any work has both static and dynamic muscular work components. Static component is significant for a durations more than one minute.
- In workstations the operators spend long period of time. **Most of the workstation design guidelines are aimed towards reduction of static pressure.**

Source of Fatigue in Standing Work

Pressure on the underside of the foot, tired leg muscles, tired back muscles, venous pooling in leg.

- **Hard floor** causes discomfort in foot. Increase of HR by 5 /min when standing on concrete floor compared to standing on carpeted floor. Provide anti-slip resilient mats for standing work.
- **Consideration of shoes**:
  - High heel shoes shifts the upper body CG more forward, increased lever arm length of the gravitational force, and causes increased back muscle activity.
  - Space for foot swelling
- **Back muscle activity**: CG of the whole body passes through front of the body. There is always significant static muscle activity at the lower back while standing.
  - Keep the upper body straight, reduce reach distances.
  - Try to incorporate sit-stand - Provide a small seat, if possible, to take occasional break
  - Design the task, which requires walking
  - Provide a bar to perch on, or a step to alter leg posture. Relie ves lower back muscles.

Source of Fatigue in neck & eye

- Head weighs about 7 lb, weight of bowling ball and neck muscles hold it in place.
- In relation to the cervical spine, at 15º forward inclination of neck is least stressful position. Tilting from this position sends the CG of head away from the fulcrum. As a result, it increases static muscle tension in neck and shoulder region and consequent muscle fatigue.
- Most tiring is the backward tilt as the anterior neck muscles are comparatively weaker. Steady tilting to the side or rotation of head is also fatiguing.
- Neutral eye angle is 15º downward. This is with respect to the vertical neck position.
- Set the heights of displays, computer screens, inspection area, etc. which requires viewing for prolonged period of time, about 30º below the eye height. Both neck and eye will be least stressed in such positions.

Source of fatigue in Hands/Arms/Shoulder

- Weighs around 8 lbs. Holding a feather requires holding 8 lbs. Avoid using the hand to hold a tool or work piece.
- Further the CG of the upper and lower arm from shoulder, more shoulder muscle activity. Work close to body, reduce reach.
- Avoid working with elevated hands, causes fatigue in shoulder muscles. Overhead or over the shoulder work is extremely fatiguing. Repeated fatigue on a daily basis is precursor of work related musculoskeletal disorder.
- Support the arms on the work surface or chair arms. Avoid sharp edges to reduce external pressure. Avoid abrasion.
- The hand muscles show largest MVC in neutral posture. When working in non-neutral postures, muscles are working at a higher percent of MVC, compared to that of neutral posture. Keeping yo ur wrist extended, flexed or deviated (ulnar and radial) for several minutes is enough for onset of forearm muscle fatigue due to static load.

Work surface height

- **Too low work height requires bending of back, which fatigues lower back muscles. Lower back muscles are balancing the upper body weight, which is about 67% of your total body weight!**
- **Too high work surface height will require lifting your shoulders for your hands to work freely. Static muscle fatigue will occur at shoulder.**
- **For both seated and standing work, the height should be 2 inches below the relaxed elbow height for general manipulative type of work This guideline seems to both maximize comfort and productivity.**
- **Consider the work piece height and hand tool height.**

Work surface height (continued)

- **For tasks that require manual force, such as working with a knife (meat and poultry industry), lower work surface height 6 to 8 inches below the elbow height. In such cases upper body weight can be used to develop downward pressure.**
- **For fine delicate work, inspection, sewing etc., work surface height need to be raised by 2-4 inches above the relaxed elbow height for the visual acuity demand of the task. Magnifying glass may help, but it reduces field of view.**
- **Exercise: Use anthropometry to determine kitchen counter height for a specific user? Do not forget the adjustment due to relaxed standing, adjustment for shoes, adjustment for pot and pans (objects on which hand will work).**

How to design work height for a population?

When no adjustment of height is possible:

fix the work surface height for average - minimum number of users will be at disadvantage.

Adjustment of height can be done in two ways: (1) Adjust the elbow height of the operator, (2) Adjust the work surface height

(1) Adjust the elbow height of the operator

- Design for taller persons and provide variable thickness platform for standing work, or provide adjustable chair.
- Set the conveyor height for taller person then provide a ramped platform
- Agricultural work – consider seating or kneeling as opposed to stooping.

How to design work height for a population (continued)?

(2) Adjust the work surface height

- Adjustable table
- Tiltable work surface
- Raise pallet in forklift
- Ramp the conveyor
- Deep-sided box/Many shallow boxes
- Adjustable height fixture used for automobile assembly line
- Inspection on movable platform

- For industrial design, the height adjustment should accommodate at least 5th to 95th percentile of the worker population.

Seated Work

Daily work that requires prolonged seating can cause back pain. Probable physiological causes are –

- Seating increases spine compressive force & intra-diskal pressure compared to standing. Increased spine compressive force is strongly correlated with lower back pain.
- The fluid filled inter-vertebral disks do not have blood capillaries. The interstitial fluid flows in and out from these discs due to change in intra-diskal pressure provides the necessary nutrition. Prolonged seating hinders disk nutrition and may cause disk degeneration and back pain.
- During standing, at the lumbar level, the spine assumes a forward convex arch (lordosis) configuration. This configuration, lordosis, increases the load bearing capacity of the lumbar spine. Seating flattens the lordotic arch (opposite to lordosis is kyposis) of the lumbar spine, hence making it susceptible to injury.

Physiological stresses in prolonged seating (Continued)

- Prolonged seating causes venous pooling in the lower limbs. Legs swell due to blood retention. Available blood volume for systemic circulation reduces causing heart to pump harder. During long airplane flights, passengers should stand up and walk occasionally. The extra load on heart could lead to heart stroke, more so for persons with compromised cardiovascular system.
- While sitting, load of the upper body is supported by relatively small bony portion of the pelvic griddle known as ischial tuberosity. Because of this small support area, pressure points reduce tissue blood flow in those regions and causes discomfort. Cushioning increases the contact area and hence reduces pressure points.

Measured Intra-discal Pressure in vivo

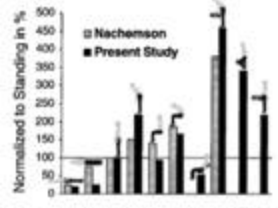


Figure 11. A comparison between data of Nachemson[17,18] and those of the current study (both for 70-kg individuals) regarding intradiscal pressure in common postures and activities, normalized to standing. Lifting weight = 20 kg in the current study; *lifting weight = 10 kg in Nachemson study.

Physiological stresses in prolonged seating (Continued)

- Contoured seat surface may increase the supporting area but prevents mobility during seating and thus fatiguing.
- Too deep seat depth causes undue pressure underneath the knee, pulling the hamstring muscles, which are attached from the pelvic griddle to tibia. Also restricts blood supply to the leg.
- Too high seat height will cause legs to dangle and cause pressure on the under side of the thigh, which becomes uncomfortable in a short while.

Seat height for a chair

- Seat height should be adjusted with respect to the work surface height not with respect to the floor. Adjust the seat height, such that elbow is 2 inch above the work surface, and eye neck postures are adequate, and then if required give a foot-rest.
- Exercise: Which anthropometric dimension should be used to determine the chair height? Hint: See popliteal height.
- Exercise: What should be the chair height for a fixed chair, which will be used for class rooms in universities? Should you go by 5th, 50th or 95th percentile data? What adjustments to the anthropometric data should be done?

Other chair design criteria

- Seat pan angle- backward sloping, forward sloping – what are the implications?
- Seat width – what should be ideal, how do you determine from the anthropometric dimensions of a population.
- Seat depth – there should be some space between the underside of the knee and the seat. Design dimension should correspond to the size for the shorter people.
- Back rest angle and height
- Arm rests

Computer workstation design

VDT – Video Display terminal (VERY DIFFICULT TASK): It is important because people use computers for a prolonged period of time. Computer workstation should have an adjustable height chair.

- Set the visual requirement first. Adjust the seat height such that the neck and eye positions are optimal. Provide a foot stool if necessary.
- For word processing, the source document may be the primary visual target. In general computer work the VDT screen normally is the primary visual target.
- The eye and neck position should allow slightly downward gaze and slight forward inclination of head. A rule of thumb is set the shoulder level at top of the display.
- Special problem arises with bifocal/ progressive lens, because it requires a backward tilt of head, to use the reading lens.

Computer workstation design (contd.)

- Distance of the screen depends on quality and size of the screen characters.
- Set the arm posture – optimum is vertical arm and horizontal forearm. Arms rests are required.
- Set the wrist posture – determined by the position and inclination of the keyboard and mouse or other input devices. Reduce ulnar and radial deviations. Reduce dorsi-flexion of wrist. What should be the ideal shape of computer key board?
- Ambient light intensity should not be too different from that of the screen. Reduce glare on the screen.
- Even with optimum design, prolonged computer task could cause muscular and eye fatigue. Encourage to take breaks, change posture.

Eronomics of Computer Keyboards





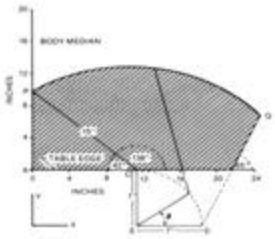

Furnish Every Employee with an Adjustable Chair

- The cost of an adjustable chair is very low compared to labor cost (1 cent/hr).
- Allow users to try chairs in their specific jobs.
- Buy chairs that are easily adjustable.
- Train people in proper adjustment.

Keep Arm Motions in the Normal Work Area

- Avoid wide work surfaces.
- For high use, keep the reach distances close.
- The shoulder is very sensitive to small changes in workplace layout.

"Windshield Wiper" Pattern of Normal Reach



Workspace reach

- Normal reach over a work surface is not a circular arc centered on elbow joint, but a more like a area covered by windshield wipers.
- Maximum reach is the reach profile without changing the upper body posture. Anthropometric data for reach profiles are available.
- These functional anthropometric dimensions are used to determine the placement of switches and other controls, when upper body movement is not intended, for example for cockpits, or automobile interiors.

Workstation design principles

Let the Small Person Reach; Let the Large Person Fit

- Design so most of the user population can use the design.
- Jobs must be designed for both sexes.
- Multi-person use of equipment and stations is becoming more common.
- Civilian industrial population anthropometric data are not the same as military anthropometric data.
- International populations should be a consideration.
- In many cases 50th percentile (average) anthropometric size is ideal, because majority of the population will have least disadvantage. However, in some situations, designing for average excludes half of the population. For example, if the force requirement is designed for the average, 50 percent of the population will not be able to operate.
- The proportion to exclude depends on the seriousness of designing people out and the cost of including more people.