

Anthropometry:

1. Find the 75th percentile elbow height, if mean = 99.79 cm sd = 4.48 cm.
2. Seated eye height = 83 cm, what is the percentile if mean = 79.20 cm & sd = 3.42 cm
3. A person with 40th percentile stature may have 70th percentile arm length, 10 percentile chest depth and so on. Anthropometric dimensions are poorly correlated. Body depth measures correlates better with weight.
4. Coefficient of variation (sd/mean) is generally low about 4-6% for the linear dimensions, which are determined by bony landmarks. But for weight cv = 22% for females and 16% for males.

Workstation Design

Reduce static load: Muscles fatigue quickly with static tension even at very low percent of MVC. Static load increases diastolic BP, thus heart has to do more work. Fatiguing effect of static muscle load is significant for the 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 muscle fatigue.

Standing work –

- CG of the whole body passes through front of the body. There is always static muscle activity at the lower back while standing.
- High heel shoes shifts the upper body CG more forward, increased lever arm length, increased back muscle activity.
- Provide a bar, or a step to alter leg posture. Relieves lower back muscles.
- Provide a small seat, if possible, to take occasional break
- 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.

Head 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 15° forward inclination is least stressful position. Tilting from this position increases muscle lever arm. Thus it increases static muscle tension and muscle fatigue, if kept for prolonged period of time. Most tiring is the backward tilt as the anterior neck muscles are comparatively weaker. Sideways tilting posture is also fatiguing.
- Neutral eye angle is 15° downward. Set the heights of displays, computer screens, delicate viewing task such as inspection, sewing etc which requires viewing for prolonged period of time, 15 to 30° below the eye height. Both neck and eye will be least stressed in such positions.

Upper and lower arms –

- Weighs around 8 lbs. Picking up a feather requires picking up 8 lbs.

- Further the CG of the upper arm and lower arm from shoulder, more shoulder and upper arm muscle activity. Remember the lever arms for the arm muscles are very short, less than an inch. Muscle tension is equal to the load (including arm weight) times the ratio of load lever arm and muscle lever arm. Thus if arms are extended the muscle tension increases many folds. Static load on muscles for deviation from the neutral posture will be enough to fatigue the arm muscles within few minutes. Repeated fatigue on a daily basis is precursor of work related musculoskeletal disorder. Arm support reduces the muscle activity.
- The same thing happens for the wrist joint. Keeping your wrist extended 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! The lever arm for the erector spinae is about 2 inches.

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 elbow height for general manipulative type of work. This guideline seems to both maximize comfort and productivity.

How can you use anthropometry to determine kitchen counter height for a specific user? Do not forget the adjustment due to relaxed standing height, adjustment for shoes, adjustment for pot and pans (objects on which hand will work).

For the 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 for visual acuity demand of the task. Magnifying glass may help, but it reduces field of view.

How to decide work height for a population? Should you design for average, taller or shorter people? When adjustment of the work surface height is not possible, design for average. Minimum number of users will be at disadvantage. When height adjustment is possible, design for taller people, and raise shorter people by providing platform of various thicknesses or by other means. Alternatively, design for shorter people, and raise the work surface height for taller people. For industrial design, the height adjustment should accommodate at least 5th to 95th percentile of the population.

Seating and chair design –

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

(1) 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. Seating increases intra-diskal pressure. Prolonged seating is thought to hinder disk nutrition and a probable cause of disk degeneration and back pain.

(2) 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 kyphosis) of the lumbar spine, hence making it susceptible to injury.

Other problems in seating are –

- Prolonged seating causes venous pooling. Legs swell due to blood retention. Available blood volume for systemic circulation reduces causing heart to work 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 girdle 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. However, 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 girdle 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.

Chair design –

- Give an adjustable chair to all workers. It costs only a penny per hour, inconsequential compared to the hourly rate of the worker.
- Seat height should be designed 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.
- What should be the chair height for a fixed chair, which will be used for class rooms in a university? Which anthropometric dimension should be used to determine the chair height? See popliteal height. Should you go by 5th, 50th or 95th percentile data? What adjustments to the anthropometric data should be done?

- 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 short people.
- Back rest angle and height
- Arm rests -

Computer workstation design

It is important because people use computers for a prolonged period of time. For occasional use, all these guide lines are not that significant.

- Set the visual requirement first. Adjust the seat height such that the neck and eye positions are optimal. 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 lense.
- Distance of the screen depends on quality and size of the screen characters.
- Set the chair height, such that the above eye/shoulder position is maintained. If needed provide a foot stool.
- 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 ulner 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.

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 Principle

Let the small people reach and let the large people fit. Include as large population as possible, without undue cost.

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.