Anthropometry

- Agenda
  - Review
  - Anthropometry

How to Design a Study

Within-Subjects

- Independent variable manipulated within a single subject
- Each subject exposed to all treatment levels
- Repeated measures; “treatment x subject”

Between-Subjects

- Independent variable manipulated between n ≥ 2 subjects
- Each subject exposed to only one treatment level
- “Separate groups”

Within-Subject

Independent Variable

Level 1	Level 2
P 1	P 1
P 2	P 2
P 3	P 3

Between-Subject

Independent Variable

Level 1	Level 2
P 1	P 4
P 2	P 5
P 3	P 6

How to Design a Study

	Within	Between
Advantages	Fewer Participants Shorter experimental time (for experimenter) Smaller variability between groups Need to counterbalance	No transfer effects between conditions No need for counterbalancing Matching can reduce inter-group variability Random assignment eliminates bias
Disadvantages	Learning effect Possible transfer between conditions ABBA counterbalancing assumes linear confounding effects All counterbalancing assumes symmetrical transfer Range effects may be problemmatic	Possible inter-group differences More participants required More experimental time (for experimenter) Matching takes effort and assumes no transfer from matching operations

From: Martin (2008) Table 8-7

Anthropometry

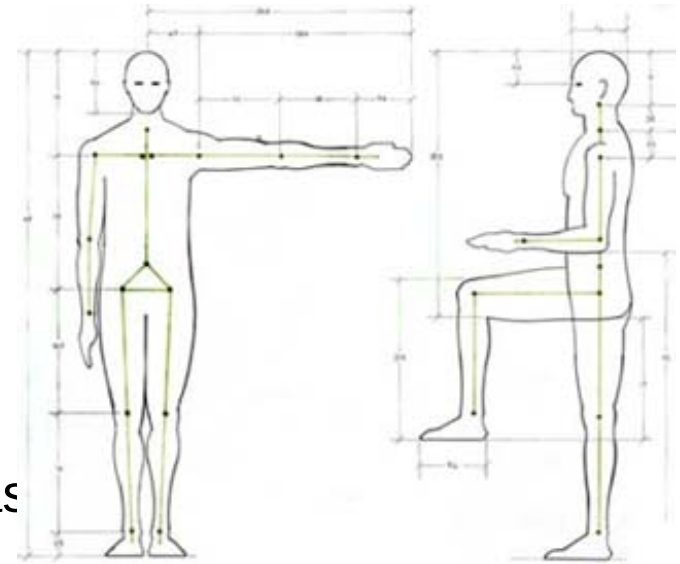
- Definition
  - Greek
    - “Anthropos”: “man”
    - “Metreo”: “to measure”
  - Detailed Definition
    - A scientific discipline provides the fundamental basis and quantitative data for matching the physical dimensions of workplaces and products with the body dimensions of intended users

Anthropometry

- Engineering anthropometry originated from anthropology, and seeks to describe the physical dimensions of the (human) body
- Engineering anthropometry as applied to ergonomics and biomechanics can be separated into:
  - **Physical (Structural/Static) anthropometry:** addresses fundamental physical dimensions of the body
  - **Functional (Dynamic) anthropometry:** physical dimensions relevant to completing particular activities or tasks
  - Develop functional design data from physical data

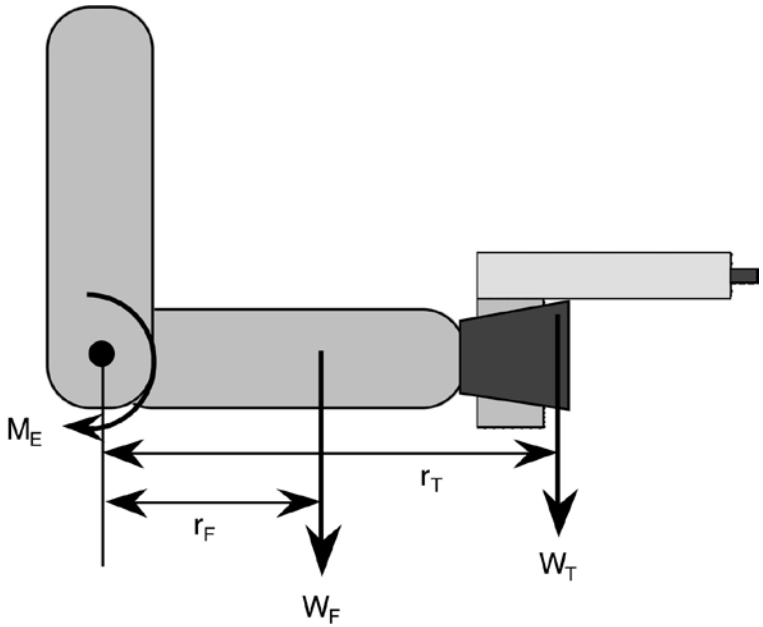
Anthropometry

- Static anthropometry
  - Weight and volume
  - Segment length and circumference
  - Shape
  - Center of mass (center of gravity)
    - A point at which body's mass behaves as it were concentrated.
    - Function of the positions and masses of the body segments.



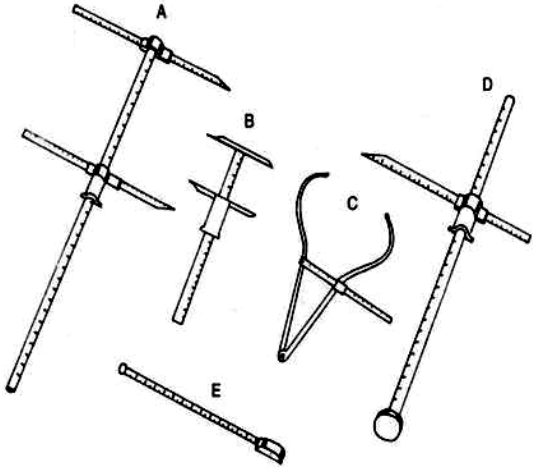
Anthropometry

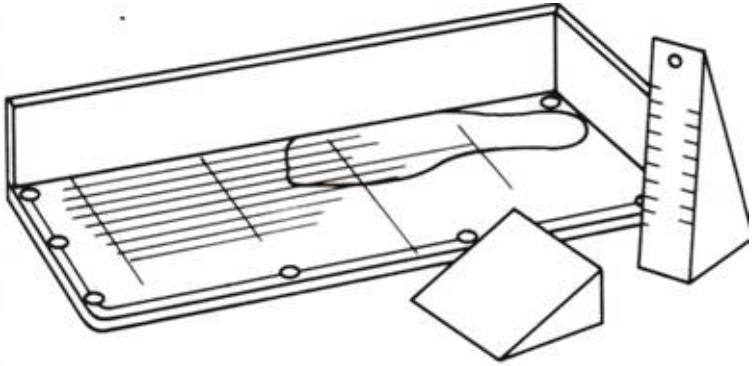
- Static anthropometry
  - Center of mass (center of gravity)
    - Use of COM in biomechanical calculations
      - ✓ E.g., External elbow moment due to weights of forearm/hand and tool
    - Requires knowing where the mass (weight) is located
    - Mass represented at a specific location = COM

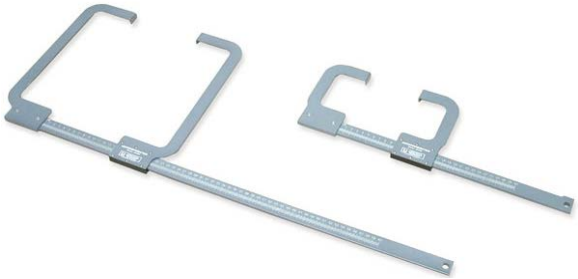


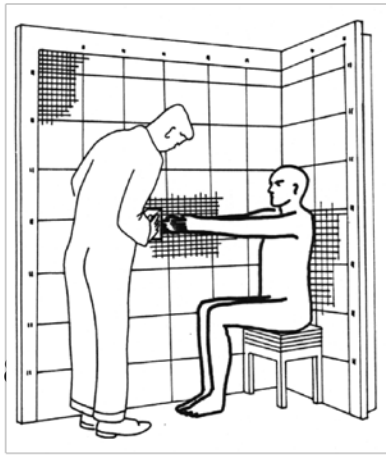
Anthropometry

- Measurement Tools
  - Anthropometer, measuring tape, scale, grid system
  - Simple but time consuming! (Very specific guidelines for use)



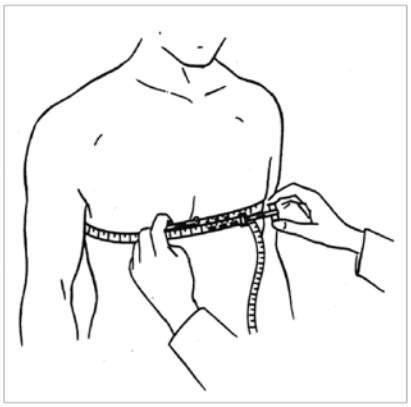


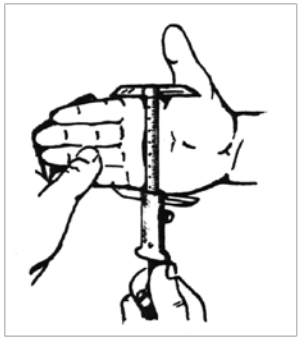


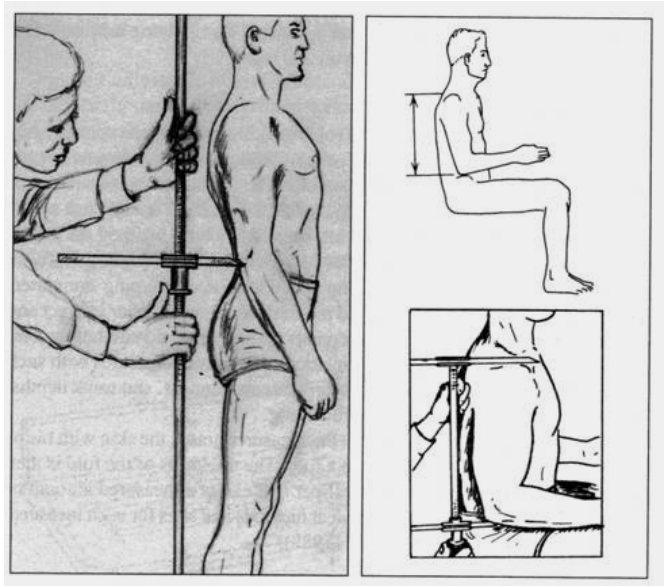


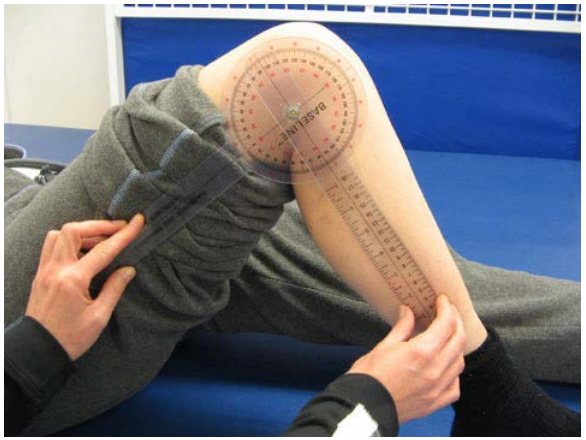
Anthropometry

- Measurement Tools







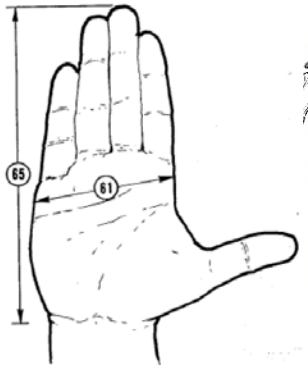


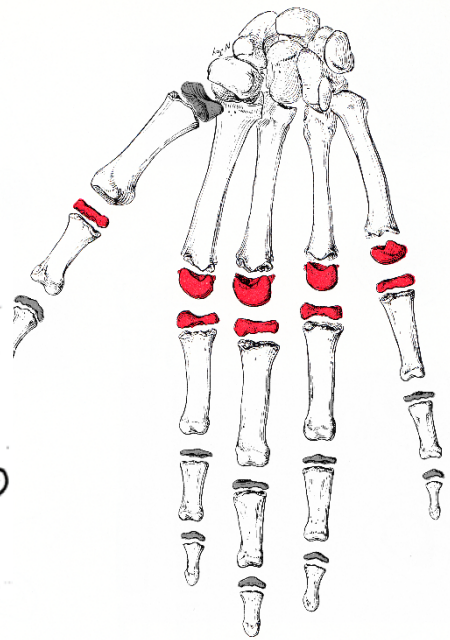
From: Kroemer, K., Kroemer, H., and Kroemer-Elbert, K. (1990). Engineering Physiology: Bases of Human Factors/ Ergonomics

Anthropometry

- Measurement
  - To obtain meaningful dimensions, extreme care must be taken to
    - Specify exactly what is being measured and how
    - Dimensions must be located relative to physical (anatomical) landmarks (common to all people and easy to locate) on the body
    - Example: Hand breadth

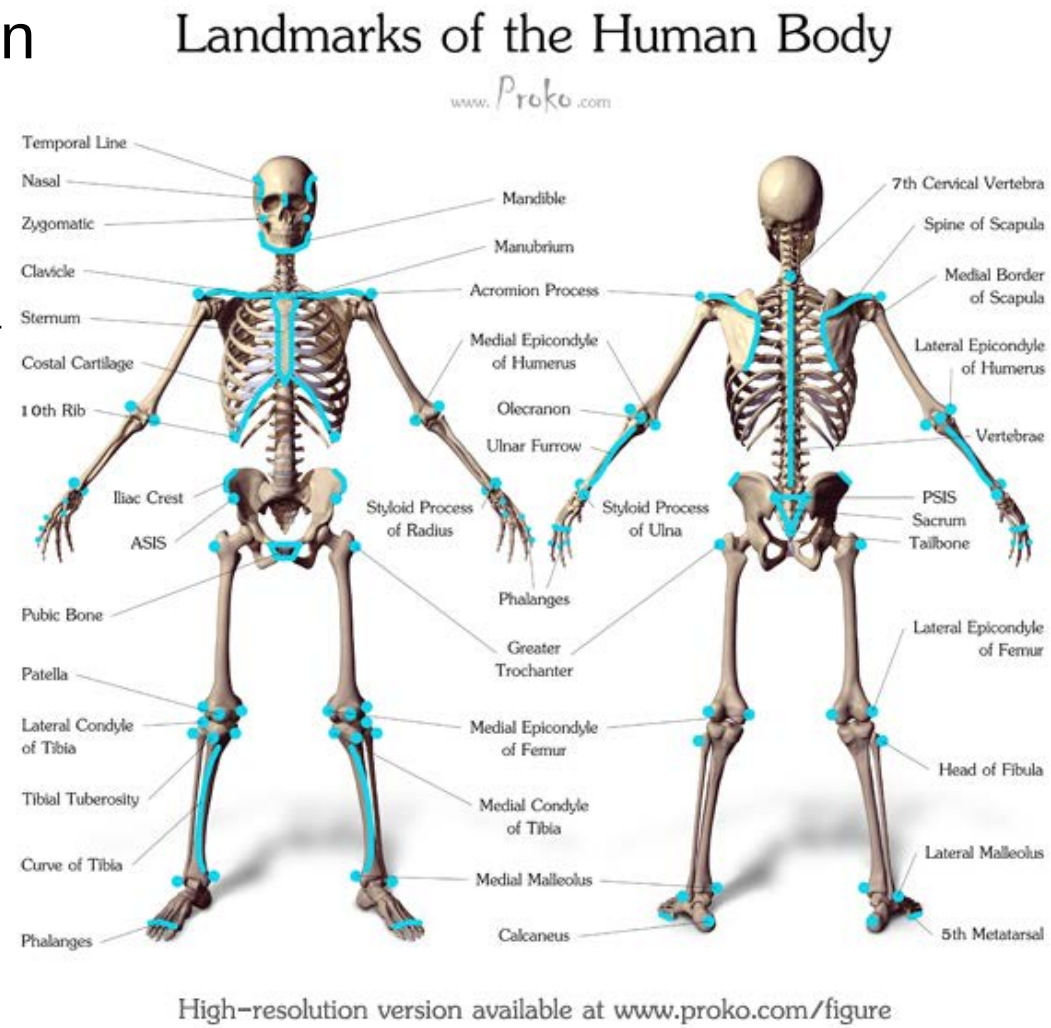
61 HAND BREADTH: The breadth of the hand between the second and the fifth metacarpal-phalangeal joints.





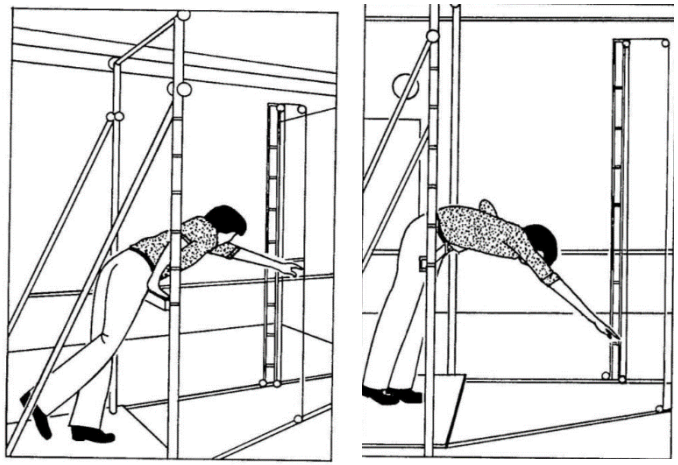
Anthropometry

- Landmarks of the human body
  - Anatomical Landmark: an anatomic structure used as a point of reference in establishing the anatomic relationships



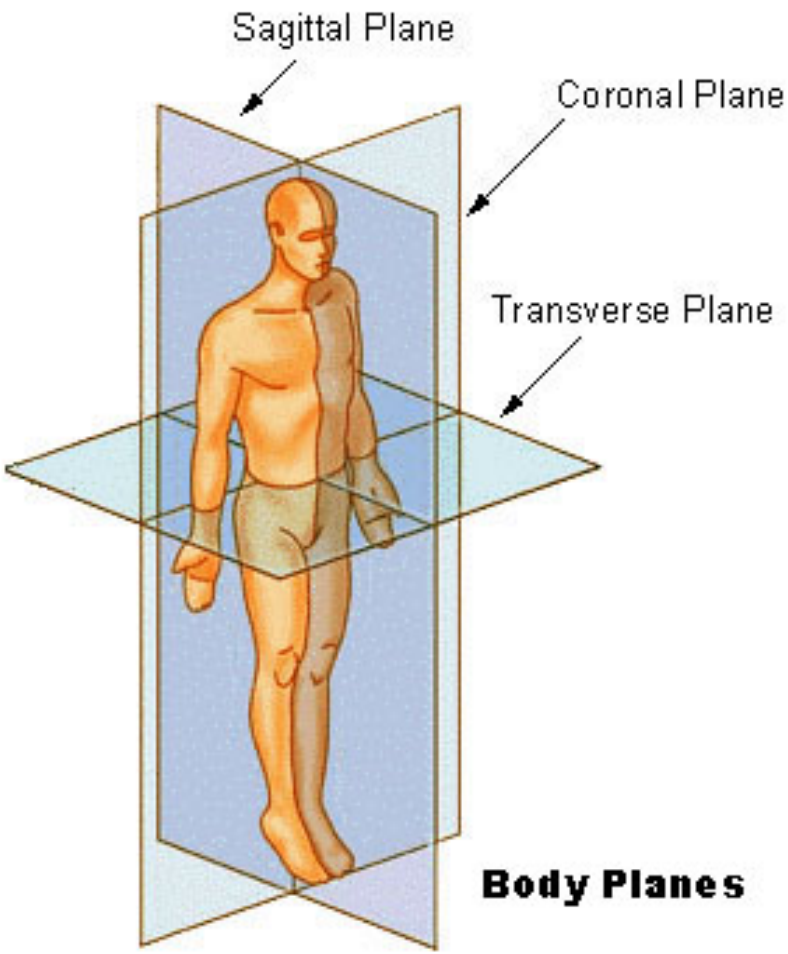
Anthropometry

- Functional anthropometry
  - Spatial information for specific activities
    - Measures are influenced by specific tasks and/or individual performance
  - Range of motion
    - Limited by body tissues such as bones, ligaments, muscle-tendon units, and other body parts.
    - Affected by age, gender, time of day, warm-up, segment length.



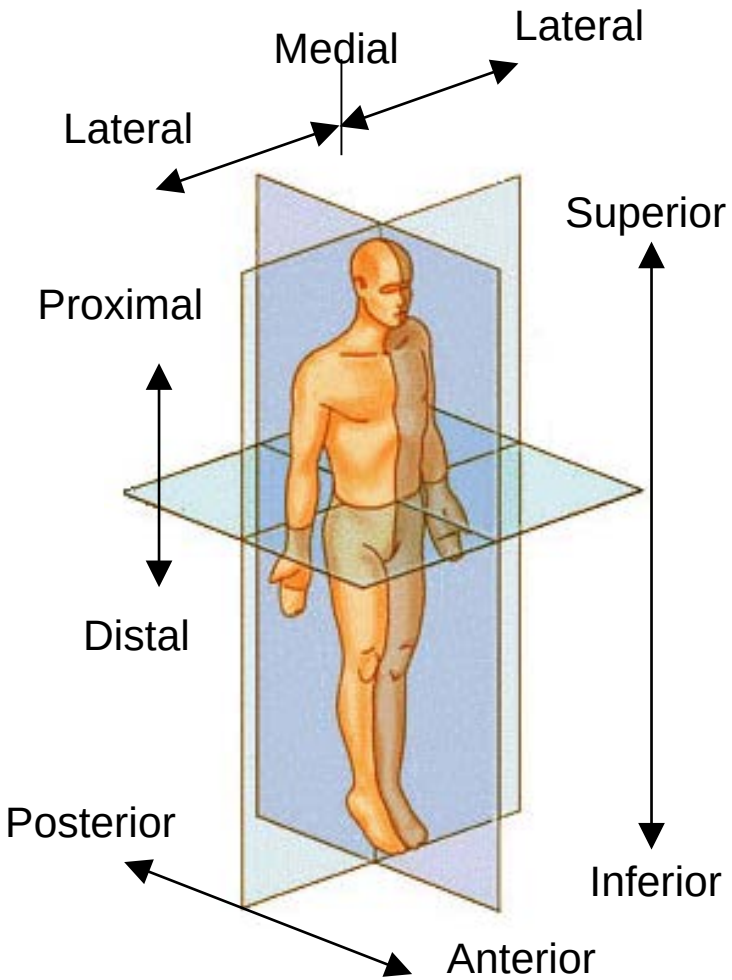
Anthropometry

- Body Planes



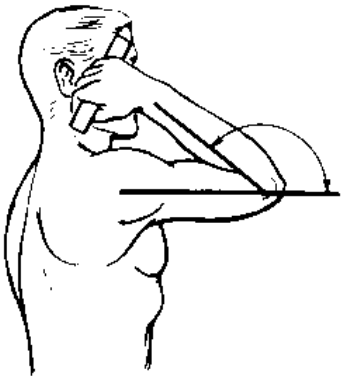
Anthropometry

- Standard terminology (Describe the relative positions of the body parts)
  - Midline: An imaginary line that divides the body into right and left halves
  - Medial: **Toward** the **midline** that divides left and right
  - Lateral: To **the side away** from the **midline**
  - Proximal: **Closer** to the **torso**, e.g. shoulder
  - Distal: **Farther away** from the **torso**, e.g. elbow
  - Superior: **Toward** the **head**
  - Inferior: **Away from** the **head**
  - Anterior: The **front** of the body or body part
  - Posterior: The **back** of the body or body part



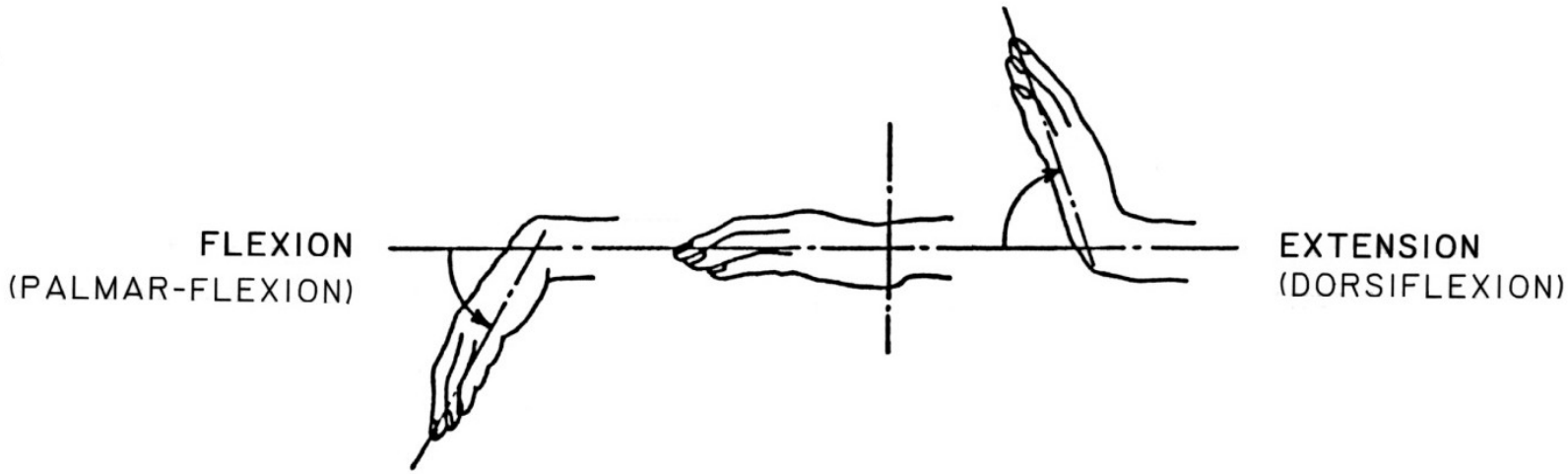
Anthropometry

- Body Movement
  - Flexion v.s. Extension
    - Flexion: Bending movement that decreases the angle between two parts.
    - Extension: Straightening movement that increases the angle between two parts.



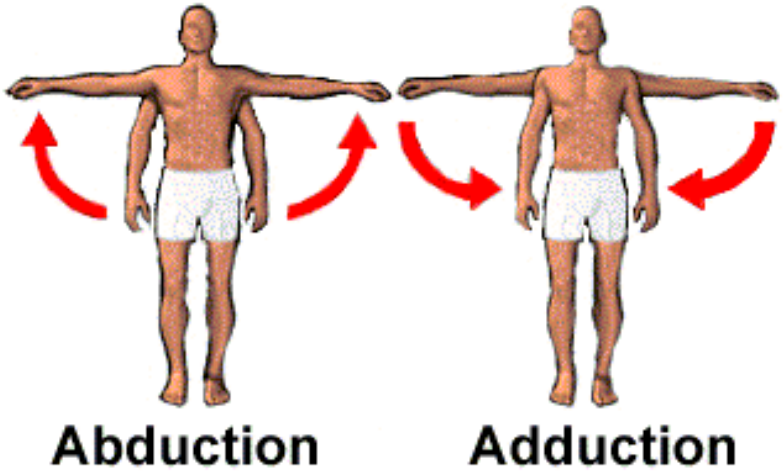
Anthropometry

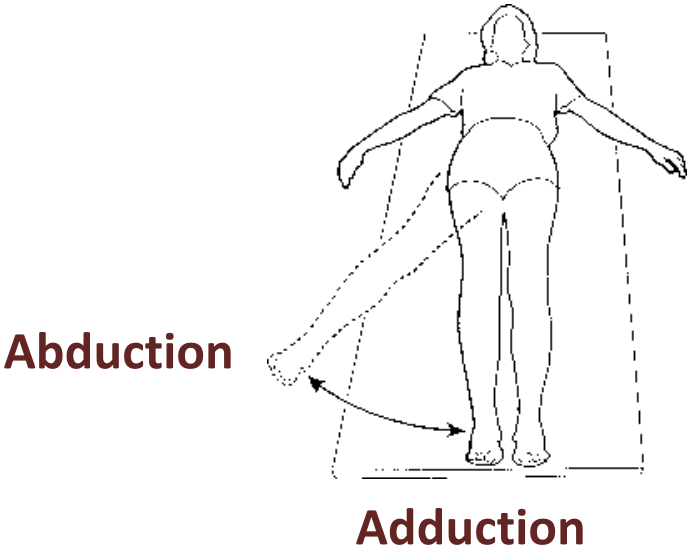
- Body Movement
  - **Wrists/Hands**
    - Flexion - Bending
    - Extension - Extending, straightening



Anthropometry

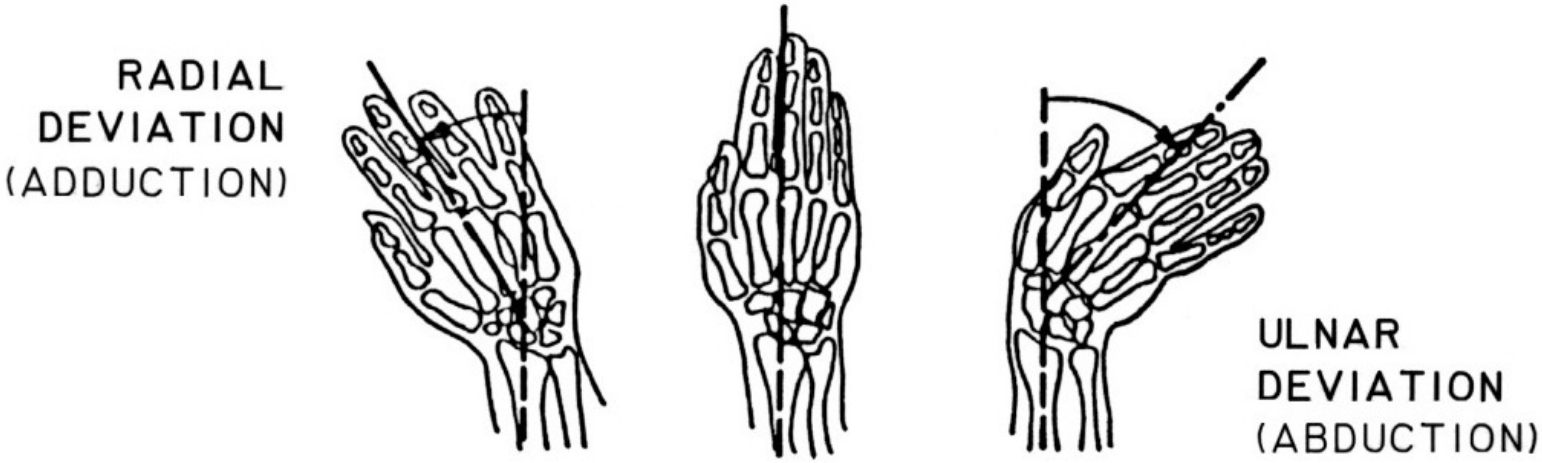
- Body Movement
  - Adduction vs. Abduction
    - Adduction: motion that pulls a segment toward the midline of the body.
    - Abduction: motion that pulls a segment away from the midline of the body.





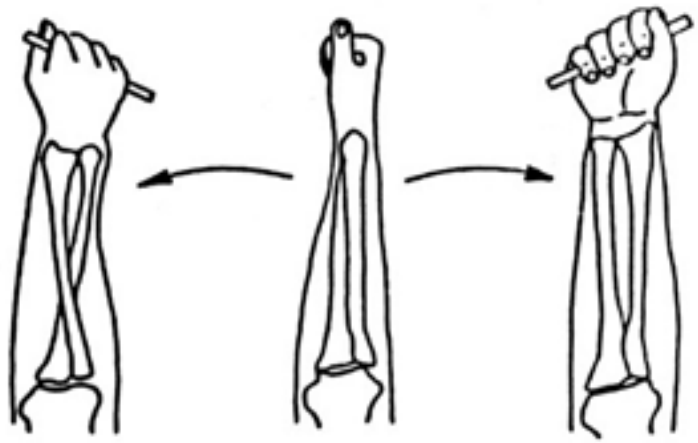
Anthropometry

- Body Movement
  - **Radial deviation/ulnar deviation**

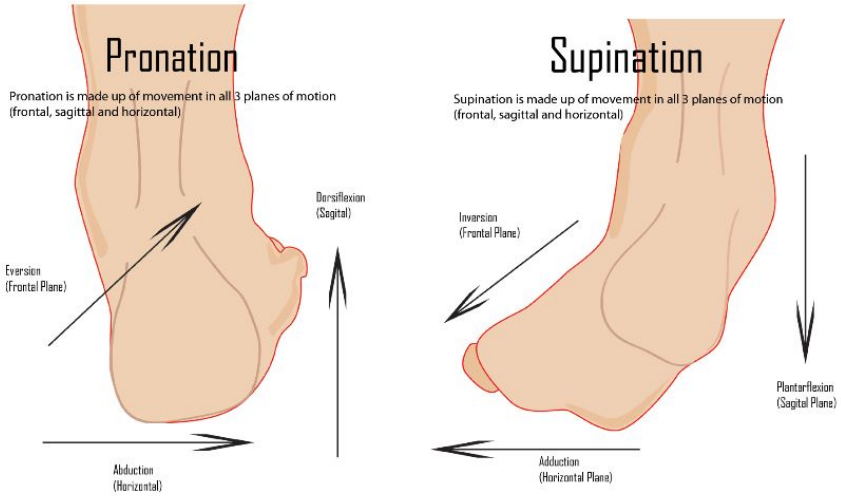


Anthropometry

- Body Movement
  - Pronation vs. Supination
    - Pronation: rotation downwards (palm facing down; sole facing laterally)
    - Supination: rotation upwards (palm facing up; sole facing medially)



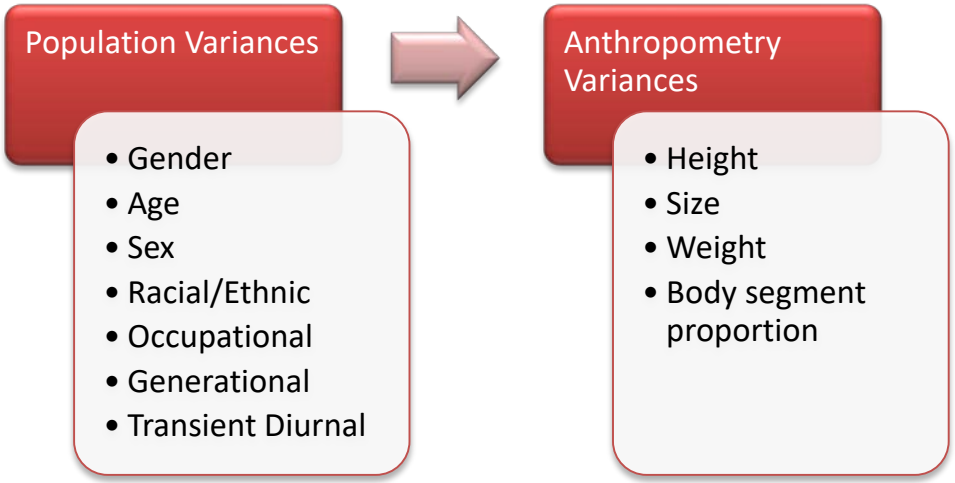
Pronation Supination



http://run360run.blogspot.com/2012_09_01_archive.html

Anthropometry

- Variability
  - Class Demonstration
    - Height
  - Source of variability
    - Measurement variability
    - Inter-subject variability
      - ✓ The variability between people.
      - ✓ The most important for most applications of anthropometry
    - Intra-subject variability
      - ✓ The variability within a person
      - ✓ Over years; within a day; transient

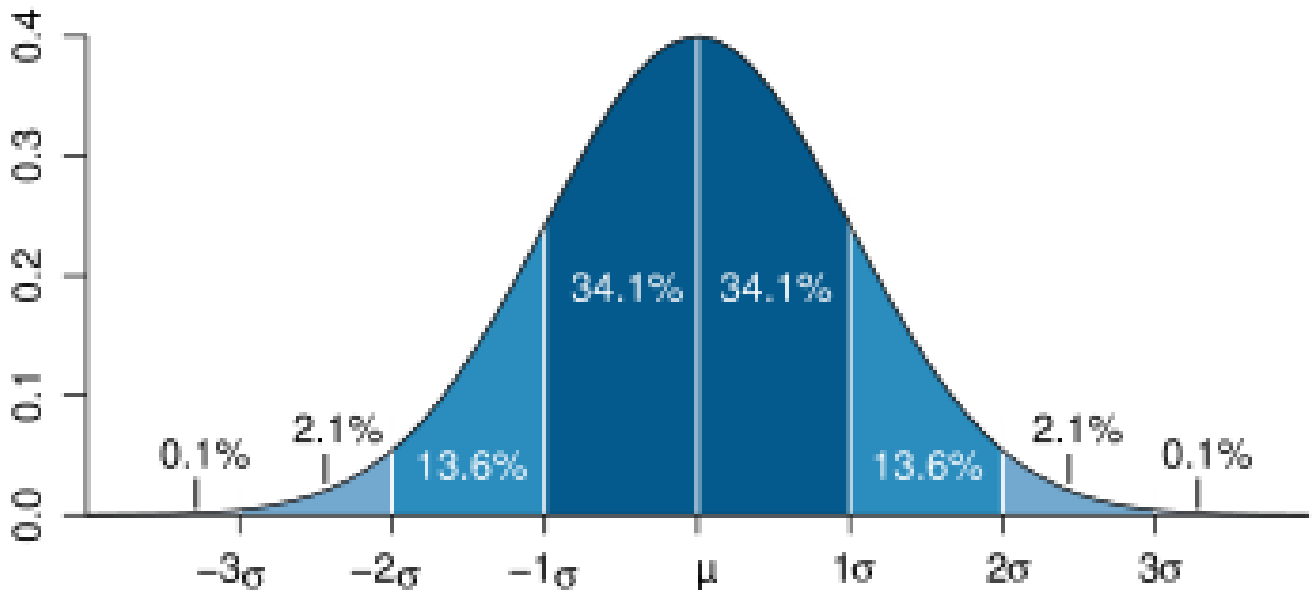


Anthropometry

- How to Minimize the Variability
  - Measure twice or more
  - Be specific in description
  - Consider purpose for data collection
    - What to collect, how to interpret, how to use
  - Consider
    - Time of day
    - Accuracy/precision of instrument
    - Bony landmarks vs. soft tissue landmarks

Anthropometry

- Statistics for Anthropometry
  - Normal distribution approximation
    - Compute mean & standard deviation.
    - Assume normal distribution (no skewness).

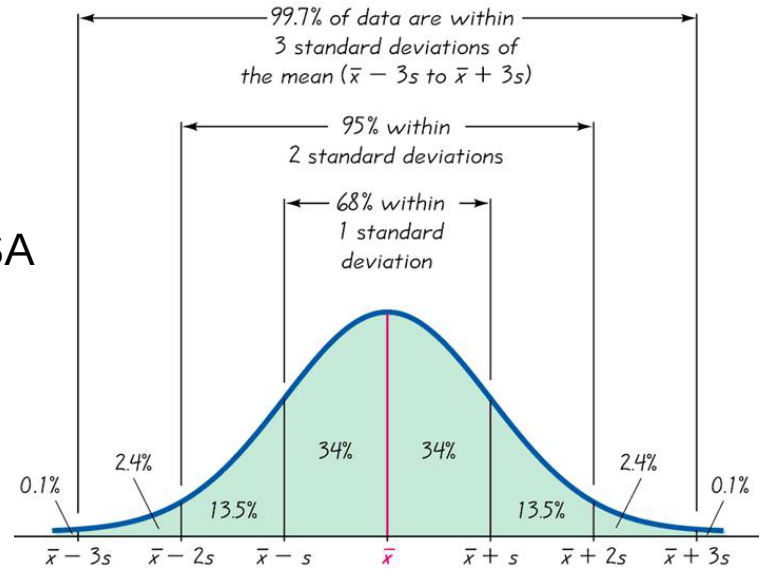


Anthropometry

- Statistics for Anthropometry
  - Normal distribution approximation
  - Example
    - Study the heights of adults, ages 18-24 in USA
    - Target population:
      - ✓ Women (1000 subjects)
        - mean: 65.0 inches
        - standard deviation: 2.5 inches
    - Men (1000 subjects)
      - ✓ mean: 70.0 inches
      - ✓ standard deviation: 2.8 inches

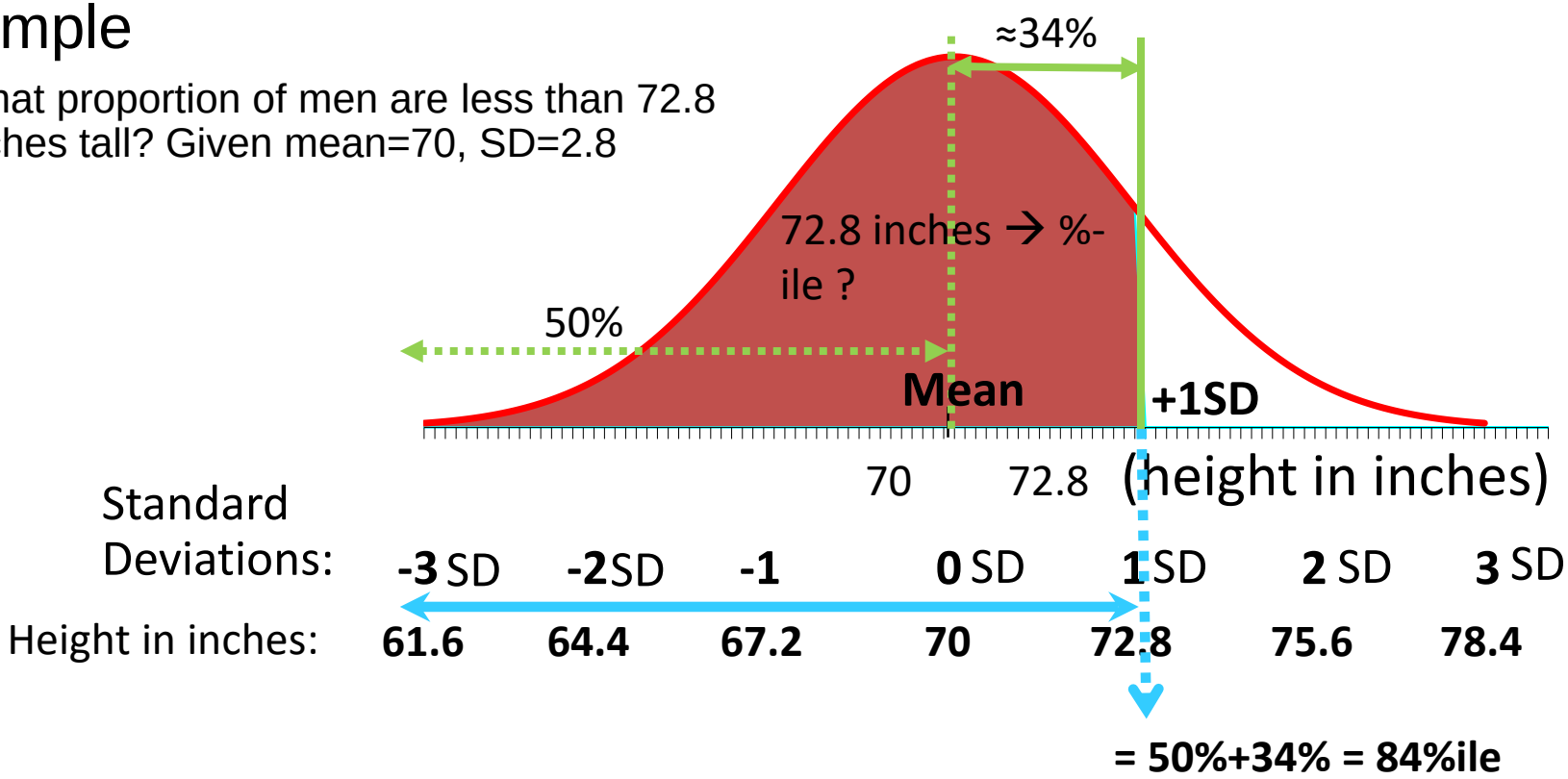
Anthropometry

- Statistics for Anthropometry
  - Normal distribution approximation
  - Example
    - Study the heights of adults, ages 18-24 in USA
      - ✓ Women
        - 68% are between 62.5 and 67.5 inches
          [mean ± 1 sd = 65.0 ± 2.5]
        - 95% are between 60.0 and 70.0 inches
        - 99.7% are between 57.5 and 72.5 inches
      - ✓ Men
        - 68% are between 67.2 and 72.8 inches
          [mean ± 1 sd = 70.0 ± 2.8]
        - 95% are between 64.4 and 75.6 inches
        - 99.7% are between 61.6 and 78.4 inches



Anthropometry

- Statistics for Anthropometry
  - Normal distribution approximation
  - Example
    - What proportion of men are less than 72.8 inches tall? Given mean=70, SD=2.8



Anthropometry

- Statistics for Anthropometry
  - Percentile Value
    - A percentile value of an anthropometric dimension represents the percentage of the population with a body dimension of a certain size or smaller
      - ✓ For example, 99th percentile value of stature means 99% of the individuals in that population would be equal or shorter than that value
    - Percentiles can easily be calculated from mean and standard deviation from population anthropometric data
    - Percentile Value = mean + z*SD (z: z score from Z-tables)

Anthropometry

Selected Structural Body Dimensions and Weights of Adults							
				Dimension, in			
			Male, percentile			Female, percentile	
	Body Feature	5th	50th	95th	5th	50th	95th
1	Height	63.6	68.3	72.8	59.0	62.9	67.1
2	Sitting height, erect	33.2	35.7	38.0	30.9	33.4	35.7
3	Sitting height, normal	31.6	34.1	36.6	29.6	32.3	34.7
4	Knee height	19.3	21.4	23.4	17.9	19.6	21.5
5	Popliteal height	15.5	17.3	19.3	14.0	15.7	17.5
6	Elbow-rest height	7.4	9.5	11.6	7.1	9.2	11.0
7	Thigh-clearance height	4.3	5.7	6.9	4.1	5.4	6.9
8	Buttock-knee length	21.3	23.3	25.2	20.4	22.4	24.6
9	Buttock-popliteal height	17.3	19.5	21.6	17.0	18.9	21.0
10	Elbow-to-elbow breadth	13.7	16.5	19.9	12.3	15.1	19.3
11	Seat breadth	12.2	14.0	15.9	12.3	14.3	17.1
12	Weight	120	166	217	104	137	199
Weight given in pounds							
Source: U.S. Public Health Service, 1965							

Anthropometry

- Statistics for Anthropometry
  - Percentile Value
    - Example
      - ✓ Assume height (stature) of OSU students: Mean = 168.0 cm, SD = 8.6 cm.
        - Q1:What is the height of the 98th percentile of this population?

          Percentile value = mean + z*SD

          98th percentile= 168.0 cm + 2.05 * 8.6 cm = 185.6 cm
        - Q2: Assume your height is 175 cm. If there are 1,000 OSU students currently registered, how many would you expect to taller than you?

          175 cm = 168 cm + Z*8.6

          Z ≈ 0.81

          Using z-table, Φ(z)=79%

          1000 *(1-0.79) = 210 students

Anthropometry

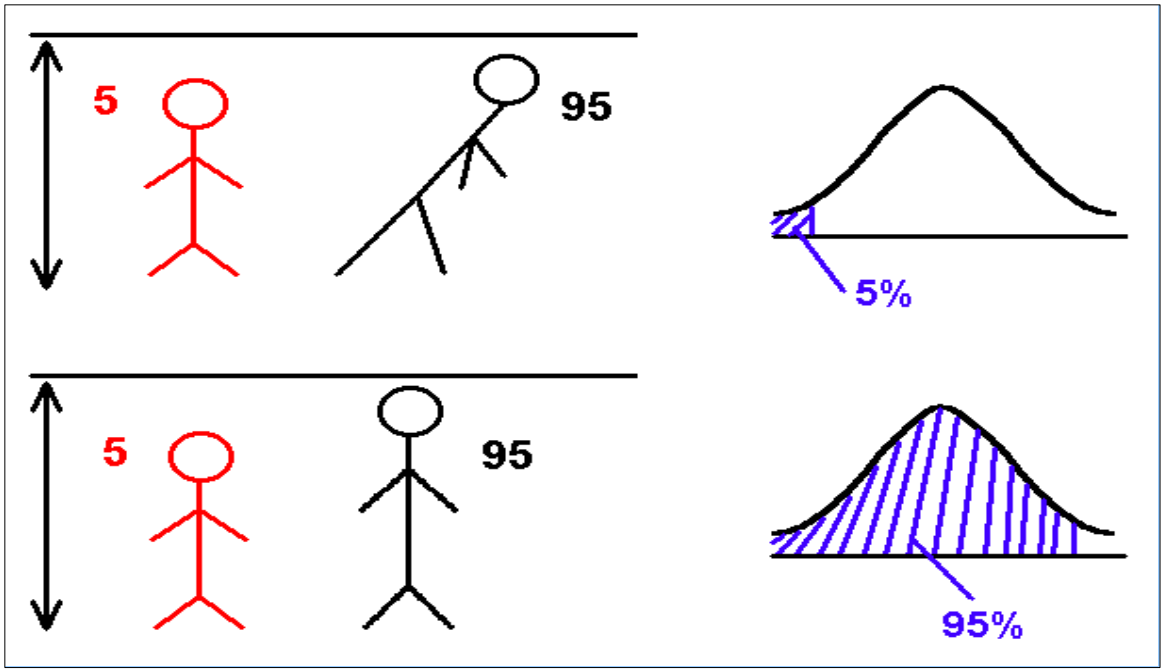
- Use of anthropometric data
  - Workplace design (reach, clearance, functional ability, postural support, vision, comfort)
  - Tool design (size, shape, weight)
  - Biomechanical models
    - Scale of human stature
    - Define body range of motion
    - Strength

Anthropometry

- Use of anthropometric data
  - Product design
    - Design principles
      - ✓ Design for clearance/accommodation
        - Design for the large person (Let the large person fit.)
      - ✓ Design for reach / accessibility
        - Design for the small person (Let the small person reach.)
      - ✓ Design for adjustability
        - Design for everyone
      - ✓ Design for the average person

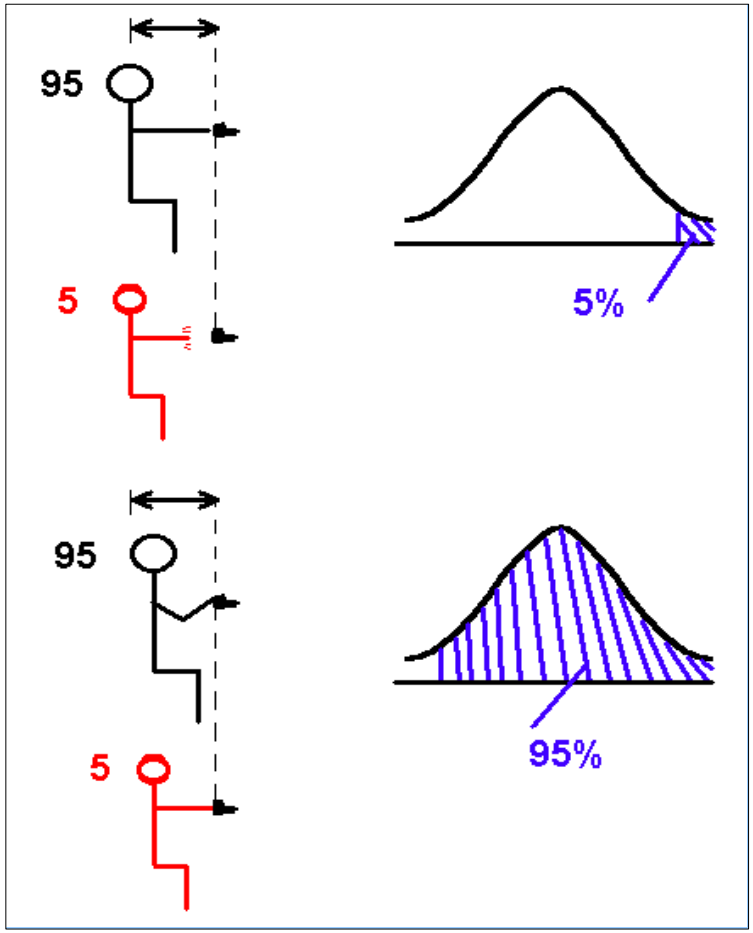
Anthropometry

- Use of anthropometric data
  - Product design
    - Design for Clearance/Accommodation
      - ✓ Design for the Large Person (Let the large person fit.)



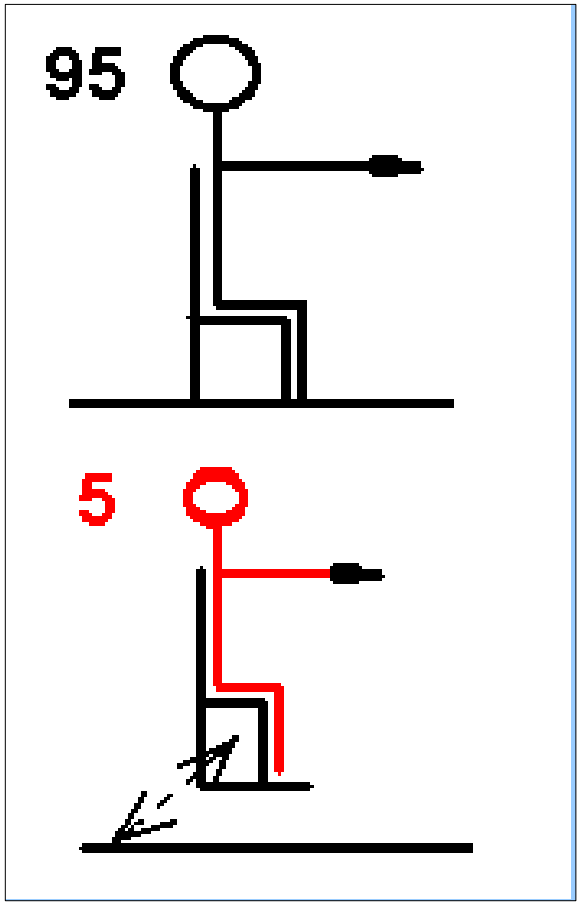
Anthropometry

- Use of anthropometric data
  - Product design
    - Design for Reach / Accessibility
      - ✓ Design for the Small Person (Let the small person reach.)



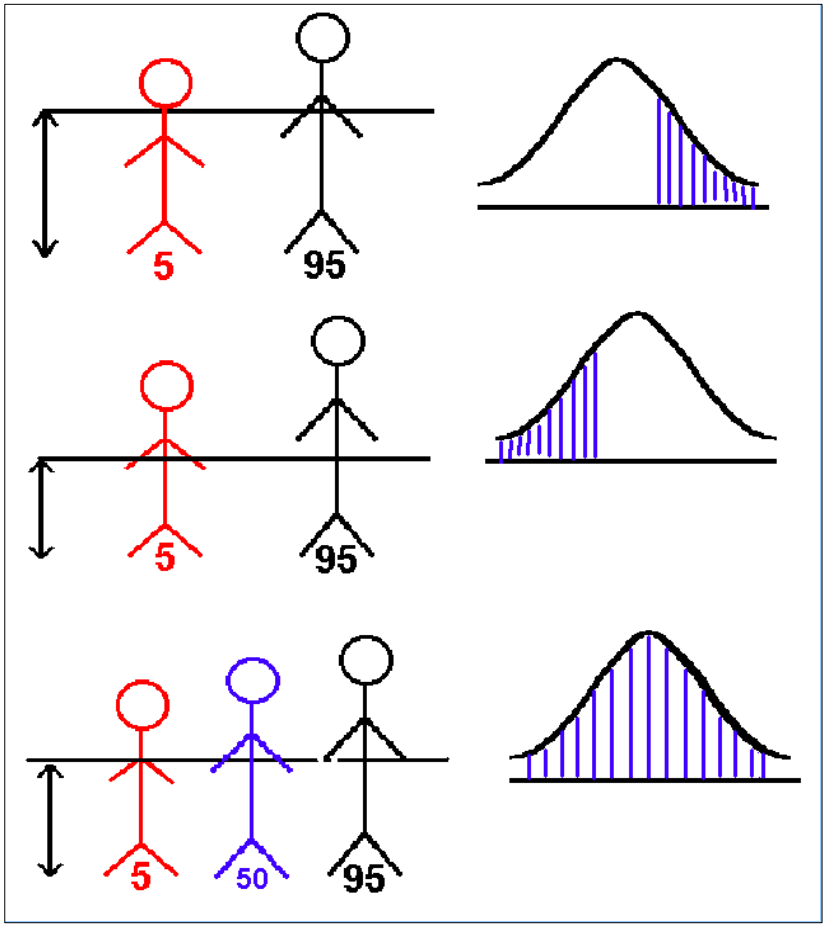
Anthropometry

- Use of anthropometric data
  - Product design
    - Design for Adjustability
      - ✓ Design for Everyone



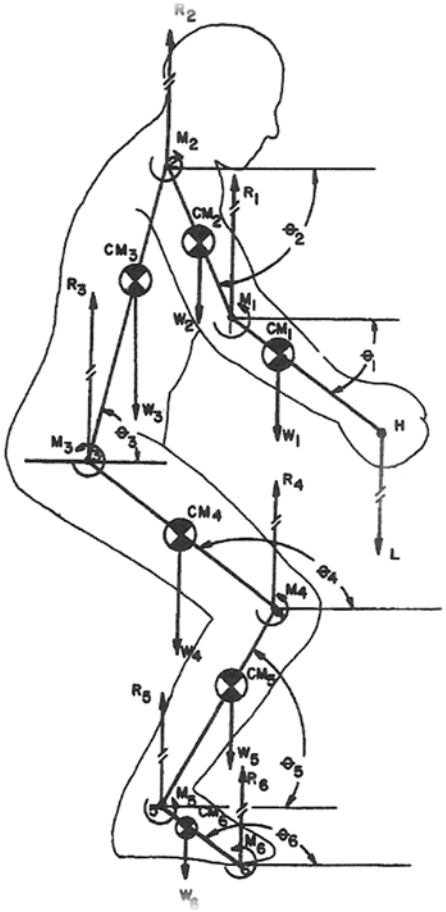
Anthropometry

- Use of anthropometric data
  - Product design
    - Design for the average person



Anthropometry

- Use of anthropometric data
  - Biomechanical model
    - Based on your **stature**, calculate the **length** of your upper arm, forearm, and hand.
    - Based on the **mass** and **length** data of your arm segments, calculate the **location of center of mass** of your arm (distance from shoulder).



Anthropometry

- Use of anthropometric data
  - Biomechanical model

TABLE 3.7 Recommended Link Length as Proportion of Stature

Length Fraction of Stature	Recommended Values	
	Females	Males
Wrist to finger tip	0.098	0.108
Forearm	0.1460	0.1510
Upper arm	0.1843	0.1877
Head	0.13	0.13
Neck	0.052	0.052
Head and neck	0.182	0.182
C7T1 to SCJ	0.063	0.063
L5S1 to shoulder center	0.231	0.226
L5S1 to hip center	0.0554	0.0542
Upper leg	0.2542	0.2574
Lower leg	0.2298	0.2287
Shoulder width	0.195	0.204
Hip width (between joint centers)	0.112	0.101
Foot width	0.055	0.055
Heel to toe	0.136	0.152
Ankle height	0.039	0.039

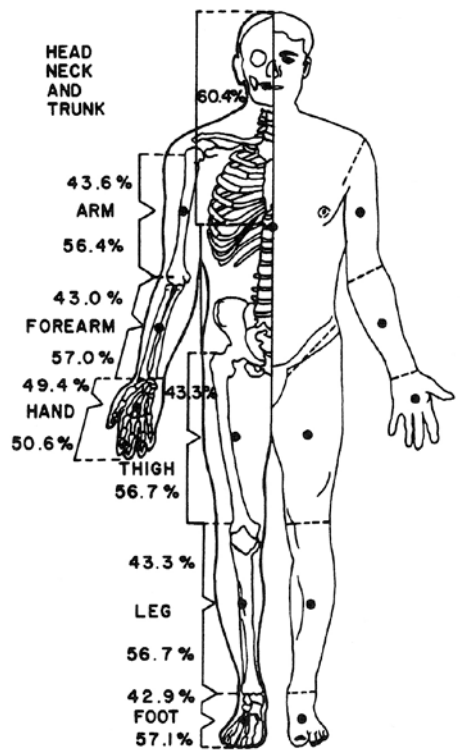


Figure 3.10. Link boundaries and locations of center of mass as a percentage of link lengths (Dempster, 1955).

Occupational Biomechanics by Chaffin

Anthropometry

- Use of anthropometric data
  - Biomechanical model
    - Example: Given, your stature=180 cm. What is the distance of your upper arm COM from your elbow
      - ✓ Male
        - Length of Upper Arm=180 cm *0.1877=33.9 cm
        - Distance=33.9 cm * 0.564= 19.1196 cm
      - ✓ Female
        - Length of Upper Arm=180 cm *0.1843=33.2 cm
        - Distance=33.2 cm * 0.564= 18.7248 cm