Wollo University
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Department of Industrial Engineering

Introduction to Ergonomics and Industrial Safety

Section Two

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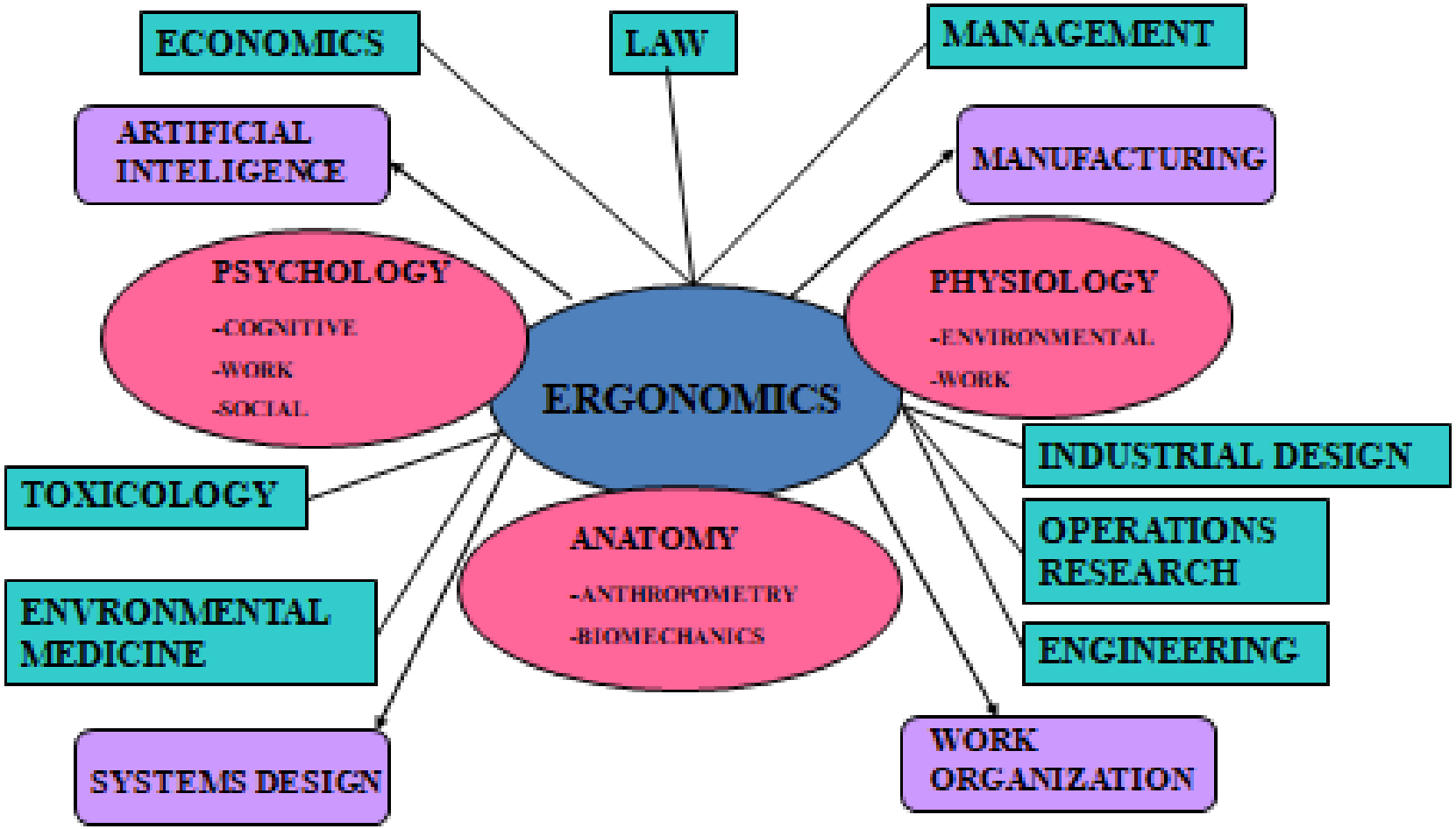
Section two

Multidiscipline of Ergonomics

1. Multidisciplinary Nature of Ergonomics
2. Physiology
3. Psychology
4. Anthropology
5. Human-Machine Systems/Interaction

Multidisciplinary Nature of Ergonomics



What is Psychology?

- Psychology is the discipline concerned with behavior and mental processes and how they are affected by an organism's physical state, mental state, and external environment
- Psychology is the scientific study of our thoughts, feelings and behaviors.
- An approach or perspective in psychology is a particular view as to why, and how, it is we think, feel, and behave as we do

what is Physiology?

- **Physiology is** the study of biological function

  Levels of Structural Organization in the Human Body
  - Chemicals
  - Cells
  - Tissues
  - Organs
  - Organ Systems

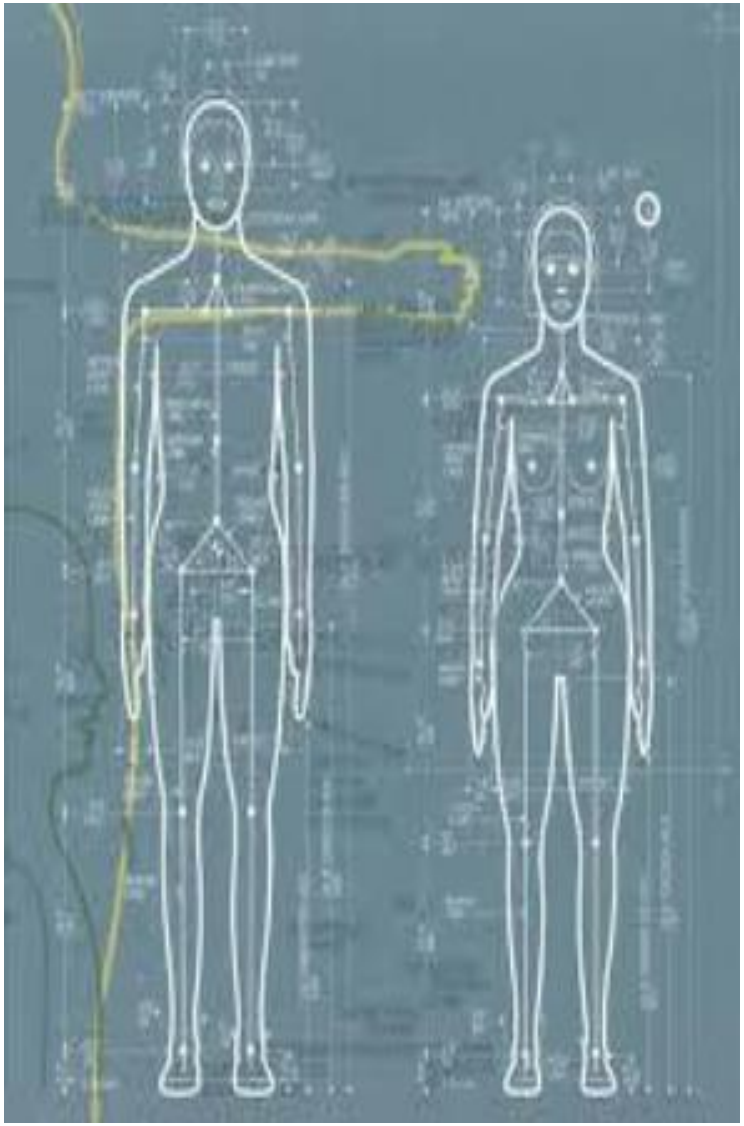
Anthropometry

- **Anthropometry :**

  literally meaning "measurement of humans", in physical anthropology, refers to the measurement of the human individual for the purposes of understanding human physical variation.

- **Anthropos = Human,**

  Metrokos = Measuring



Con...

- The science of measuring the human body as to height, weight, and size of component parts, including skin fold thickness, to study and compare the relative proportions under normal/abnormal conditions and for the purposes of understanding human physical variation.
- Anthropometry is the science that measures the range of body sizes in a population. When designing products it is important to remember that people come in many sizes and shapes.

Con...

- Anthropometric data varies considerably between regional populations. For example, Scandinavian populations tend to be taller, while Asian and Italian populations tend to be shorter.
- The basic applications of Anthropometry in design is finding appropriate dimensions to be incorporated in the design

Con...

- There are **two types** of dimensions that determine what the design dimensions should be **clearance** and **reach**
- **Clearance** dimensions determine the minimum space required for a human being to perform work activities in a workplace, such as operating and maintaining machines.

✓ Clearances are established by the larger people from the expected user population (e.g., door frame).

- **Reach** dimensions determine the maximum space allowable for a human being who operates equipment and are established by the small people in the expected user population (e.g., Control height).

Types of Anthropometry

There are two types of anthropometry measurements

1. Structural anthropometry

(often called "static anthropometry")
measurement of the body at rest including overall measurements like total stature and weight, measurements of links or circumferences like wrist to elbow, knee to hip, circumference of head and measurement of specific landmarks in reference to some other point, like the floor, e.g eye height.

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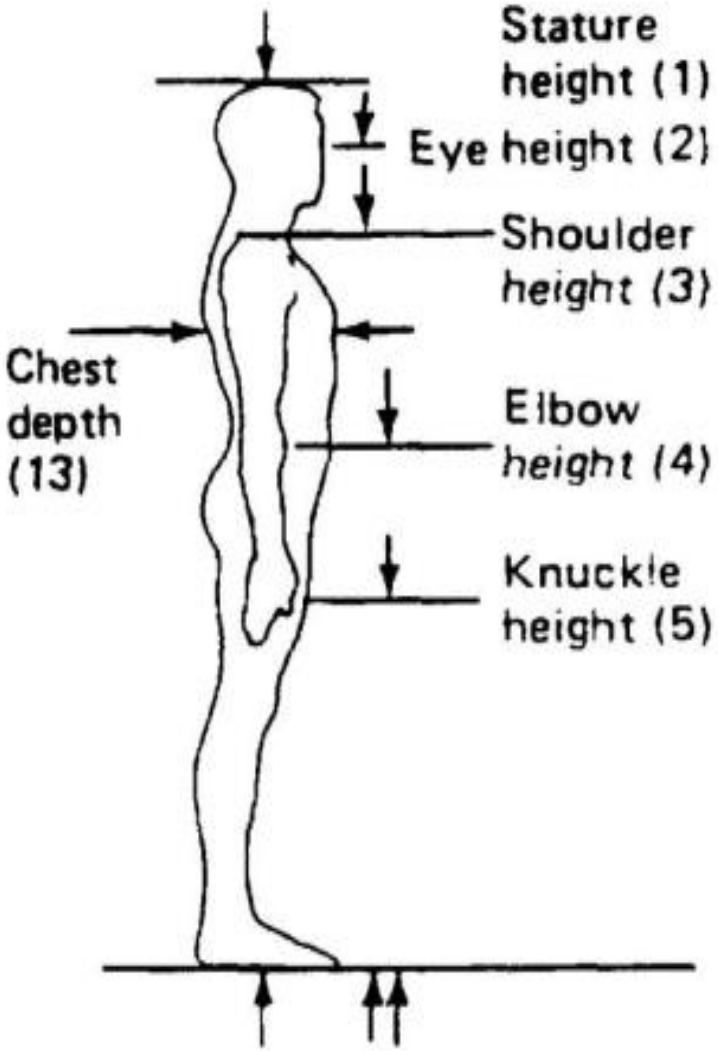
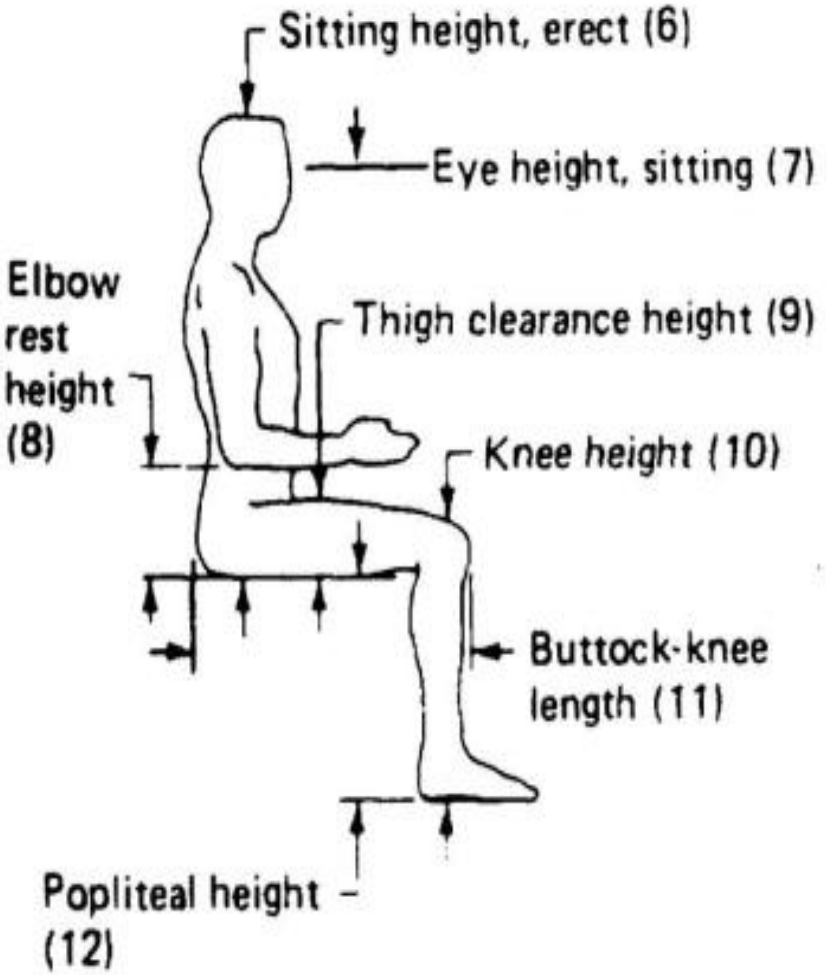

Stature height (1)
Eye height (2)
Shoulder height (3)
Chest depth (13)
Elbow height (4)
Knuckle height (5)


Sitting height, erect (6)
Eye height, sitting (7)
Elbow rest height (8)
Thigh clearance height (9)
Knee height (10)
Buttock-knee length (11)
Popliteal height (12)

Con...

2. Functional anthropometry

(often called "dynamic anthropometry") – measurement of the body in motion like the reach envelope of seated work, the movement of body parts in relationship to one another or the space required to turn a wheelchair.

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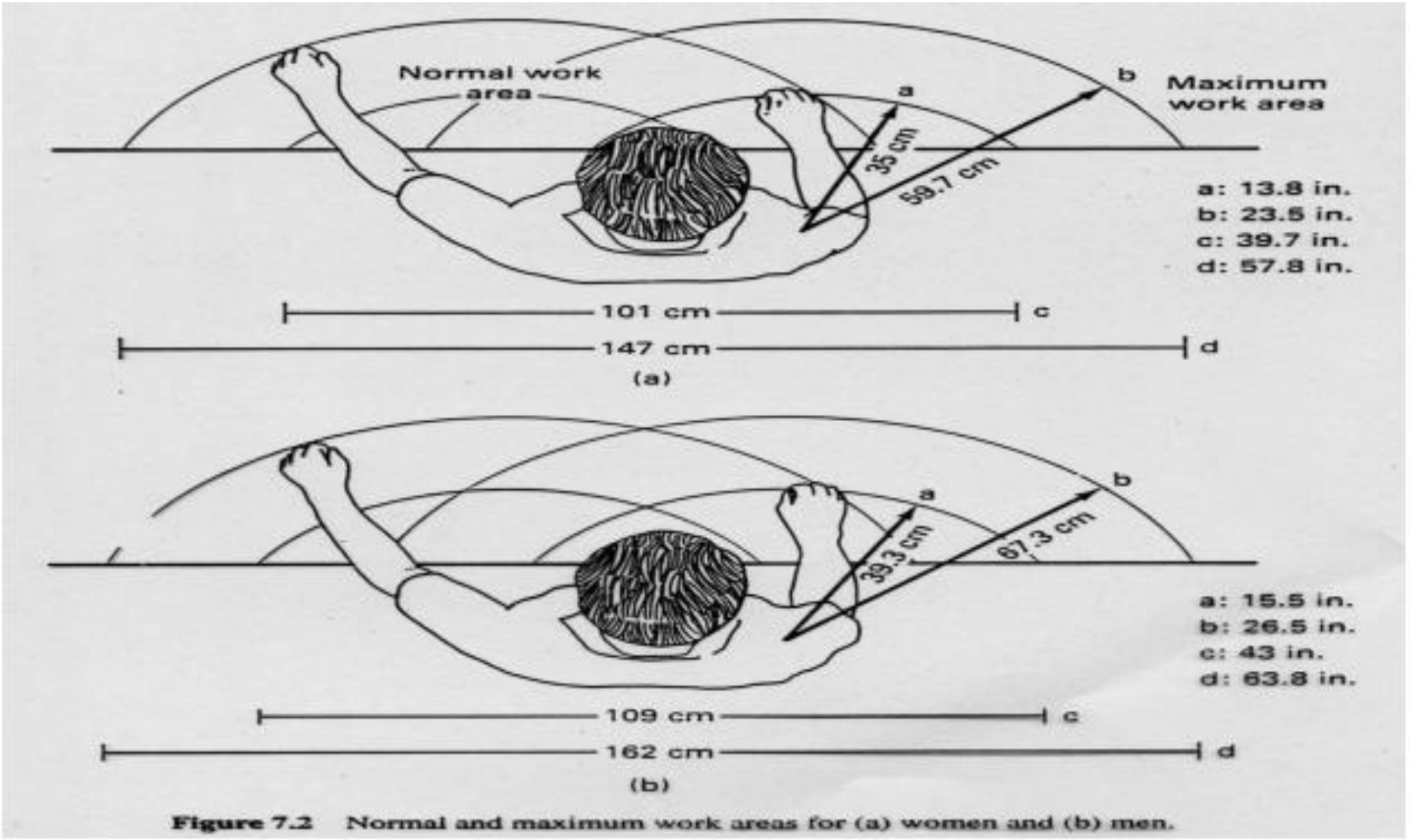


Figure 7.2 Normal and maximum work areas for (a) women and (b) men.

Anthropometry design motto

A. Let the small person reach
B. Let the large person fit.

- ✓ The anthropometric motto implies that reach distances should be designed for the small, 5th percentile individual, where as clearance dimensions should be designed for the large, 95th percentile individual
- ✓ It is common practice to design for the 5th percentile (5th%) female to the 95th percentile (95th%) male.
- ✓ The 5th% female value for a particular dimension (e.g. sitting height) usually represents the smallest measurement for design in a population.

Con...

- Conversely, a 95th% male value may represent the largest dimension for which one is designing.
- The 5th% to 95th% range accommodates approximately 90% of the population.
- To design for a larger portion of the population, one might use the range from the 1st% female to the 99th% male.

Figure below shows comparisons of percentile males and females

Con...

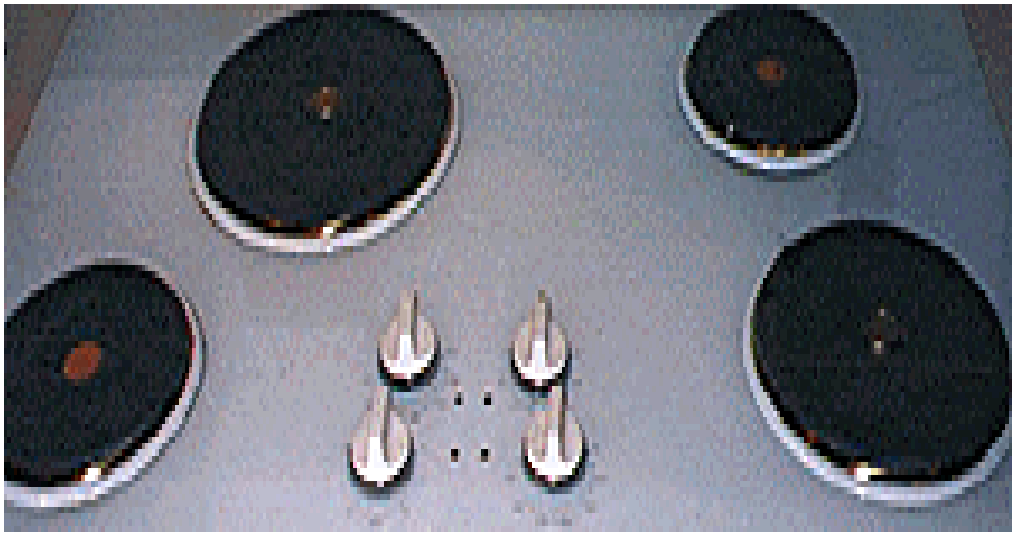
- No average person
- If you design a product suitable for use between the 5th and 95th percentile then it will not be suitable for 10% of people.

✓ The layout of a kitchen to make it more efficient.

✓ The interior of a car to ensure comfort to the user.

What is the problem?

Con…



- The problem is that it is difficult to tell which control goes with which burner.

- The solution is to arrange the controls in the same configuration as the burners. It is quite easy to tell which burner goes with which control.
- Why do you think all stove tops layouts aren't designed like this one?

Anthropometrics Design Principles

- There are three general anthropometric design principles useful in the design of workspaces.

1. **Design for Average:**

✓ With the design for average principle, you design a workspace for the **average-sized person** or a **one-size-fit all approach**. This is a commonly used approach by designers without knowledge of population variability.

✓ It is generally not recommended.

Con...

- For situations in which design for extreme individuals and adjustability are not feasible.
- Design for 50th percentile Examples:

➢ Stair heights

➢ Stadium seats

➢ Sofas

➢ Heights of checkout counters at supermarkets

➢ Lengths of shovel handles

Con...

2. Design for Extreme:

The design for extreme principle is very useful in specific circumstances when it make sense to design a dimension at an extreme end of the distribution and, because of its function, the entire distribution is accommodated.

Con...

- Designing for the maximum (95th percentile)
  - Doorway heights
  - Automobile door openings
  - Escape apparatus,
  - Ladders,
- Designing for the minimum (5th percentile)
  - Heights of kitchen cabinets
  - Fire alarm
  - Locations of levers and dials on equipment
  - Weights of portable power tools

Con...

3. Design for Range:

Designing for the range normally means designing an adjustable workspace.

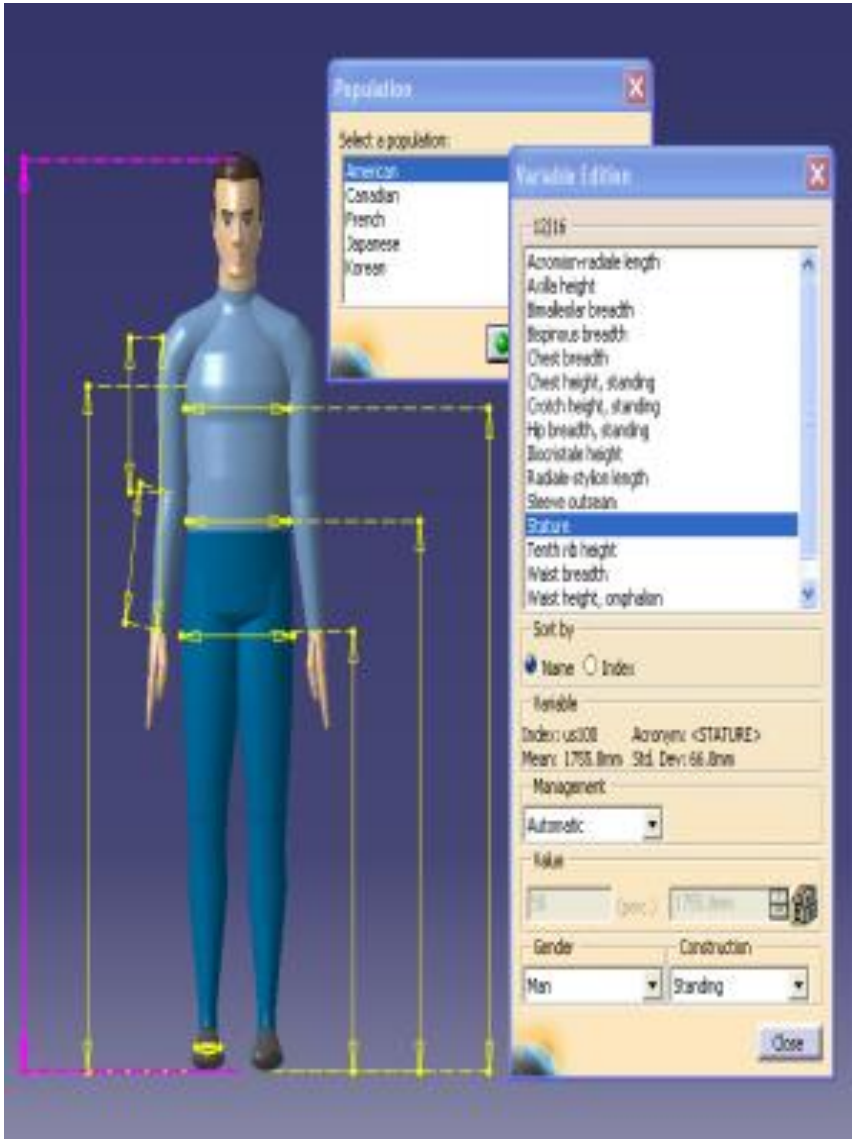
To accommodate a wide range of users

Examples:

- ✓ Automobile driver seats
- ✓ Office chairs
- ✓ Worktable heights
- ✓ Tilt angles of computer monitors
- ✓ Lawnmower handle heights
- ✓ Bicycle handlebars
- ✓ Adjustable steering wheel in an automobile

Human Measurement Editor (HME)

- **HME** allowed the designer to ***personalize the manikin*** dimensions and to select its work position.
- After establishing the manikin's type and dimension, the user must choose the work position by correct manipulation of the object.



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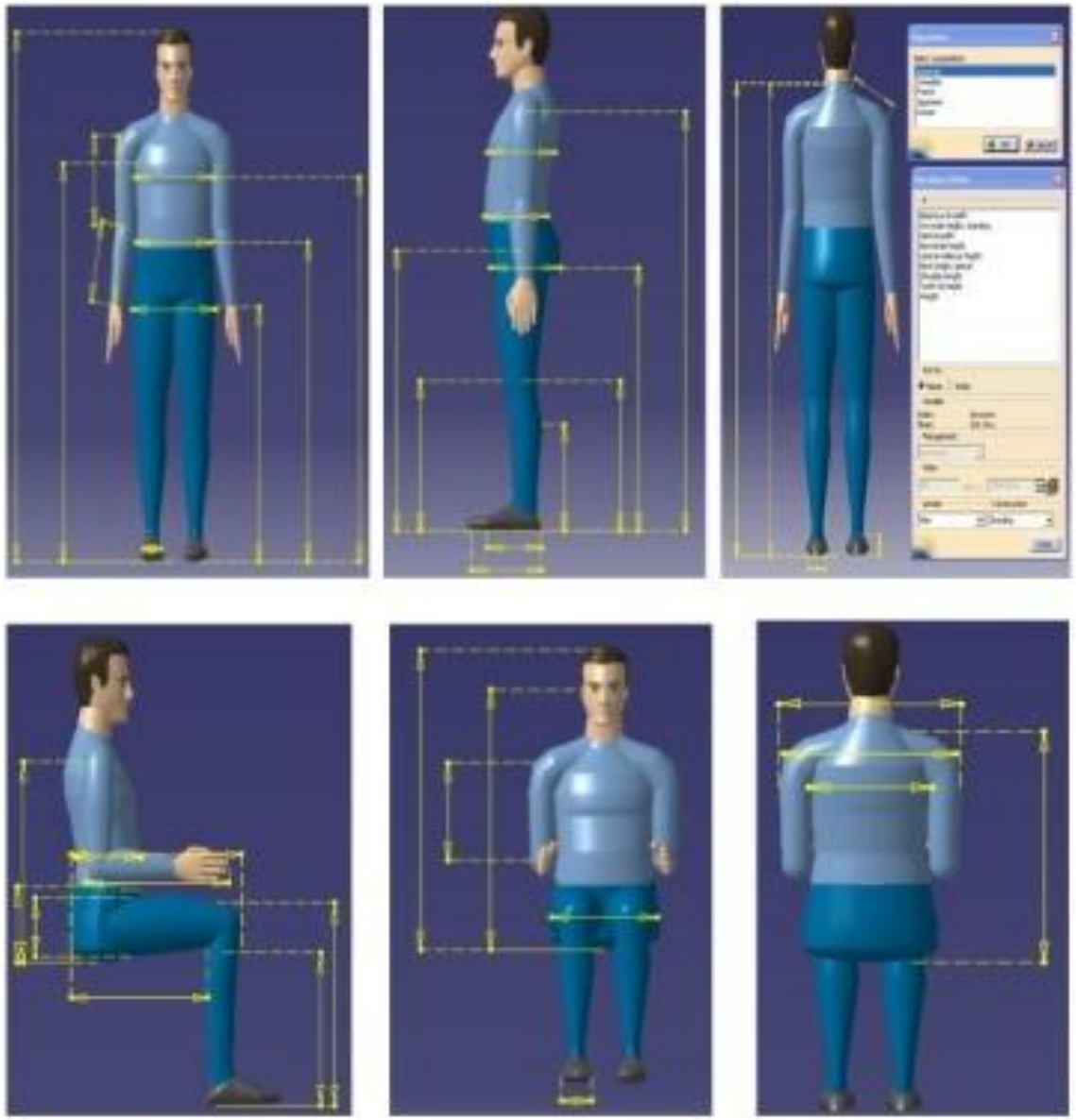
- Users can amend all 103 anthropometric variables on the manikin.

- The HME also has the capacity to define the mean and standard deviation of all anthropometry variables.



Population Variance

- The concept of "population is important in anthropometrics as there are differences in **size** and **body segment** proportions due to **age**, **gender**, and **ethnicity**.
- So, in order to properly select the data to use, it is necessary to know about **population composition**, and **percentage of the population** which must be accommodated

Con…

- Differences in body dimensions exist among people because of:
  - Ethnicity and Nationality
  - Heredity
  - Diet
  - Health
  - Sex
  - Age
  - Living conditions

Common Workplace Postures

- There are common postures found in working environment that can be considered when designing workplace products or space. This section reviews guidelines for these postures:
  - Standing
  - Sitting
  - Reaching
  - Moving

Standing

- Some users may need or want to stand while at their workstations.
- If this is the case, an appropriate desk can be designed and Selected for the type of work being performed

Con...

- Desk height for a standing operator can range from 28 43"(Grandjean, 1997) depending on whether the Desk is for precision, light, or heavy work
- **Different work-surface heights can be used depending on the type of work performed.**

Different work surface heights can be used depending on the type of work performed.

Sitting

- Knowing what parameters to design for while the user is seated can help increase the comfort of the user. Common seated anthropometric measurements can be seen in Figure below

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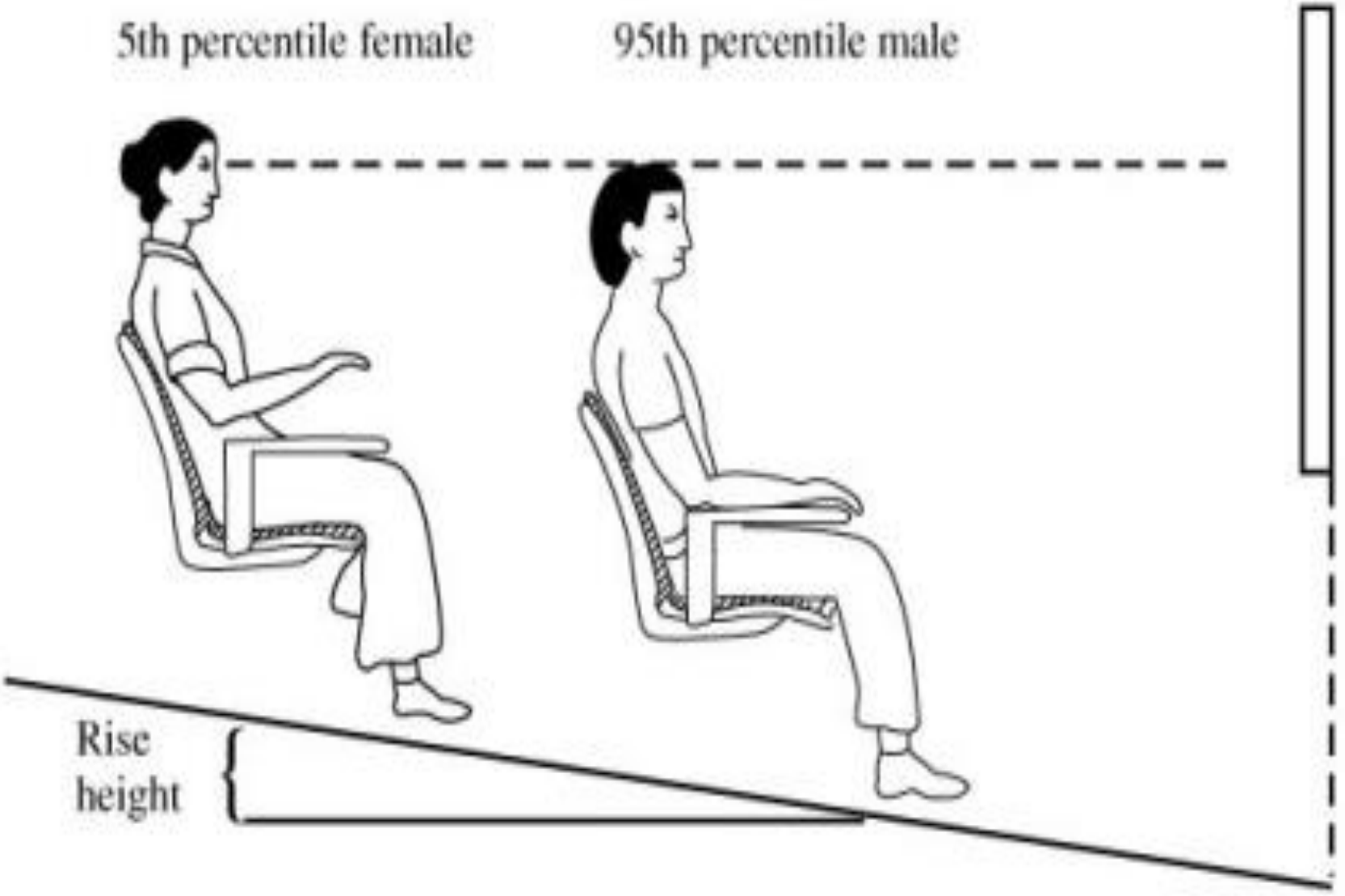
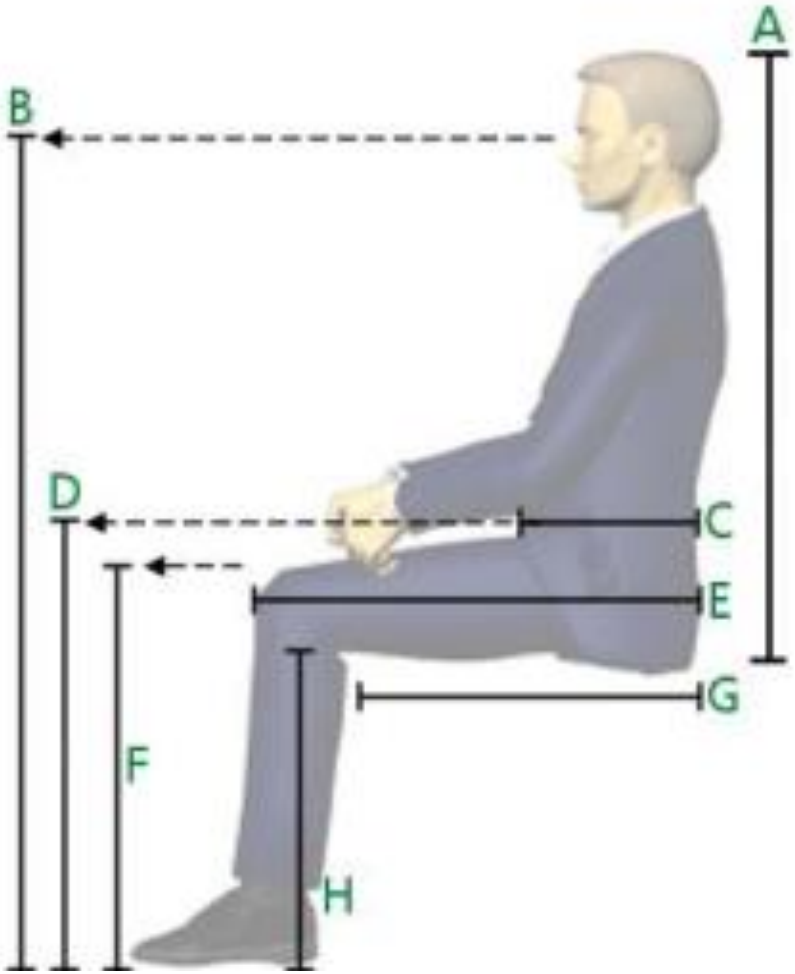


Common anthropometric measurements for the seated position



A- Sitting Height

B- Sitting Eye Height

C- Waist Depth

D- Thigh Clearance

E- Buttock-to-Knee

F- Knee Height

G- Seat Length/Depth

H- Popliteal Height

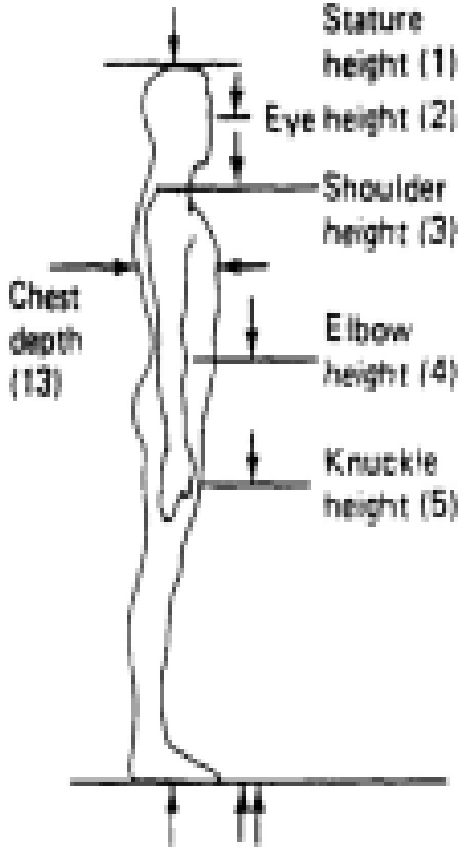
Reaching

- While sitting or standing, an individual at work will usually have to reach for something.
- The workstation, and parts that go with workstations (such as overhead storage and pedestals), should allow the majority of movement of the user's body joints within healthy zones

Moving

- Users will move around in their environment to file papers, answer a phone, or stretch.
- An occasional break from sitting is encouraged because it helps to stimulate muscles, and increases blood flow, which decreases fatigue.

Anthropometric data



Body dimension	Sex	Dimension, In 5th	50th	95th
1. Stature (height)	Male	63.7	68.3	72.6
	Female	58.9	63.2	67.4
2. Eye height	Male	59.5	63.9	68.0
	Female	54.4	58.6	62.7
3. Shoulder height	Male	52.1	56.2	60.0
Female	47.7	51.6	55.9	
4. Elbow height	Male	39.4	43.3	46.9
	Female	36.9	39.8	42.8
5. Knuckle height	Male	27.5	29.7	31.7
	Female	25.3	27.6	29.9
13.Chest depth	Male	8.4	9.5	10.9
	Female	8.4	9.5	11.7

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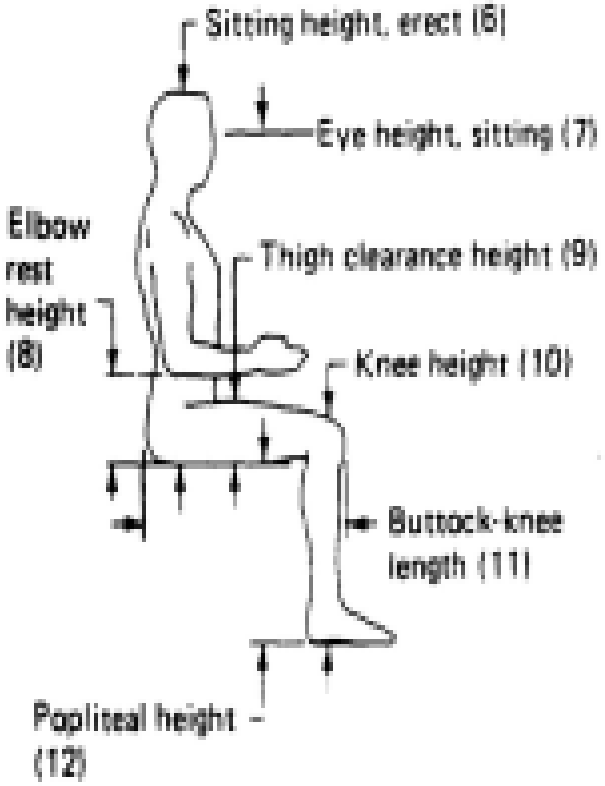
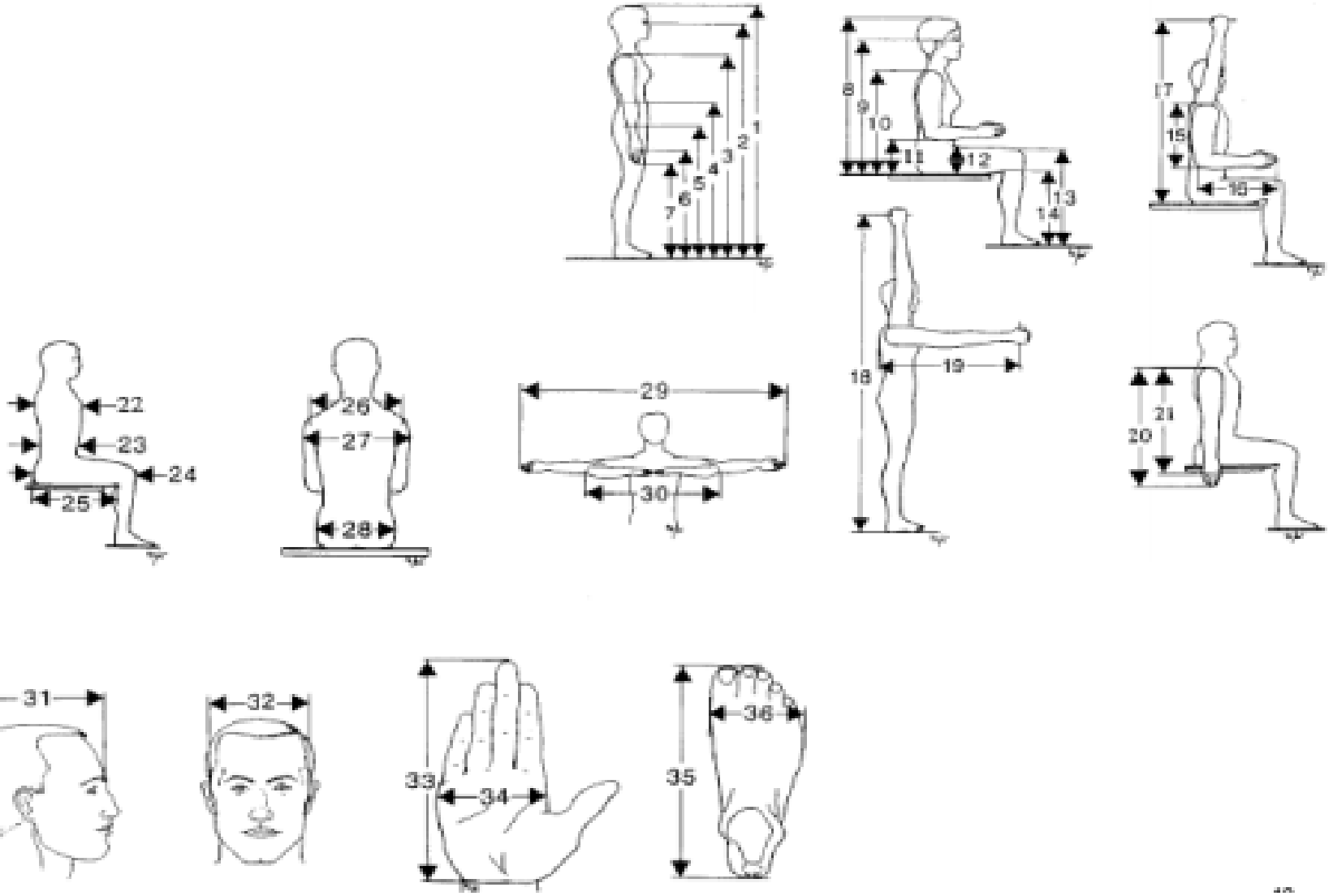


Body dimension	Sex	Dimension, In 5th	50th	95th
6. Height, sitting	Male	33.1	35.7	38.1
	Female	30.9	33.5	35.7
7. Eye height, sitting	Male	28.6	30.9	33.2
	Female	26.6	28.9	30.9
8. Elbow rest height, sitting	Male	7.5	9.6	11.6
	Female	7.1	9.2	11.1
9. Thigh clearance height	Male	4.5	5.7	7.
	Female	4.2	5.4	6.9
10. Knee height, sitting	Male	19.4	21.4	23.3
	Female	17.8	19.6	21.5
11. Buttock-knee distance, sitting	Male	21.3	23.4	25.3
	Female	20.4	22.4	24.6
12. Popliteal height, sitting	Male	15.4	17.4	19.2
	Female	14.0	15.7	17.4

Con…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Anthropometry – BSA

- Body Surface Area (BSA) Important in studying
  - Human response to thermal conditions
  - Metabolic energy expenditure
  - Exposure to ionizing radiation

BSA = 0.007184*Wt0.425*Ht0.725

BSA= Body Surface Area(m2)

Wt = Body weight (kg)

Ht = Body Height (cm)

Con...

- Example 1:- what is the body surface area of two people with height of 175cm and 195cm and weight of 67kg and 118 kg respectively

Con...

- Given

Person 1

- ✓ Weight = 67kg
- ✓ Height = 175m

Person 2

- ➢ Weight =118 kg
- ➢ Height =195cm

$$BSA = 0.007184 * Wt^{0.425} * Ht^{0.725}$$

$$BSA_1 = 0.007184 * 67^{0.425} * 175^{0.725}$$

$$= 1.81\ m^2$$

$$BSA_2 = 0.007184 * 118^{0.425} * 195^{0.725}$$

$$= 2.49\ m^2$$

Con...

THANK YOU…!!