Al-Muthanna University
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Medical physics

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Forces in and on the body

- Gravitational force: is attraction between any two objects

❖ our weight is due to the attraction between the earth and our bodies. F=mg

❖ medical effects of gravitational force is the formation of varicose veins in the legs as the venous blood travels against the force of the gravity on its way to the heart.

Forces in and on the body

- Electrical force: is either attractive or repulsive

❖The forces produced by the muscles are caused by electrical charges

❖Each of the billions of living cells in the body has an electrical potential difference

❖The amount of voltage is less than 0.1V but it may produce a field as large as 10^5V/cm

Forces in and on the body

- the strong nuclear force: it acts as ‘glue’ to hold the nucleus together against the repulsive forces produced by the protons on each other

- weak nuclear force: which is involved with electron decay from the nucleus

Forces in and on the body

- For the body to be at rest and in equilibrium (static)

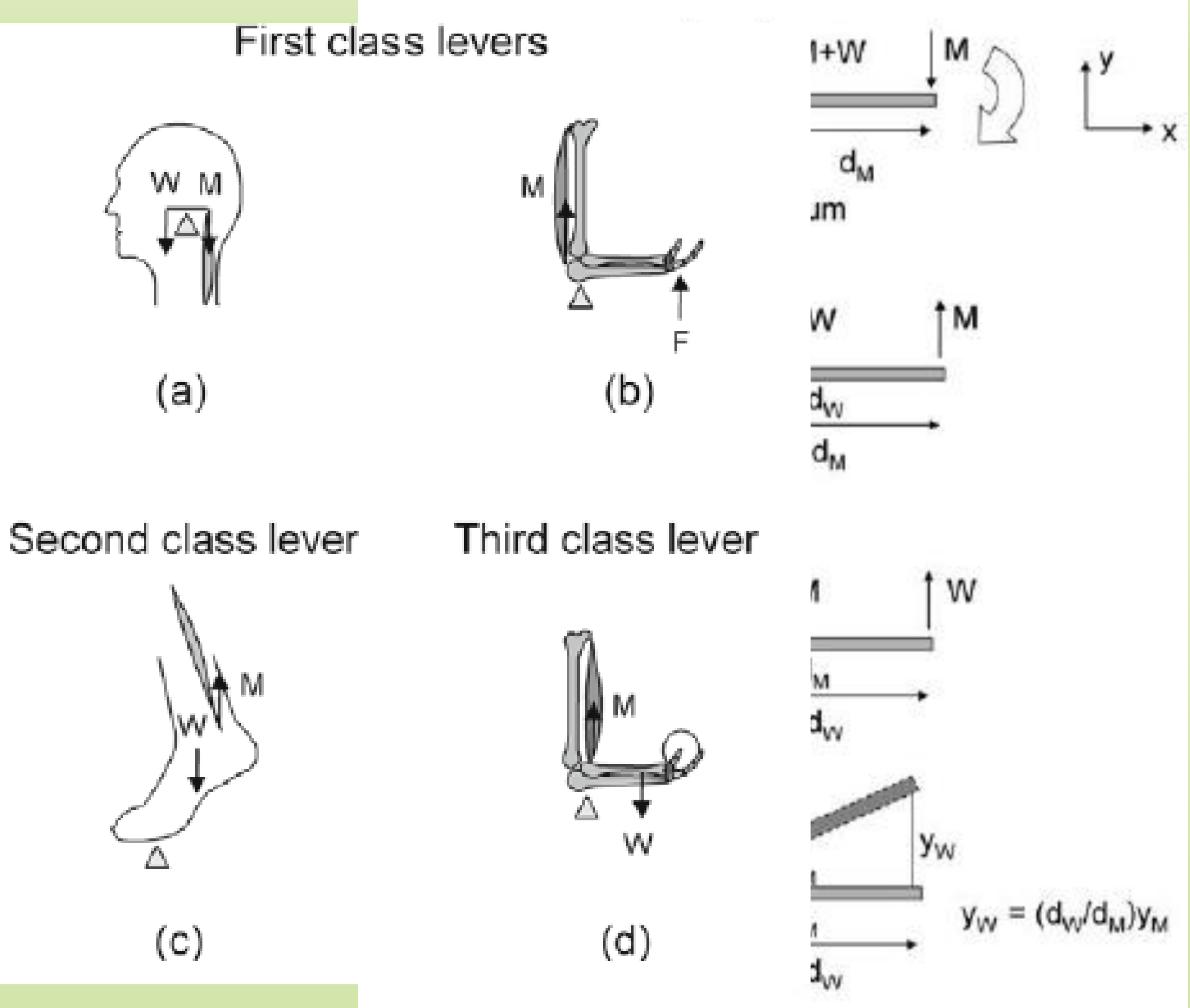
$$\sum Fx = 0, \sum Fy = 0, \sum Fz = 0$$

$$\sum \tau x = 0, \sum \tau y = 0, \sum \tau z = 0.$$

- Many of the muscle and bone systems of the body act as levers

Muscle Forces Involving Levers

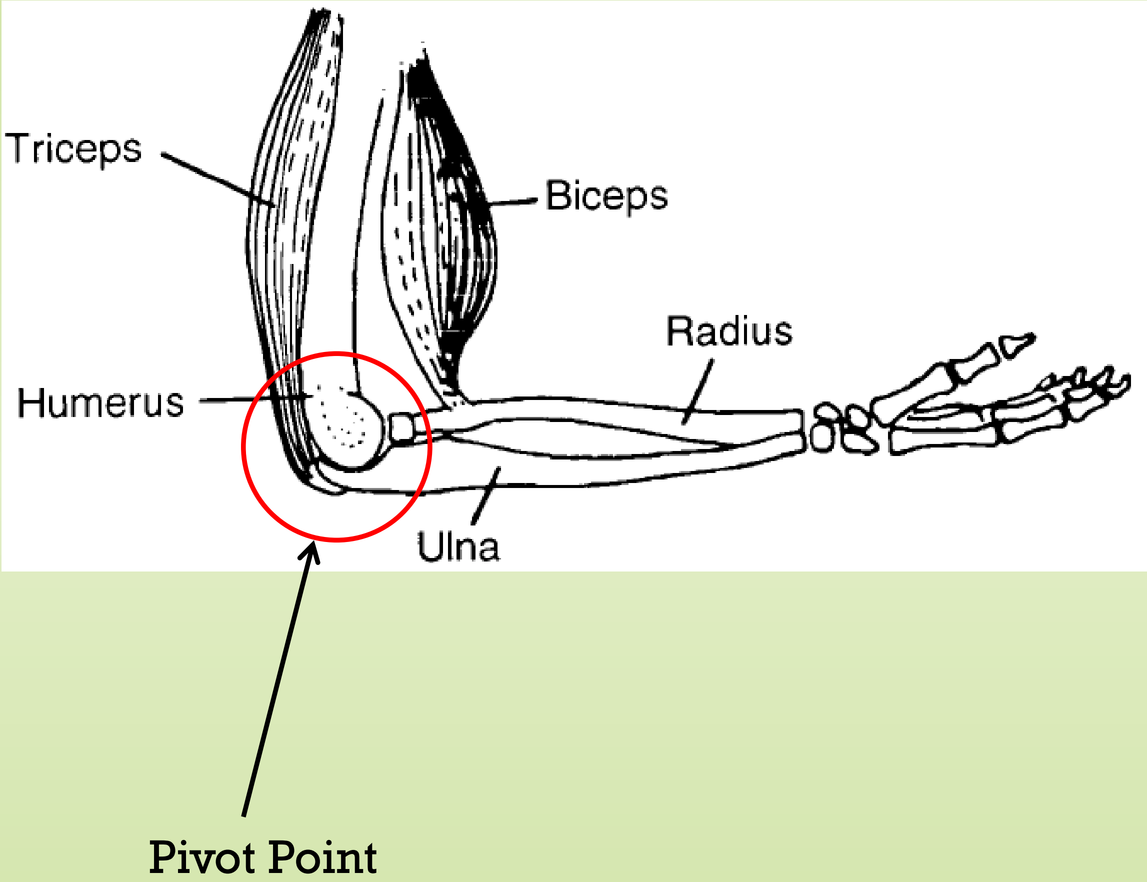
- Many of the muscle and bone systems of the body act as levers
- Levers are classified as First, second, and third class systems. Third class levers are most common in the body
- In general levers are used to lift loads in an advantageous way and to transfer movement from one point to another

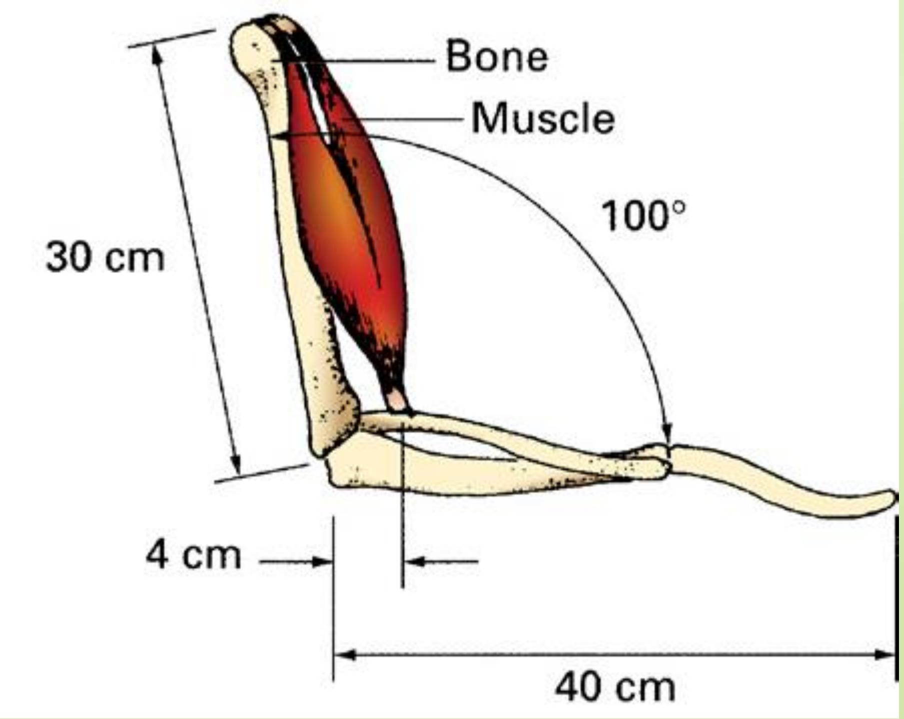


the elbow is an excellent example

- The biceps act to raise the forearm toward the upper arm

- the triceps pull the forearm away from the upper arm.





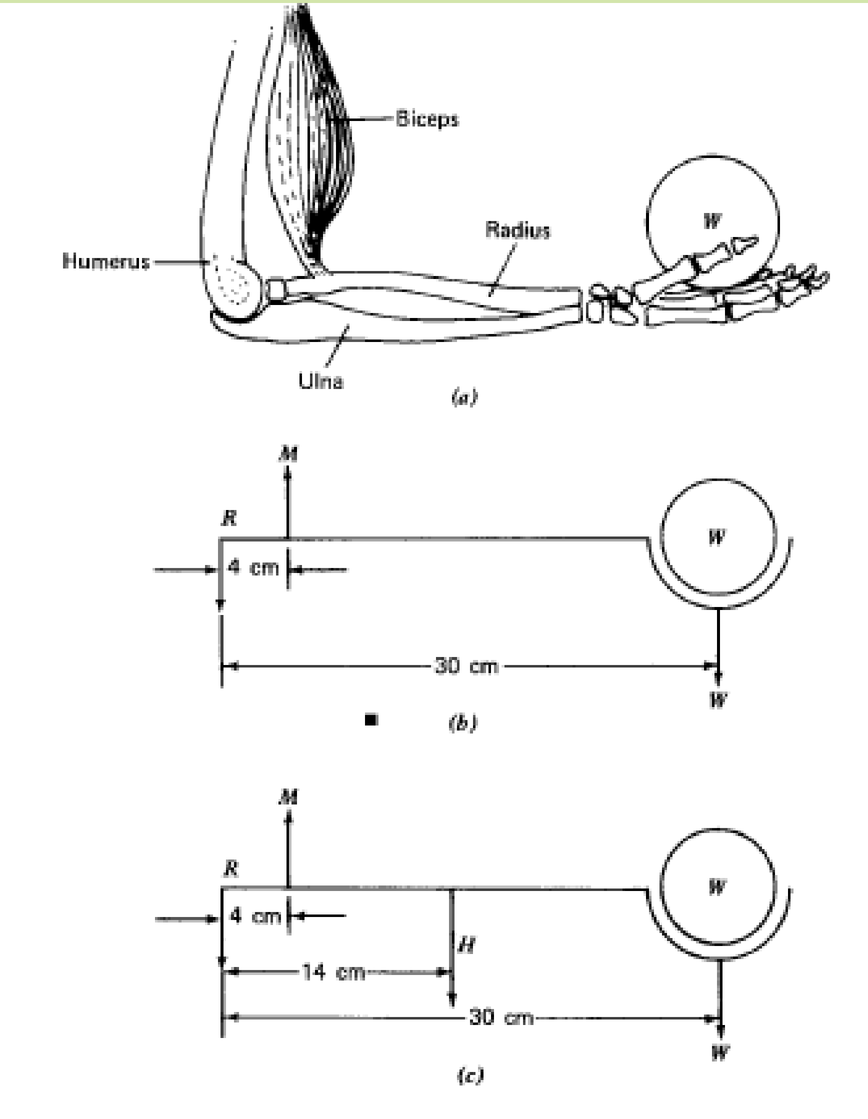
The force and the torques of the elbow

- **The force of the biceps and the torques (force times distance moment arm) about the pivot point at the joint.**

MdM = WdW

- two torques: one of them due to the weight W (which is equal to 30W acting clockwise) and the other produced by the muscle force M (which acts counterclockwise and of magnitude 4M).

M = 7.5 W

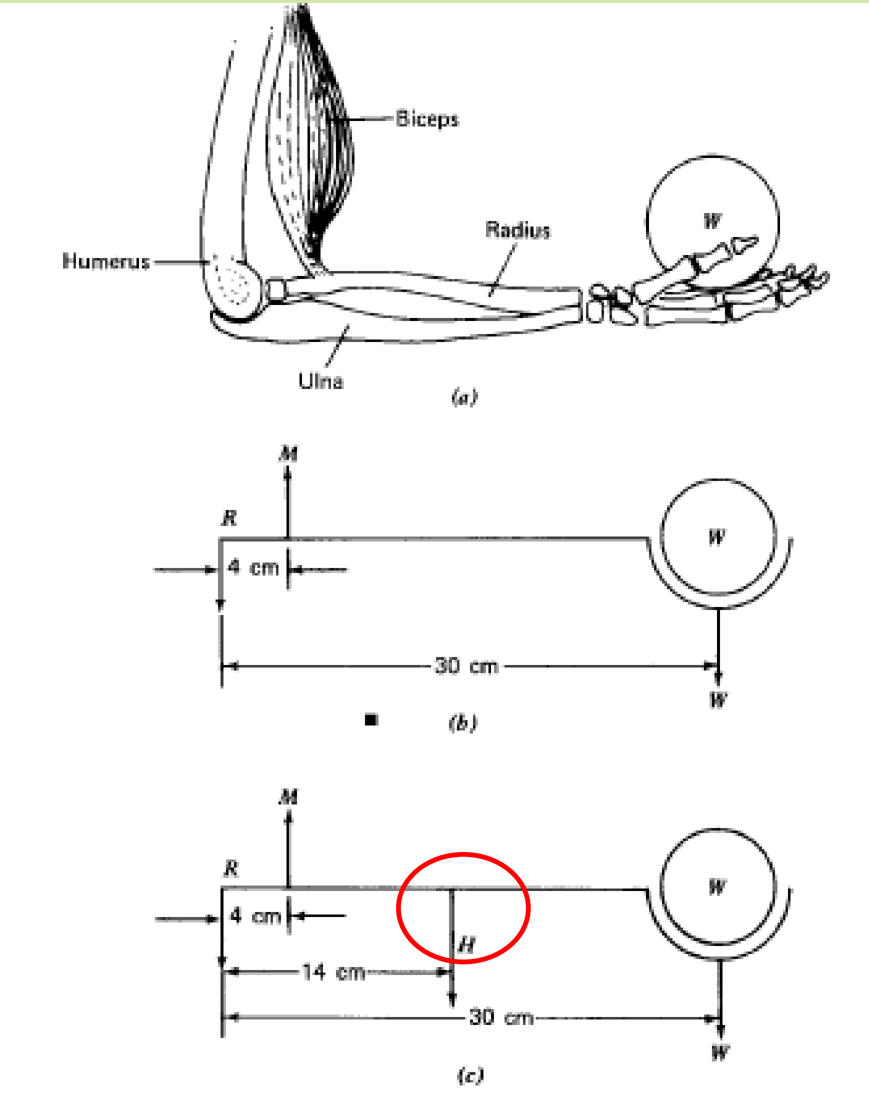


The force and the torques of the elbow

- it is better to find the center of gravity for the weight of the forearm and hand and assume all the weight is at that point
- weight of the forearm and hand H included

$$4\ M = 14\ H + 30\ W$$

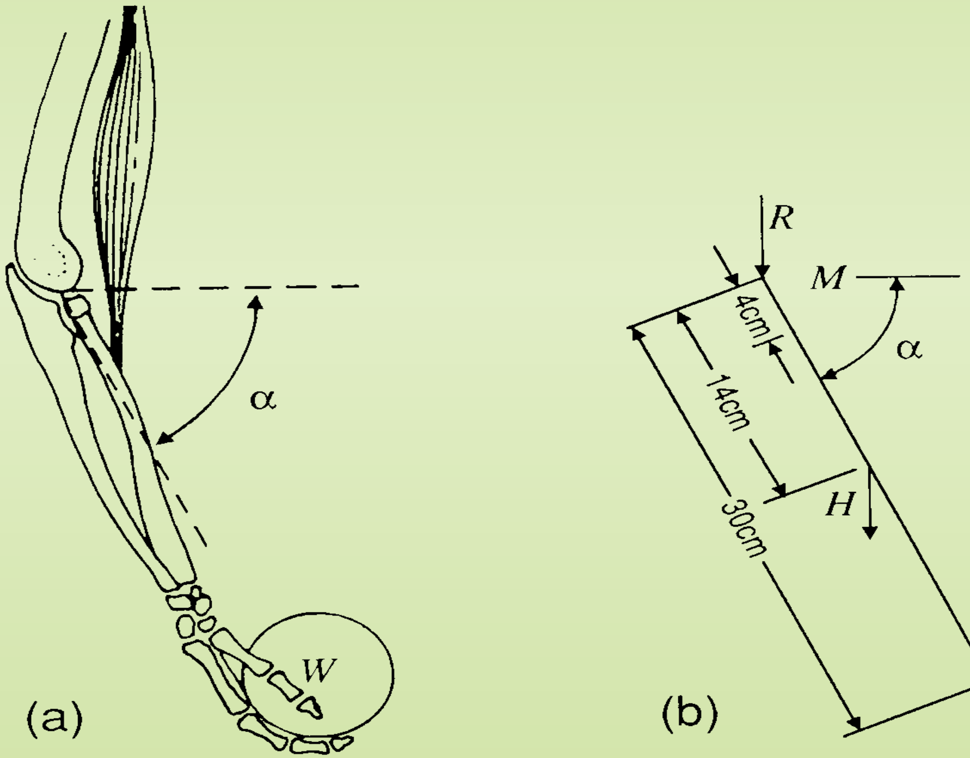
muscle must be larger than that indicated by first calculation by an amount 3.5 H = (3.5) (15) = 52.5 N



In the lower arm

- A force is applied in such a way to cause the angle of the elbow to increase

- it's founded that M remains constant as alpha changes. However, the length of the biceps muscle changes with the angle



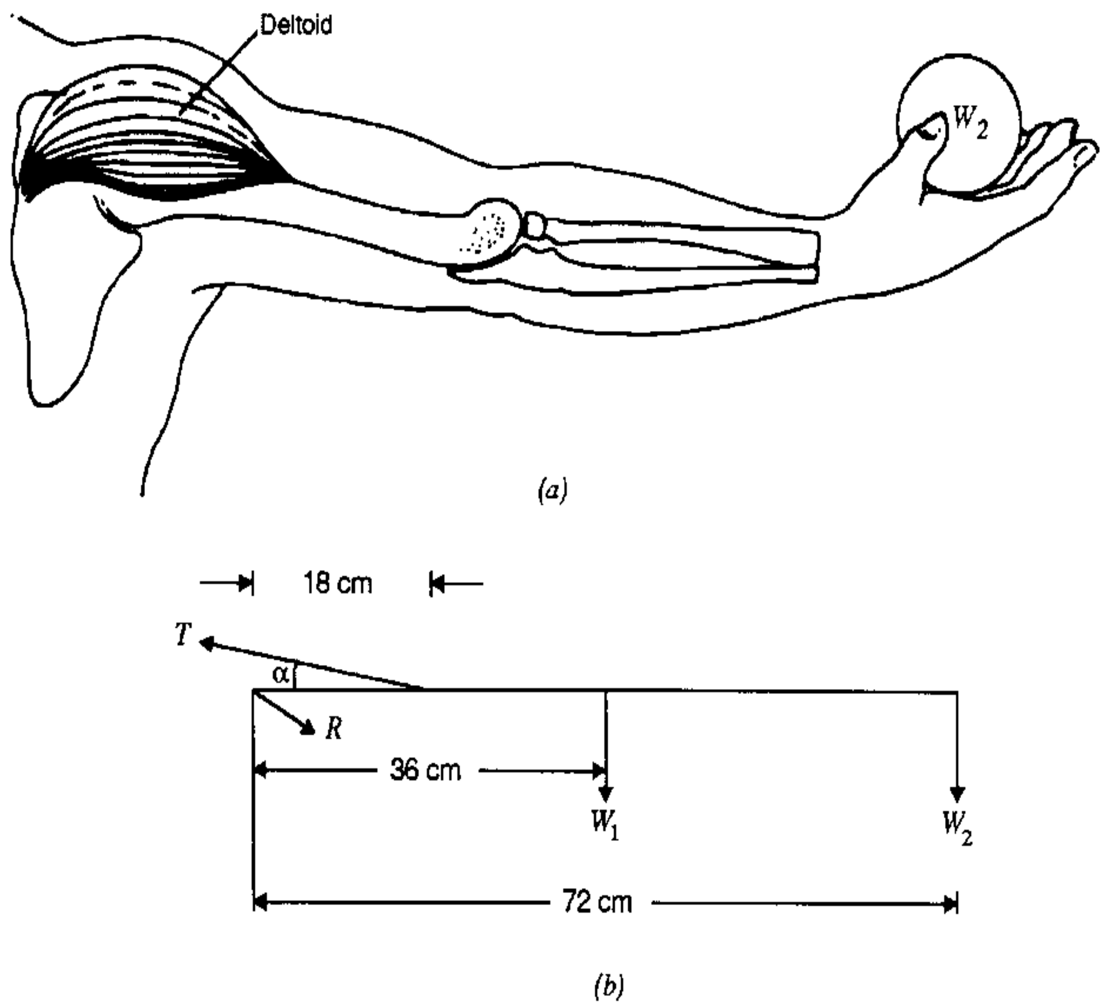
Raised Arm

- The arm can be raised and held out horizontally from the shoulder by the deltoid muscle

$$T = (2\,W_1 + 4\,W_2)/\sin\alpha$$

- If $\alpha = 16°$, the weight of the arm W1 = 68 N and the weight in the hand W2 = 45N, then T = 1145 N.

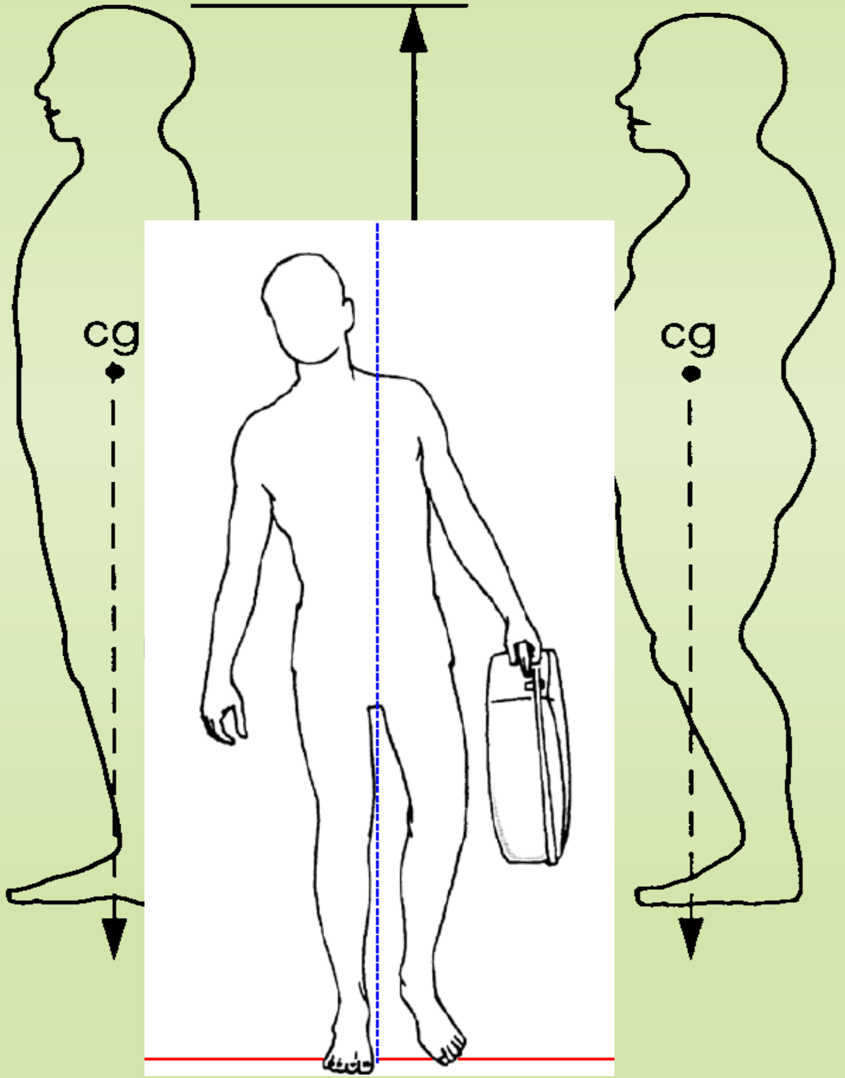
- The force needed to hold up the arm is surprisingly large



Stability While Standing

- The center of gravity (c.g.) is at approximately 58% of the person’s height measured from the soles of the feet .
- A person falls when his center of gravity is displaced beyond the position of the feet. Poor muscle control, accidents, disease, pregnancies, over weight conditions ,or poor posture change the position of the cg to unnatural location in the body lead to a forward shift of the cg.

- To retain stability while standing, you have to keep the vertical projection of your cg inside the area covered by your feet

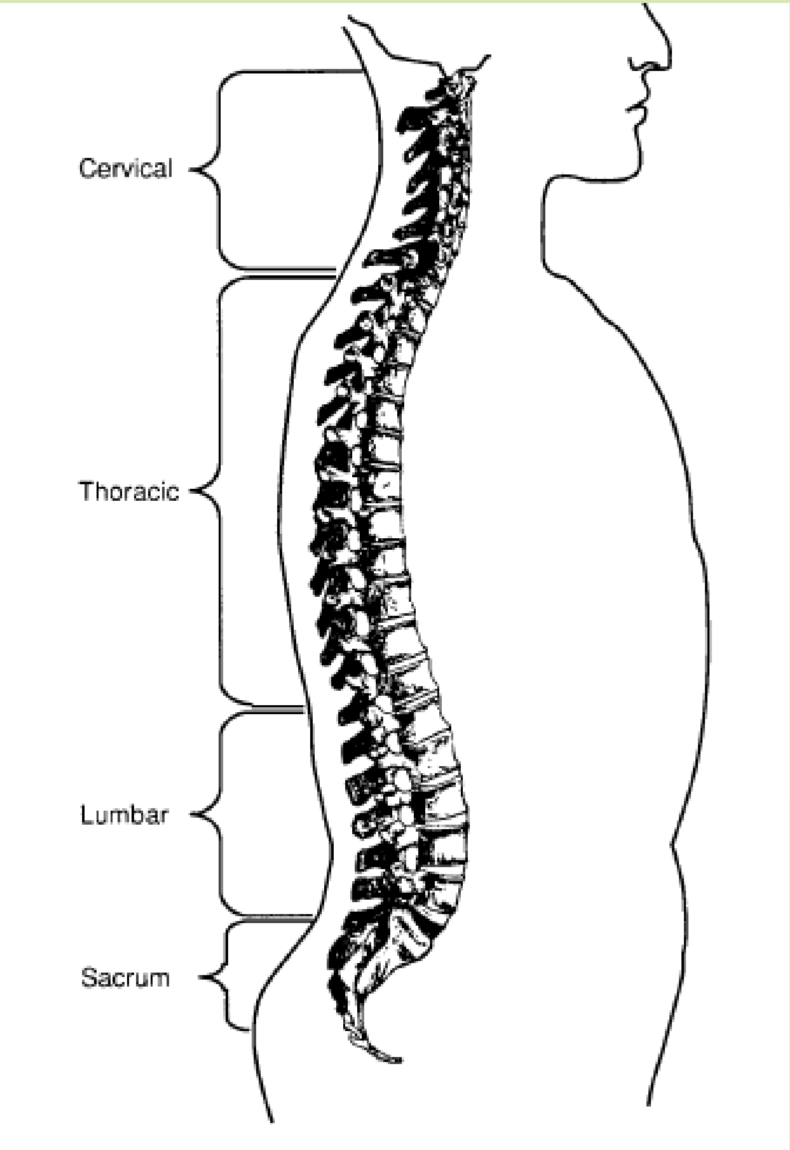


The Spinal Column

- The body follows the same physics' principles as used in the design of a building where the major support strength is in the base

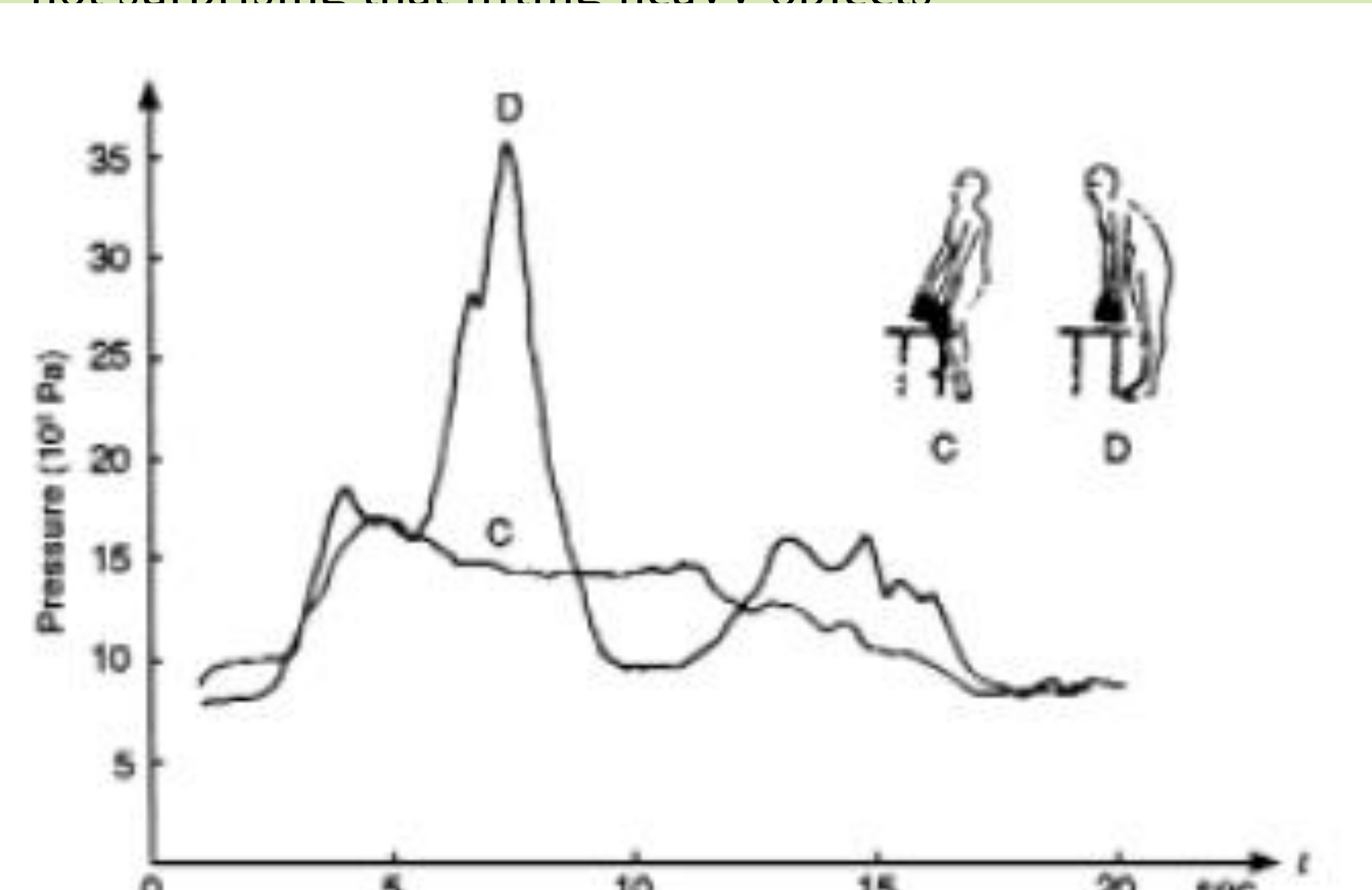
- The vertebrae in the spinal column of a skeleton increase in both thickness and cross-sectional area as you go from the neck (cervical) region to the lower back (lumbar) region

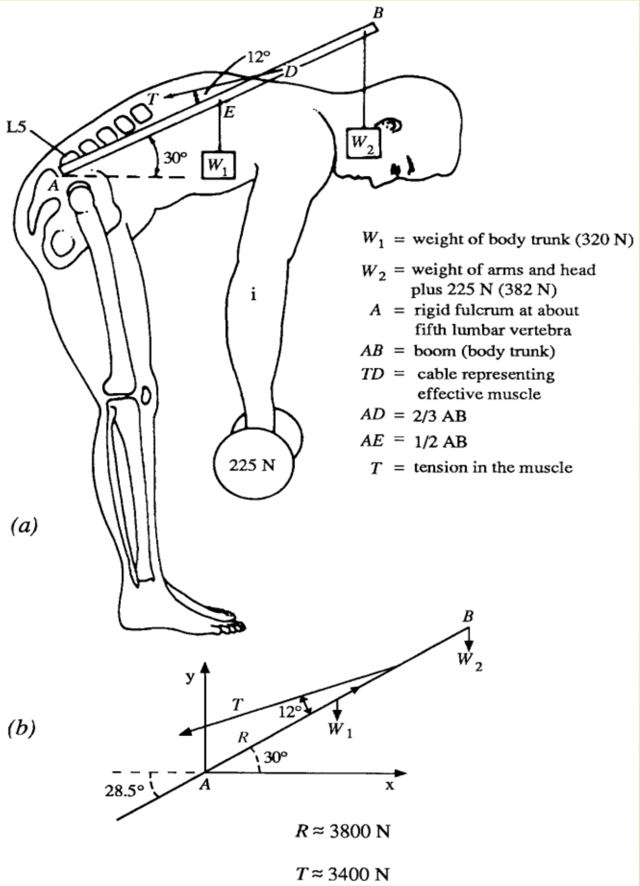
- The length of the spinal column shortens of about 0.7 m (male) by as much as 0.015 m (1.5 cm = 0.6 in) after arising from sleep.

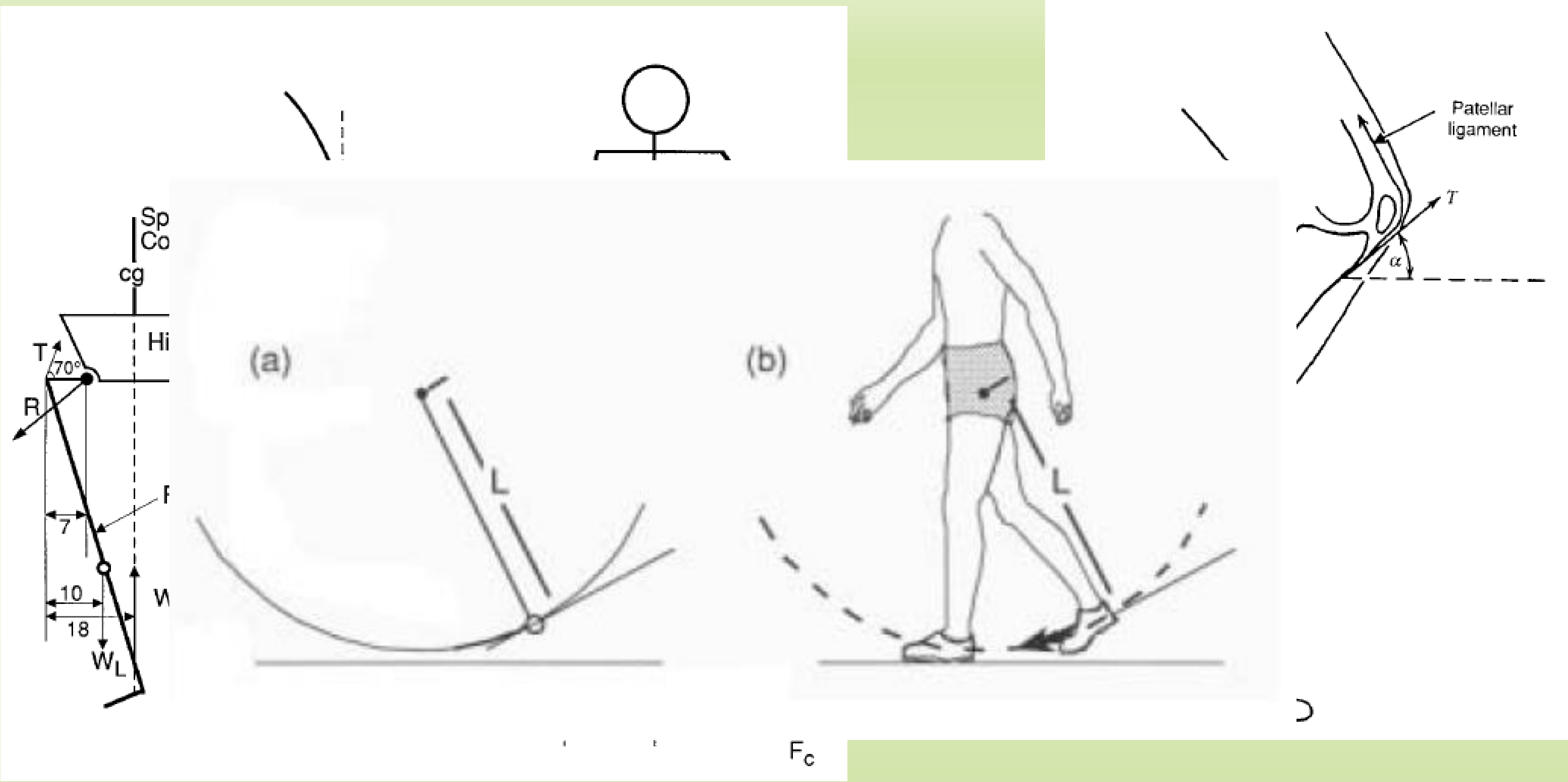


The Spinal Column

➢ not surprising that lifting heavy objects







cg
T
70°
R
7
10
18
W_L
(a)
L
(b)
L
Patellar
ligament
T
α
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Thank you