Lecture 1:

Forces On and In the Body

By

Dr. Noor Al-Huda Talib Al-Aaraji

Objectives: after the end of this lecture, the student must know:

1- The application of gravitational forces on Various body parts

2- The application of Newtons laws of dynamics in medicine

Gravitational force : Newton's law: this law state that there is a force of attraction between any two objects, our weight is due to attraction between the earth and our body .

One important medical effect of gravitational force is the formation of varicose veins in the legs, as the venous blood travels against force of gravity on its way to the heart.

Another medical effect of gravity is on the bones. Gravitational force on the skeleton in some way contributes to healthy bones, if person becomes weight less such as in orbiting satellite, he may lose bone mineral and may be serious problem on very longjourney.

Statics Many of muscle and bone systems of the body acts as levers, levers are classified as, first, second, and third. The last are most common in the body, second are next common.

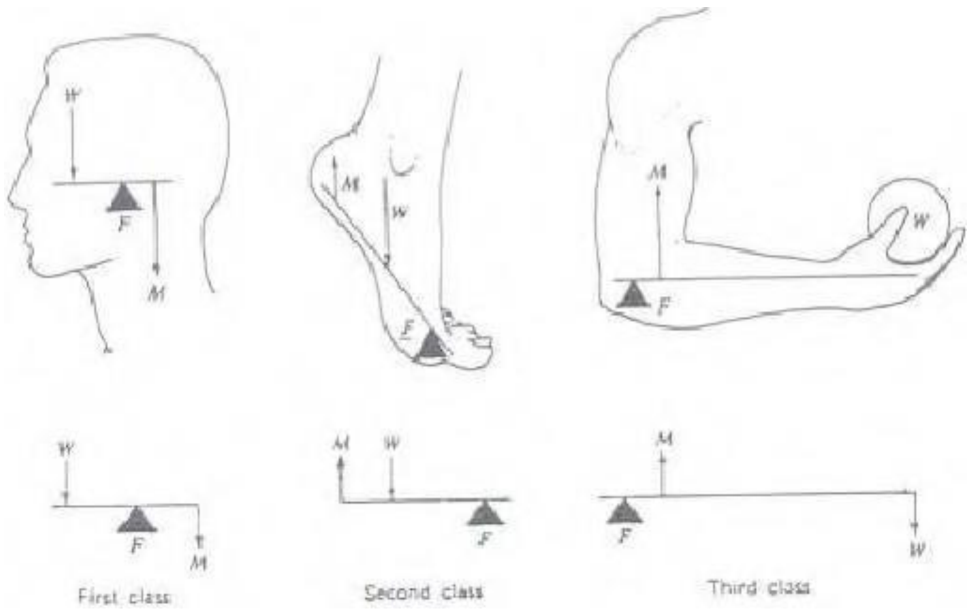

Figure 1: lever system in the body

We can find the force supplied by the biceps, if we sum the torques about pivot point at the joint

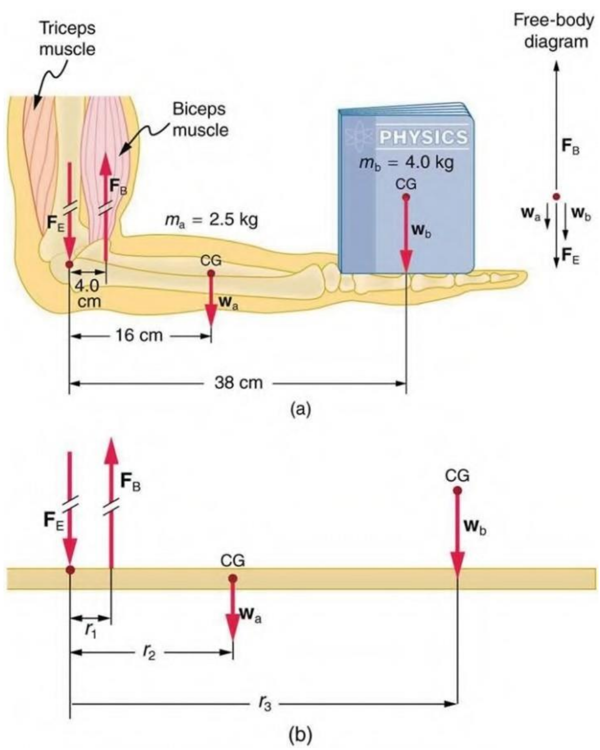

Figure 2: lever system in the body, forearm

$4\ M - 30\ W = 0$

$M = 7.5\ W$ we neglect the weight of forearm

$M = 3.5\ H + 7.5\ W$ include forearm

The arm can be raised and held out horizontally from shoulder by deltoid muscle, by taking sum of torques about shoulder joint

$T = 2\ W1 + 4\ W2\ /\ \sin\ \alpha$

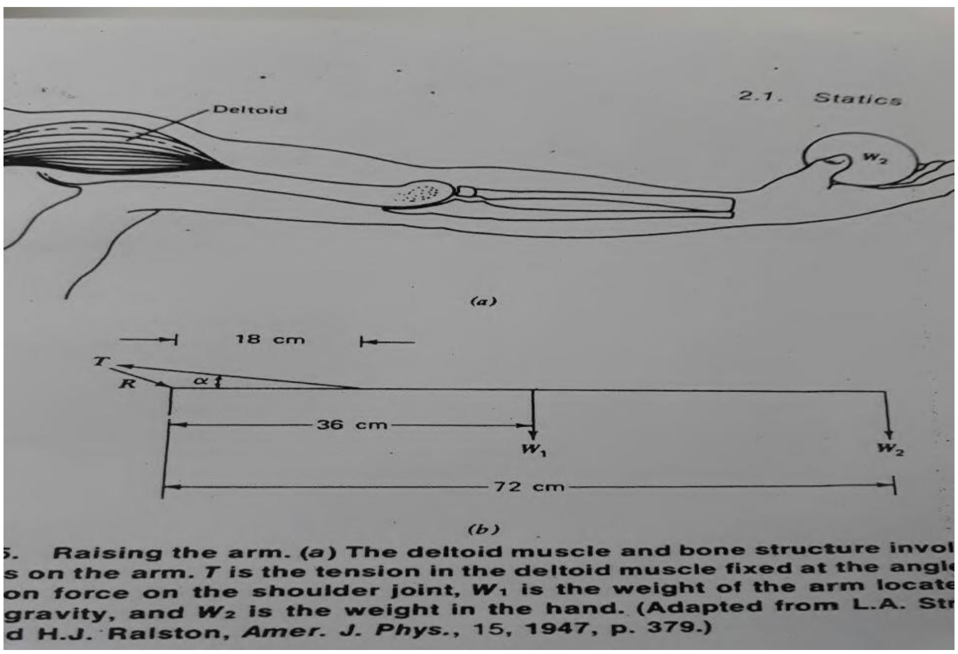

Figure3: the forearm at an angle

W1= weight of the arm = 68 N

W2 = weight in the hand = 45 N

$T = 1145\ N$

The force needed to hold up the arm is large.

Frictional Forces

When person walking as the hell of the foot touch the ground a force is transmitted from the foot to the ground.

Canresolvethisforce in tohorizontal and vertical components. Maximumforce of friction f is:

$F = \mu N$

Where N is the normal force, μ is the coefficient of friction, horizontal force = 0.15 w where is W is the person weight (this is large frictional force must be in order to prevent heel from slipping).

The coefficient of friction in the joints is lower than in engineering materials. The lungs move inside the chest, the intestine have slow rhythmic motion (peristalsis) as they move the food toward its final destination. All of these organs are lubricated by slippery mucus covering to minimize friction.

Dynamics

Newtons second lawis:

$F = m a$ a = acceleration$=dv/dt$

$F = \Delta(mv) / \Delta t$

Example of dynamic force in the body is the apparent increase in weight when the heart beats (systole). About 60 gm of blood is given velocity about 1m/ sec upward in about 0.1sec.

The momentum P = m v = 0.6 Kg x 1 m/sec = 0.06 Kg m /sec The downward reaction force (Newtons third law) produced is:

0.06 Kg/sec /0.1 sec = 0.6 N (this is enough to produce noticeable jiggle)

Stokes has shown that for spherical object of radius (a), retarding force (Fd) and terminal velocity (v) are related by

$$Fd = 6\Pi a \eta v \qquad \eta = \text{viscosity}$$

When the particle is moving at constant speed the retarding force is equilibrium with the difference between gravitational force and upward buoyant force (the weight of the liquid the particle displaces) thus we have Force of gravity

$$F_g = 4/3 \, \Pi \, a^3 \rho \, g$$

Buoyant force

$$Fb = 4/3 \, \Pi \, a^3 \rho_{\circ} \, g$$

Retarding force

$$Fd = 6\Pi a \eta v$$

$$Fg - Fb = Fd$$

$$V = 2 a^2 / 9 \eta [g (\rho - \rho_{\circ})] \qquad \text{sedimentation velocity}$$

This equation is valid for spherical objects.

In some forms of diseases such as rheumatic fever, rheumatic heart disease, and gout RBC clumps together ,and the effective radius increase thus increased sedimentation velocity occur.

In other diseases such as hemolytic jaundice and sickle cellanemia RBC change shape or break, the radius decreases, thus the rate of sedimentation velocity decreases.