BIOMECHANICS

بسم الله الرحمن الرحيم

Aspects in Injury Prevention

BIOMECHANICS 1

- What is Biomechanics?

“ Branch of mechanics that is applied to biological tissues”

“The study of mechanical motion in biological systems”

Biomechanics 2

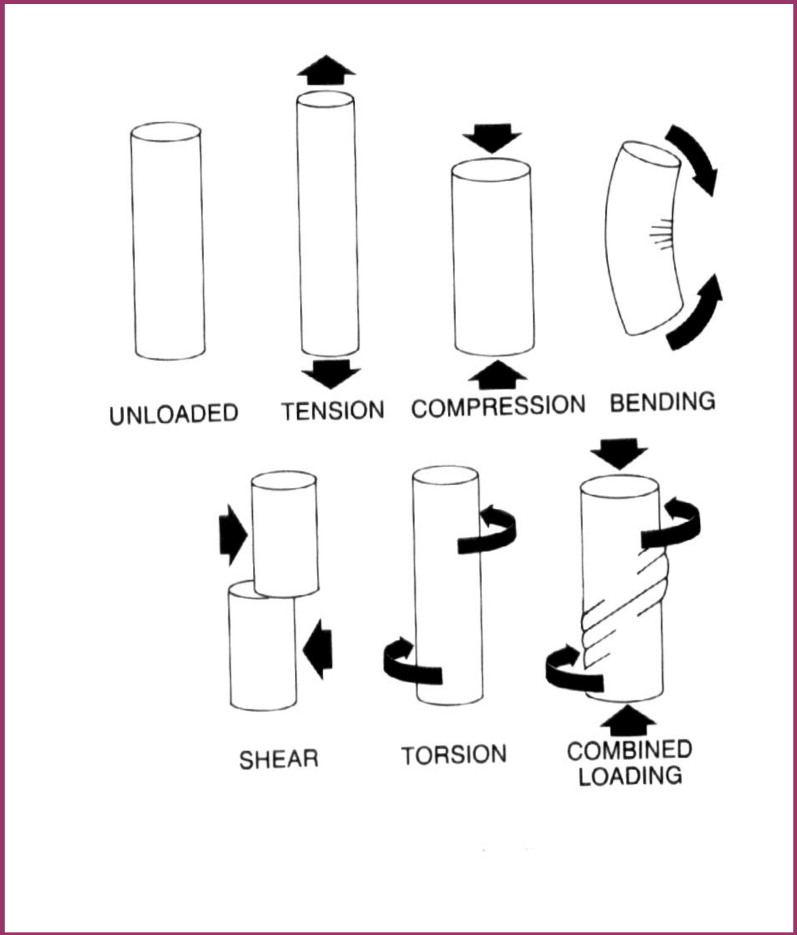
- The two main goals for the science are:
  - performance improvement
  - Injury prevention

Biomechanics 3

- How does injury occur?
  - There must be a mechanical load.
  - This load could be acute (one or few repetitions with high loads) or chronic load (many repetitions with low load).

Biomechanics

- What are the loads encountered in life and sports?



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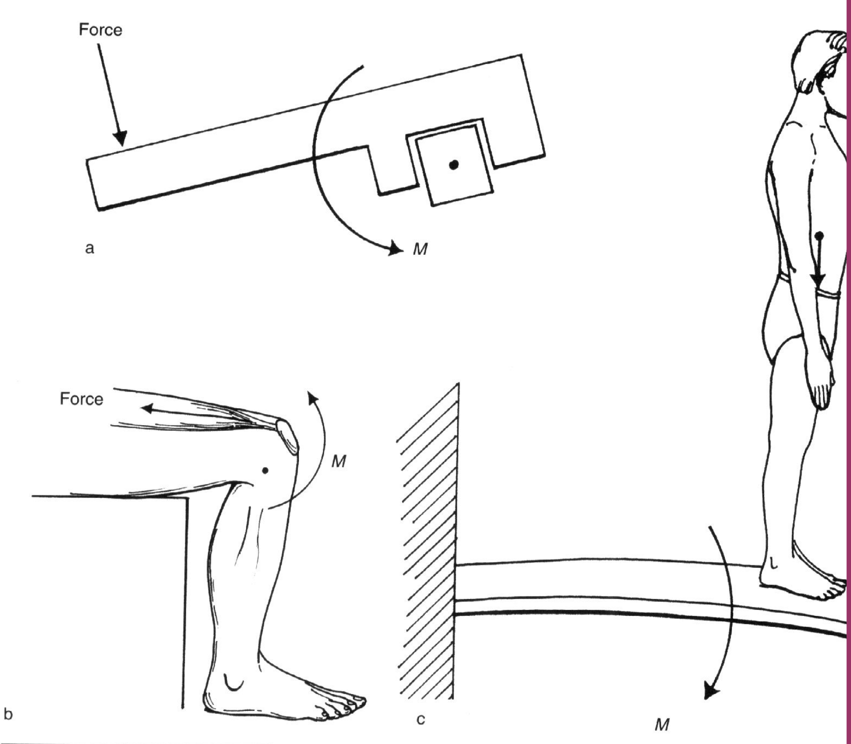
- Some mechanical concepts:
  - Force (A pull or a push)
  - Torque (a force directs off the center of rotation)
  - Mass (the amount of matter of body) or resistance to change in the linear direction



Applied examples of moment of force (*M*), or torque. (*a*) Force applied to a wrench creates a mom turn a nut on a bolt. (*b*) Quadriceps muscle group creates an extensor moment about the knee joint axis. (*c*) Th weight of a diver creates a moment that bends the diving board.

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- Physical laws related to injury:

$$ft = \Delta mv$$

$$Fd = \Delta E$$

$$p = \frac{F}{A}$$

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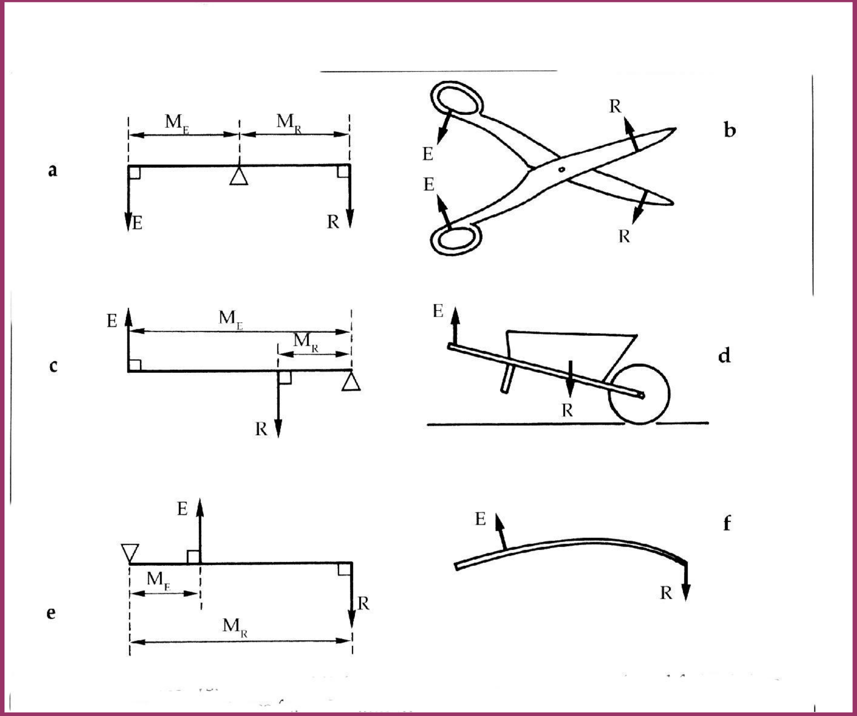
- Levers

  1 – First class

  2 - second class

  3 - third class

  What is the dominant lever kind in the human body?



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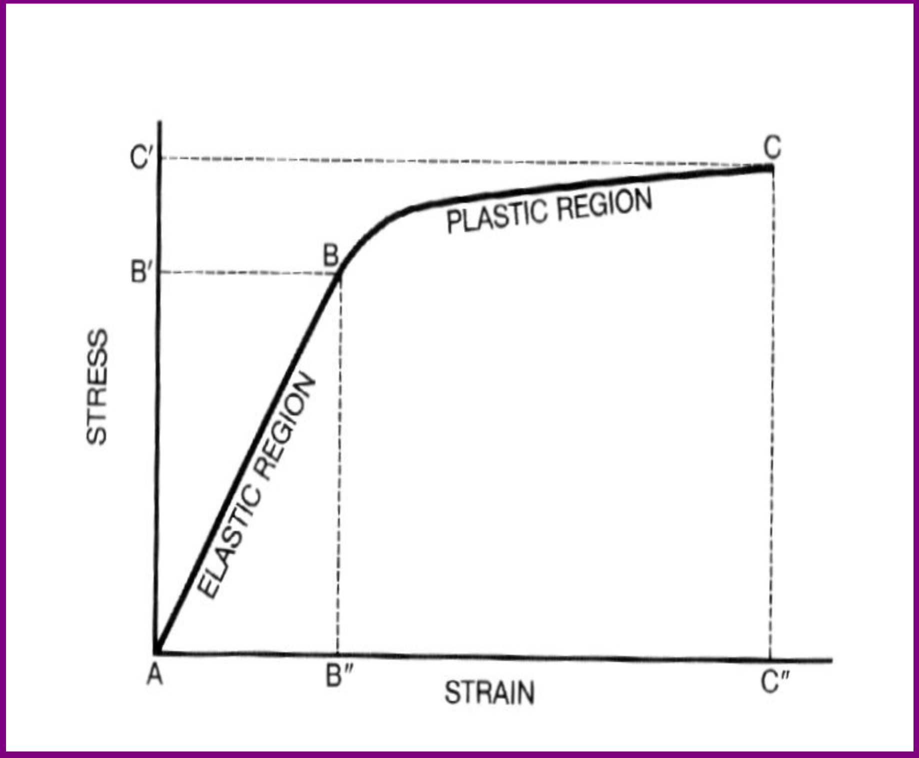
Tissue Biomechanics

- Bone
  - Stiffness
  - Strength
  - Elasticity
  - Plasticity
  - Yield Pointt
  - Area under the curve



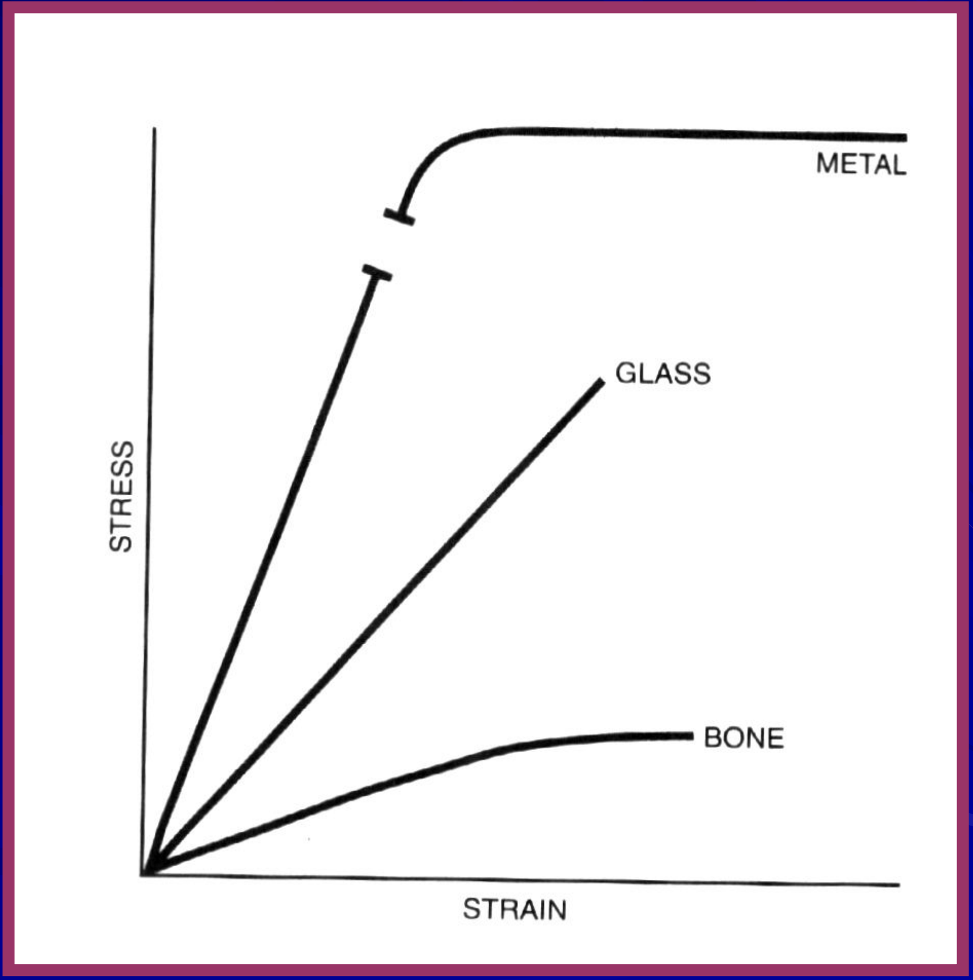
Biomechanics
Bone

Comparison of bone properties with other materials.

-Glass: brittle, stiff

-Metal: stiff, pliable

-Bone: Elastic, weak



Biomechanics

Bone

Comparison of bone with other materials using standardized procedures .

Bone is flexible and weak

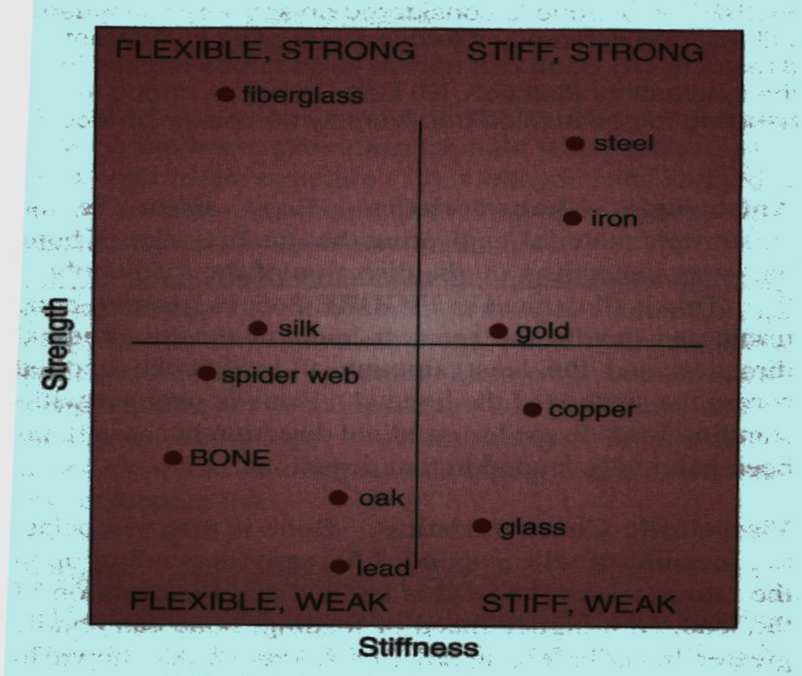
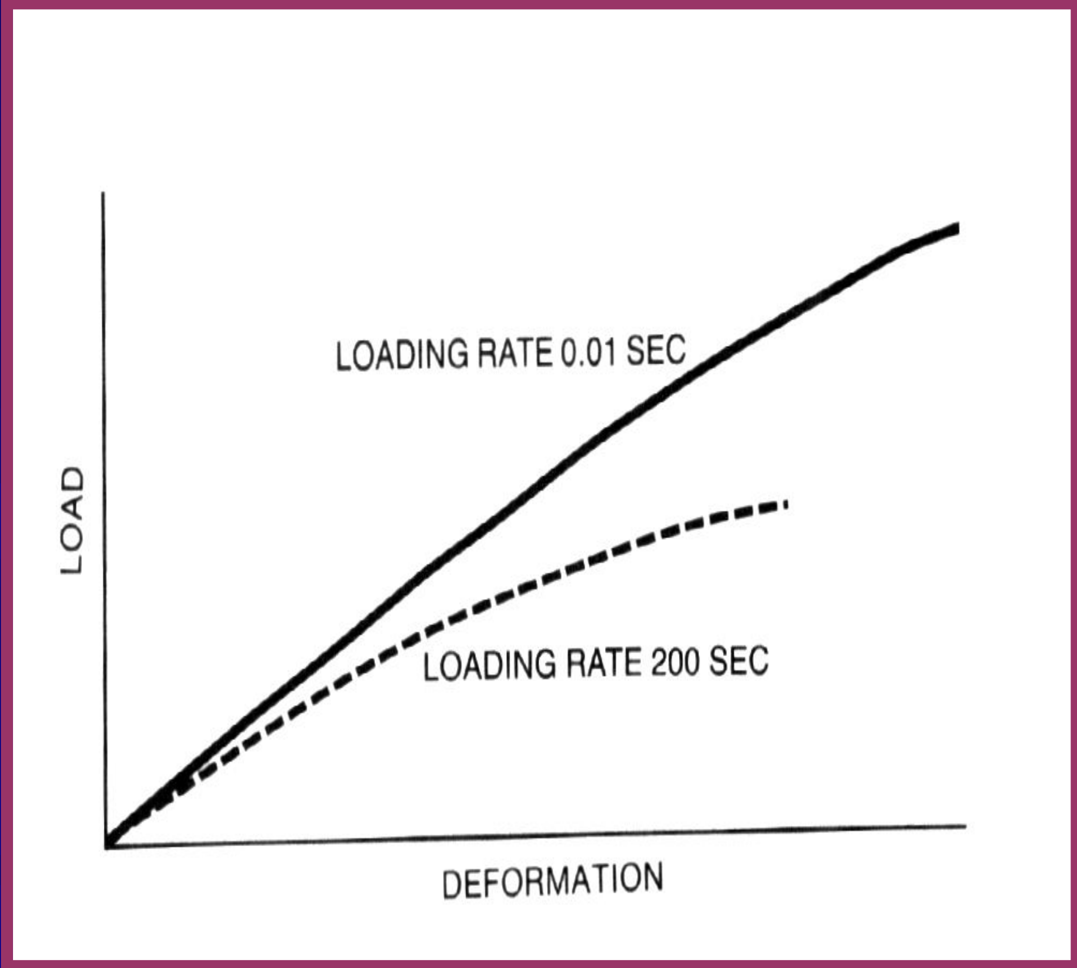


FIGURE 2–9. The strength and stiffness of a variety of different materials are plotted in four quadrants representing material which is (A) flexible and weak; (B) stiff and weak; (C) stiff and strong; and (D) flexible and strong. Note that bone is categorized as being flexible and weak along with other materials such as a spider web and oak wood. (Adapted from P. Shipman et al., 1985)

Biomechanics
Bone

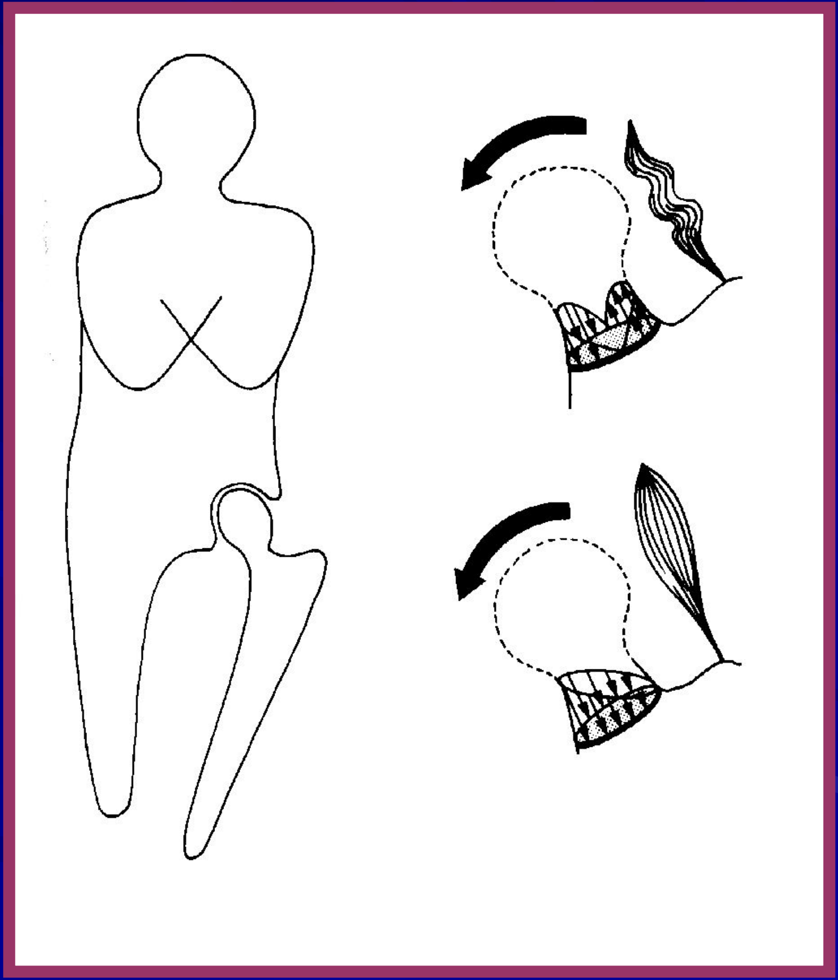
Load rate and its effect on bone



Biomechanics
Bone

The contribution of muscles in load relieving of bone

- With muscle contraction, the bending load is evenly distributed.



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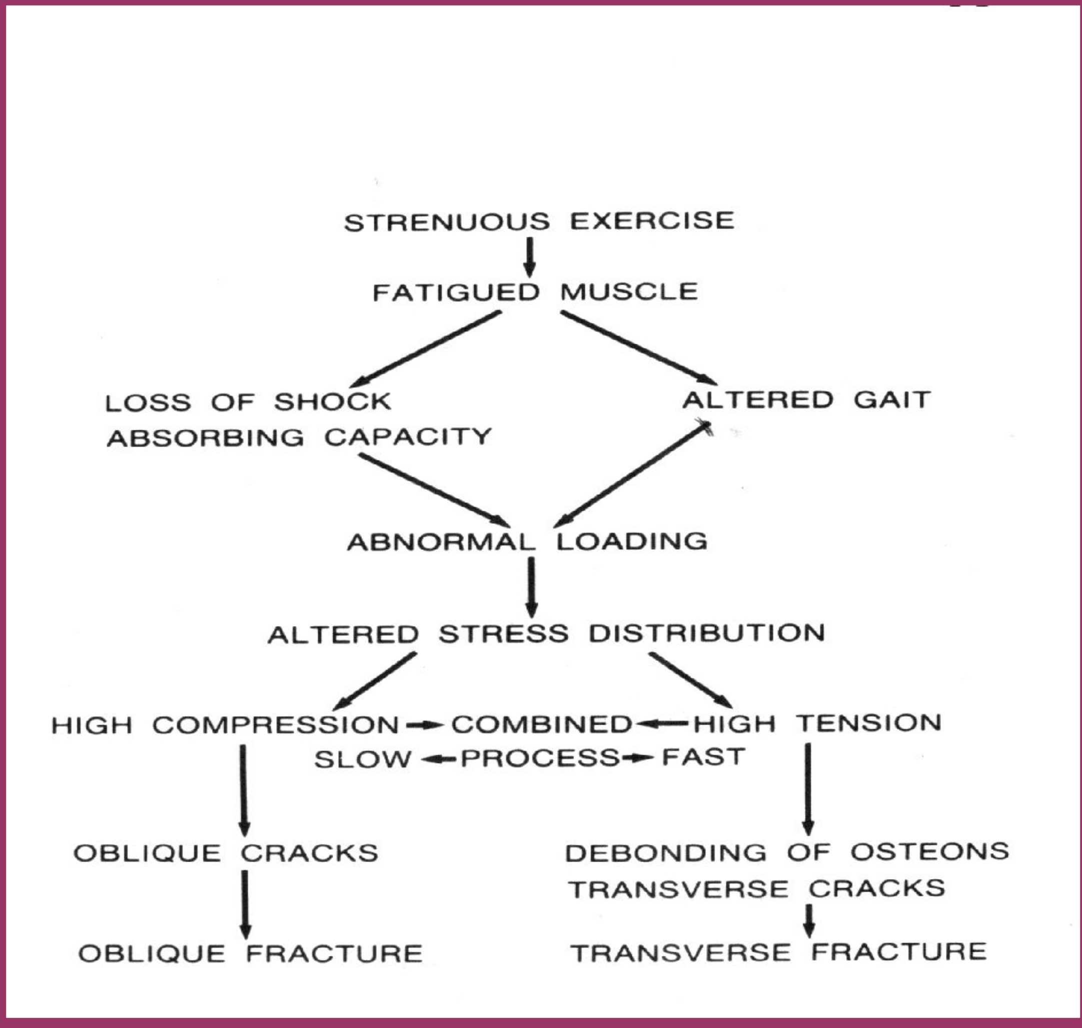
Bone

-Fatigue of bone under repetitive loading.

- Fatigue fracture occurs only when the remodeling process is outpaced by fatigue process

- Wolff's Law:

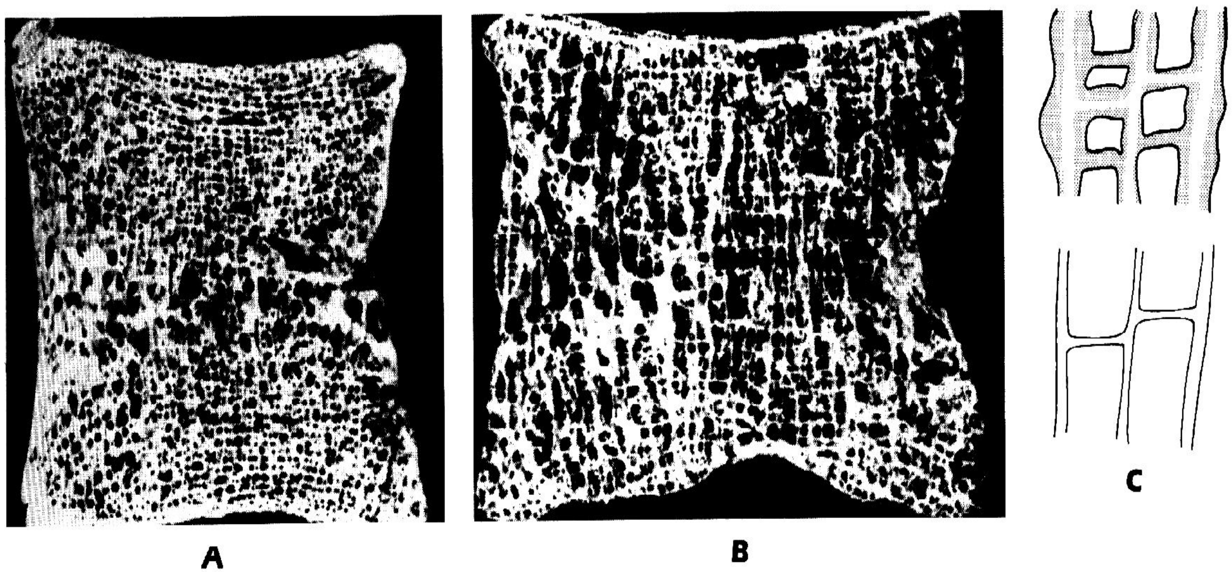
-"Bone is laid down where needed and resorbed where not needed"



Biomechanics

Bone

The effect of aging on bone



Vertebral cross sections from autopsy specimens of young **(A)** and old **(B)** bone show a marked reduction in cancellous bone in the latter. (Reprinted with permission from Nordin, B.E.C.: Metabolic Bone and Stone Disease. Edinburgh, Churchill Livingstone, 1973.) **C.** Bone reduction with aging is schematically depicted. As normal bone (top) is subjected to absorption (shaded area) during the aging process, the longitudinal trabeculae become thinner and some transverse trabeculae disappear (bottom). (Adapted from Siffert and Levy, 1981.)

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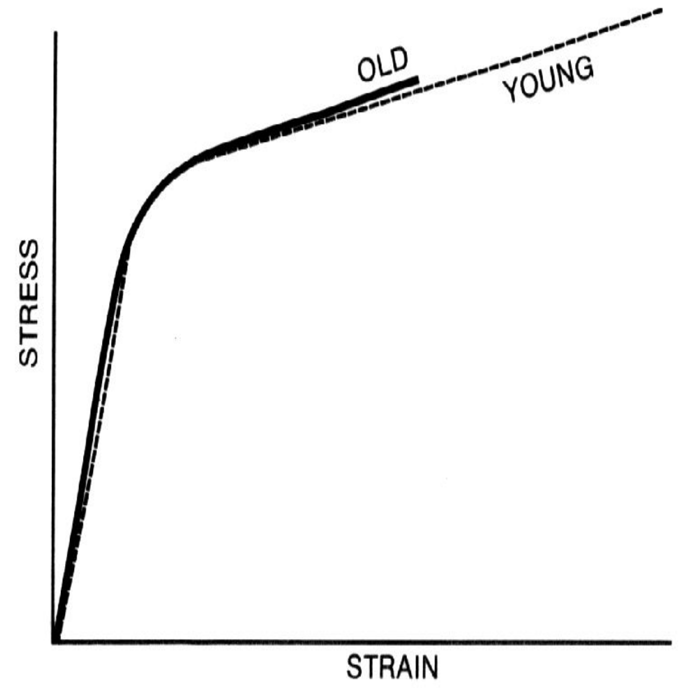
Bone

- The effect of aging on bone mechanical properties.

- With aging, both strength and stiffness decrease.



Stress-strain curves for samples of adult human tibiae of two widely differing ages tested in tension. (Adapted from Burstein et al., 1976.)

Biomechanics
Tendon and Cartilage

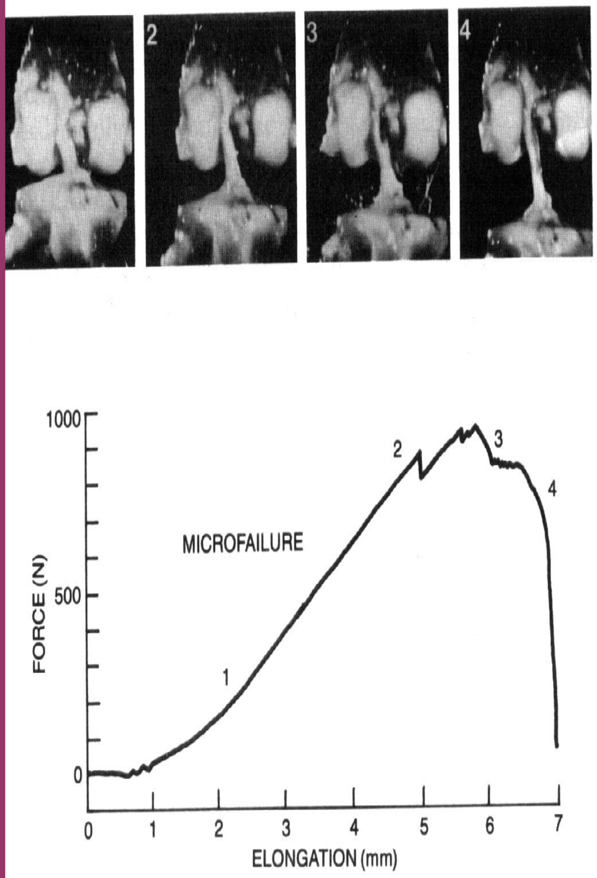
The regions on the curve are:

(1)The tissue elongate with small increase in load as the wavy collagen fibers straightened.

(2) The fibers straightened and the stiffness increases rapidly.

(3) Failure of collagen fibers occur after this point.

(4) Maximum load representing the ultimate tensile strength of the material



Progressive failure of the anterior cruciate ligament from a cadaver knee tested in tension to failure at a physiologic strain rate (Noyes, 1977). The joint was displaced 7 mm before the ligament failed completely. The force-elongation curve generated during this experiment is correlated with various degrees of joint displacement recorded photographically; photos correspond to similarly numbered points on the curve. (Courtesy of Frank R. Noyes, M.D., and Edward S. Grood, Ph.D.)

Biomechanics

Tendon and Ligament

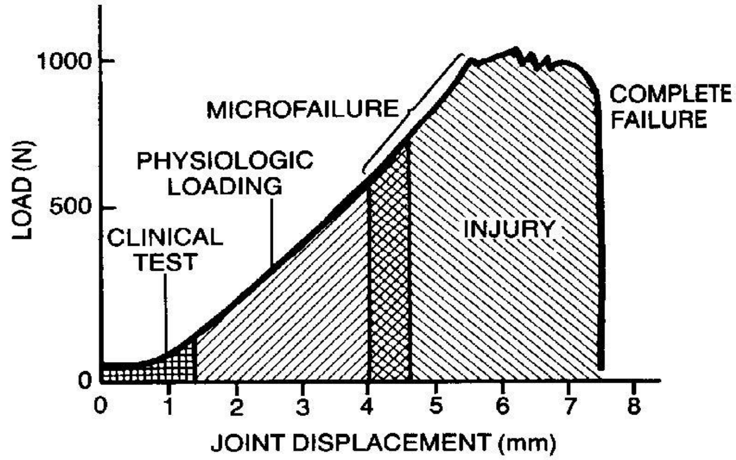
The load –elongation curve is converted to load-joint displacement curve correlating with clinical finding.

It is divided to three regions:

(1) The load imposed during the anterior drawer test.

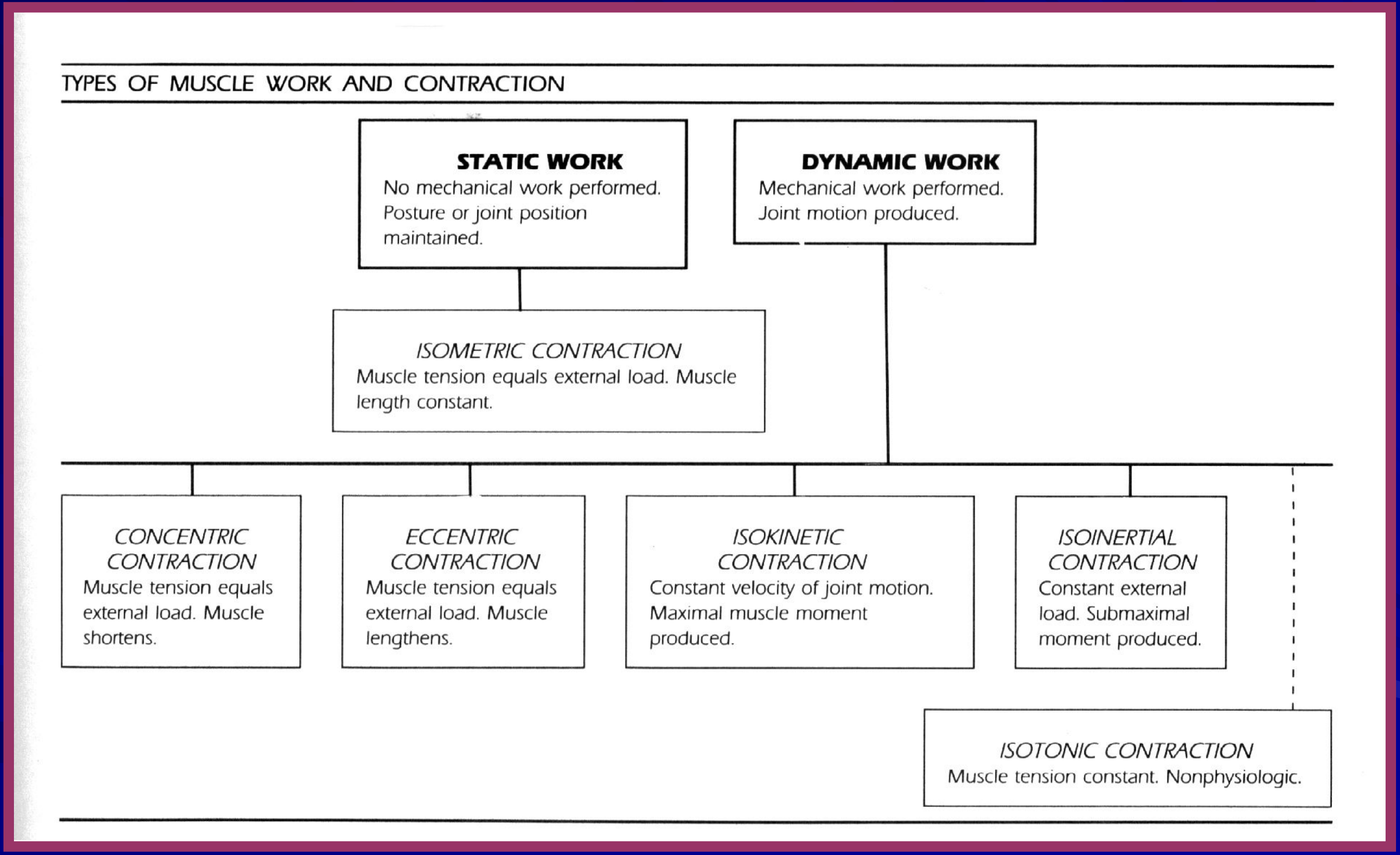
(2) load placed in ligament during physiological activity

(3) load imposed on ligament from partial injury to complete rupture



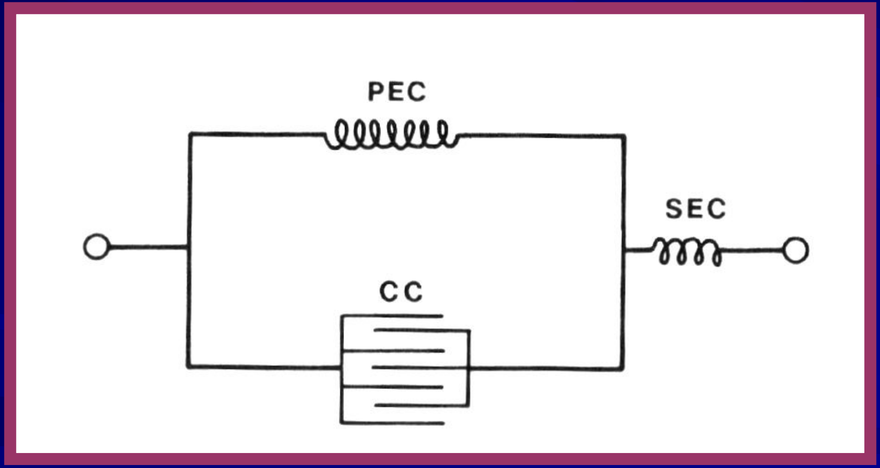
The curve produced during tensile testing of a human anterior cruciate ligament in vitro (Noyes, 1977) (see Fig. 3–8) has been converted to a load-displacement curve and divided into three regions correlating with clinical findings: (1) the load imposed on the anterior cruciate ligament during the anterior drawer test; (2) that placed on the ligament during physiologic activity; and (3) that imposed on the ligament from partial injury to complete rupture. It should be noted that the divisions shown here represent a generalization. Microfailure is shown to begin toward the end of the physiologic loading region, but it may take place well before this point in any given ligament.

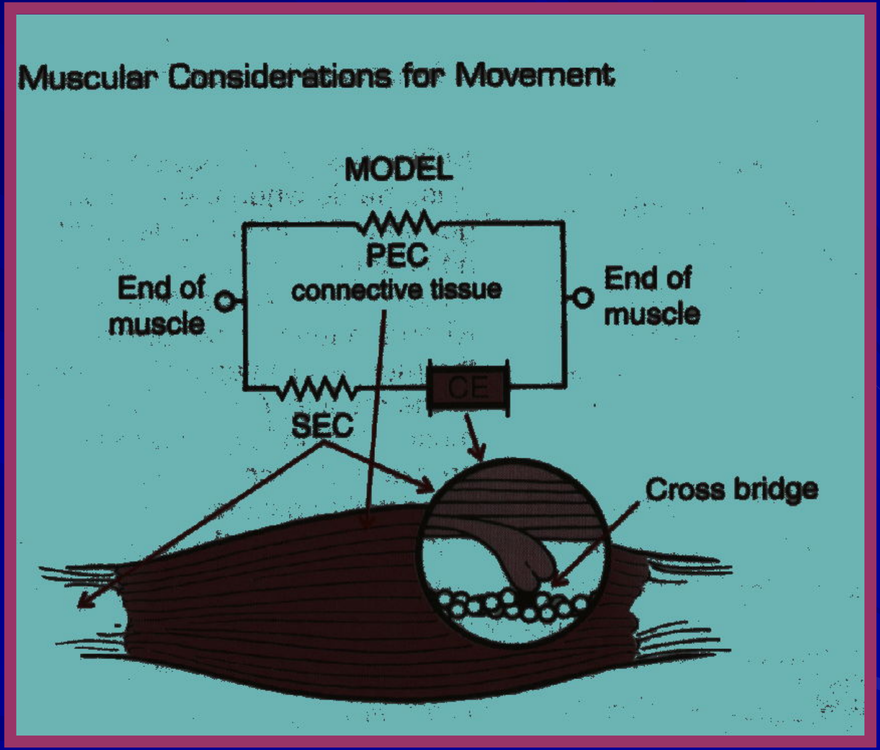
Biomechanics
Muscles



Biomechanics
Muscles

Mechanical components of muscles

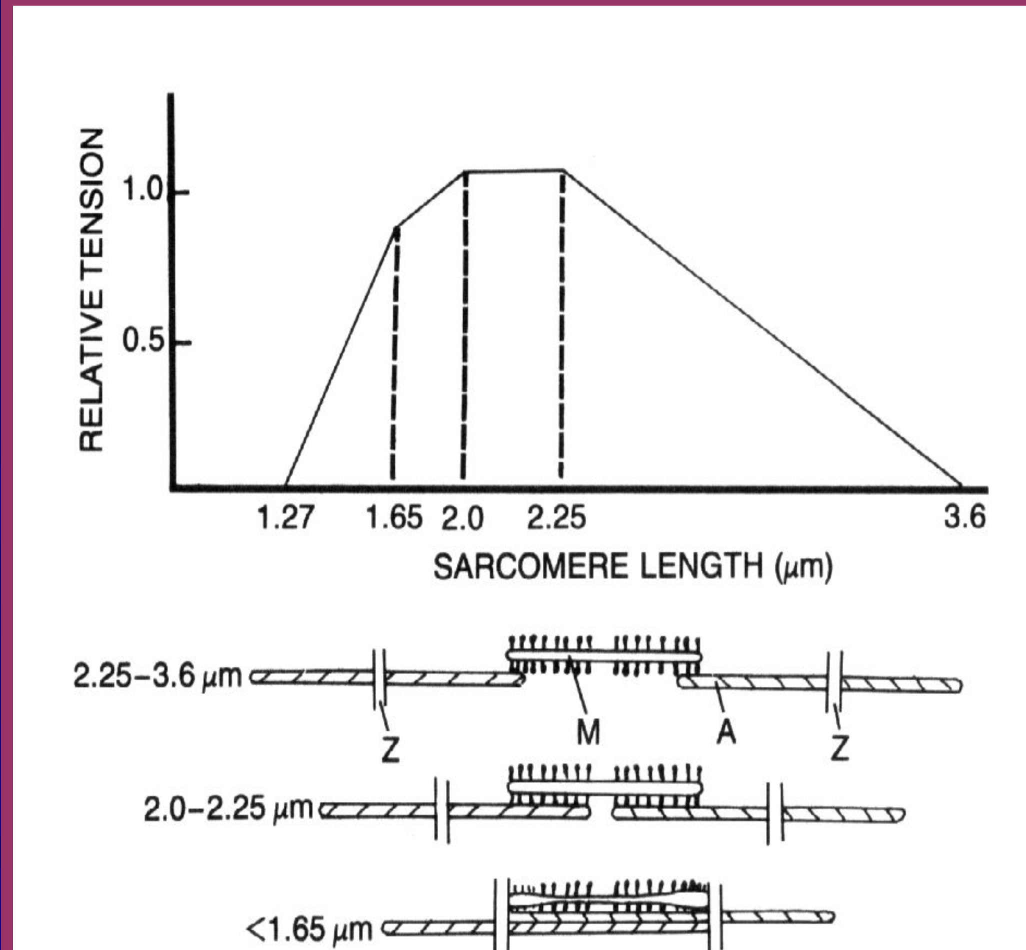




Biomechanics

Muscles

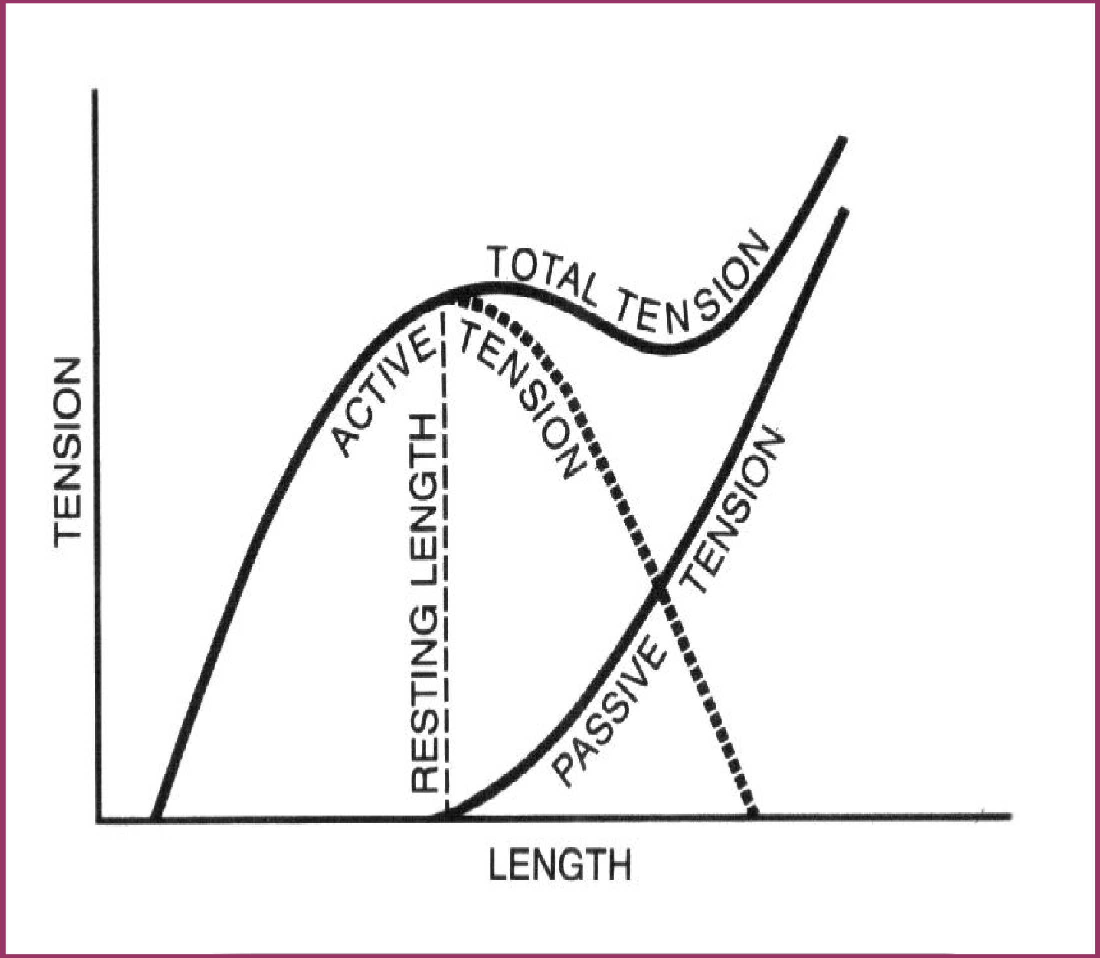
The relationship between macromere length and relative tension



Biomechanics

Muscles

The contribution of muscle mechanical components to tension



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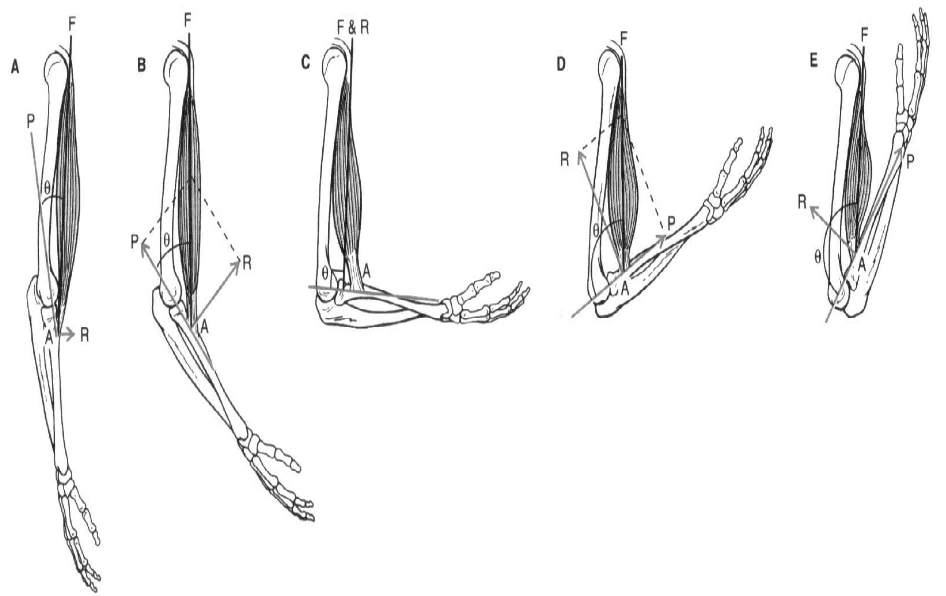
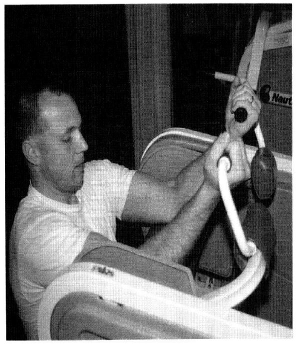
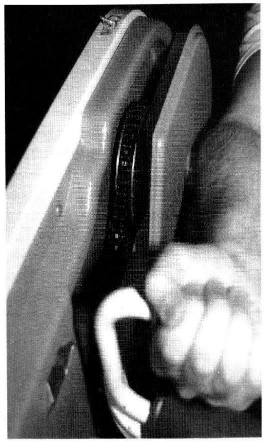
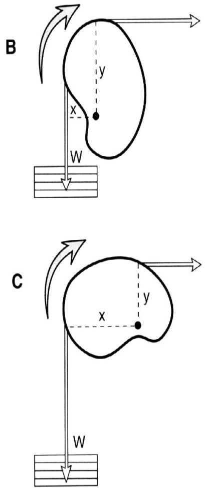


When muscle attachment angles are acute, the parallel component of the force (P) is highest and is stabilizing the joint. The rotatory component (R) is low (see A above). The rotatory component increases to its maximum level at a 90 degree angle of attachment (see C above). Beyond a 90 degree angle of attachment, the rotatory component diminishes and the parallel component increases to produce a dislocating force (see D and E above).





A



The Nautilus machine for the forearm flexors is shown in (A) above. A photograph of the actual cam is also presented. This machine uses a cam system which changes the moment arm of the weight, making it easier (B) or harder (C) to lift.

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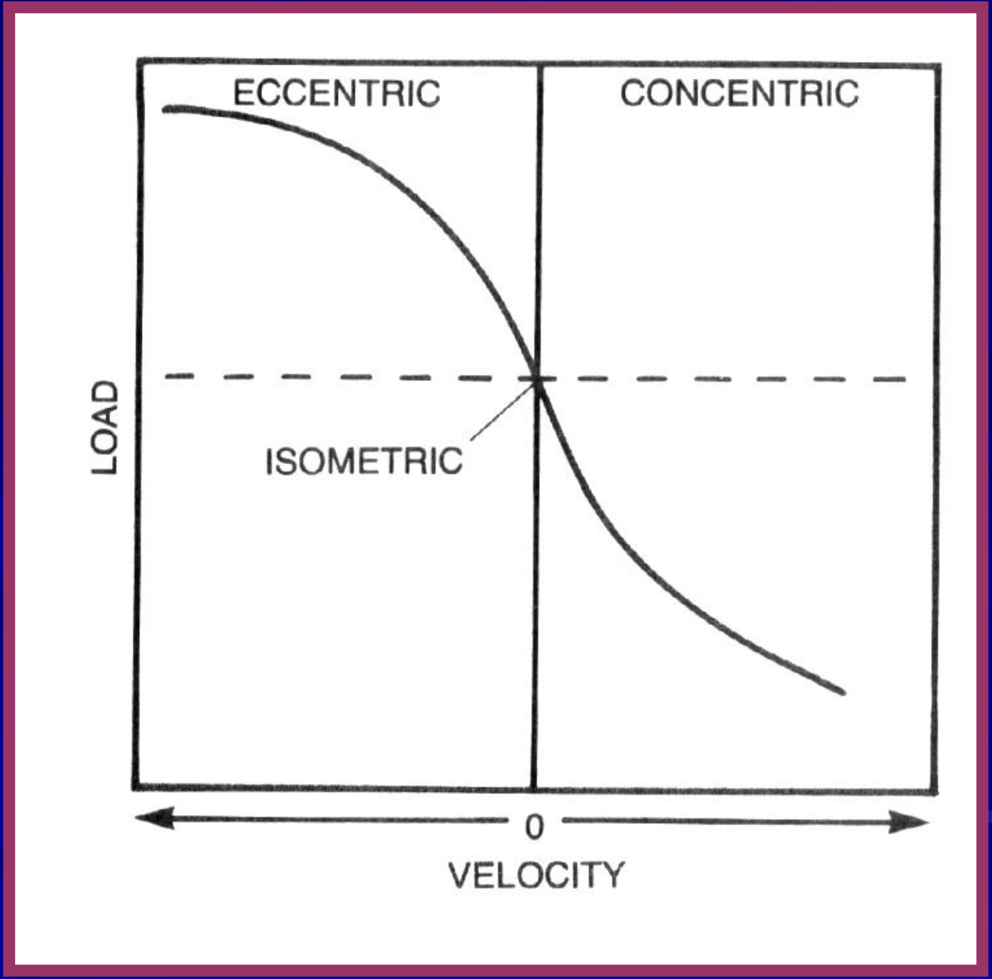
Muscle

The relationship between force (Muscle work) and velocity



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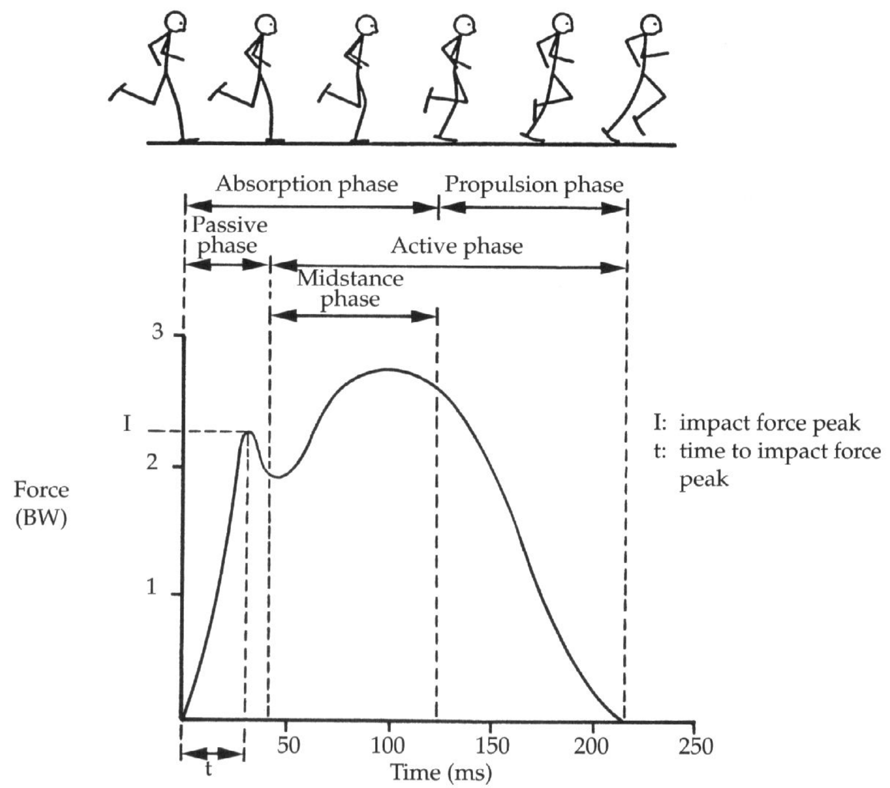
Equipments

Running and shoes



Force-time curve of the vertical component of the ground reaction force of a heel striker running at 4.5 m/s in running shoes. BW = body weight.

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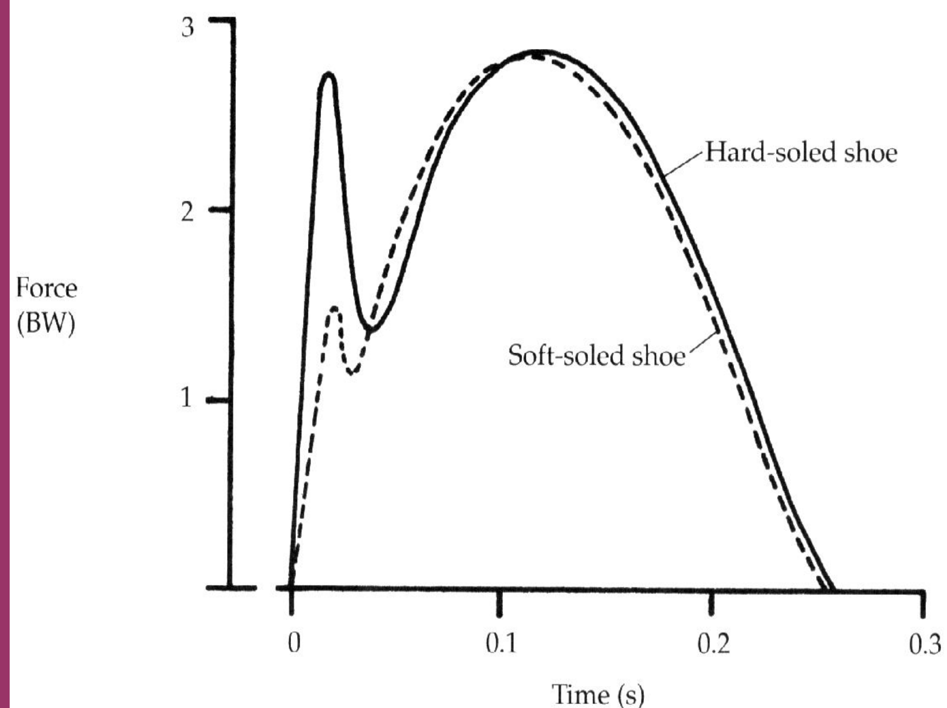
Equipments

Shoe anatomy

Biomechanics

Equipments

The effect of mid sole on vertical ground reaction force



Vertical component of the ground reaction force while running at 5 m/s in hard- and soft-soled shoes. BW = body weight.
ted, with permission, from Nigg, Denoth, and Neukomm 1981.

THANK YOU