- **Terms**

Origin

(Proximal Attachment)

Insertion

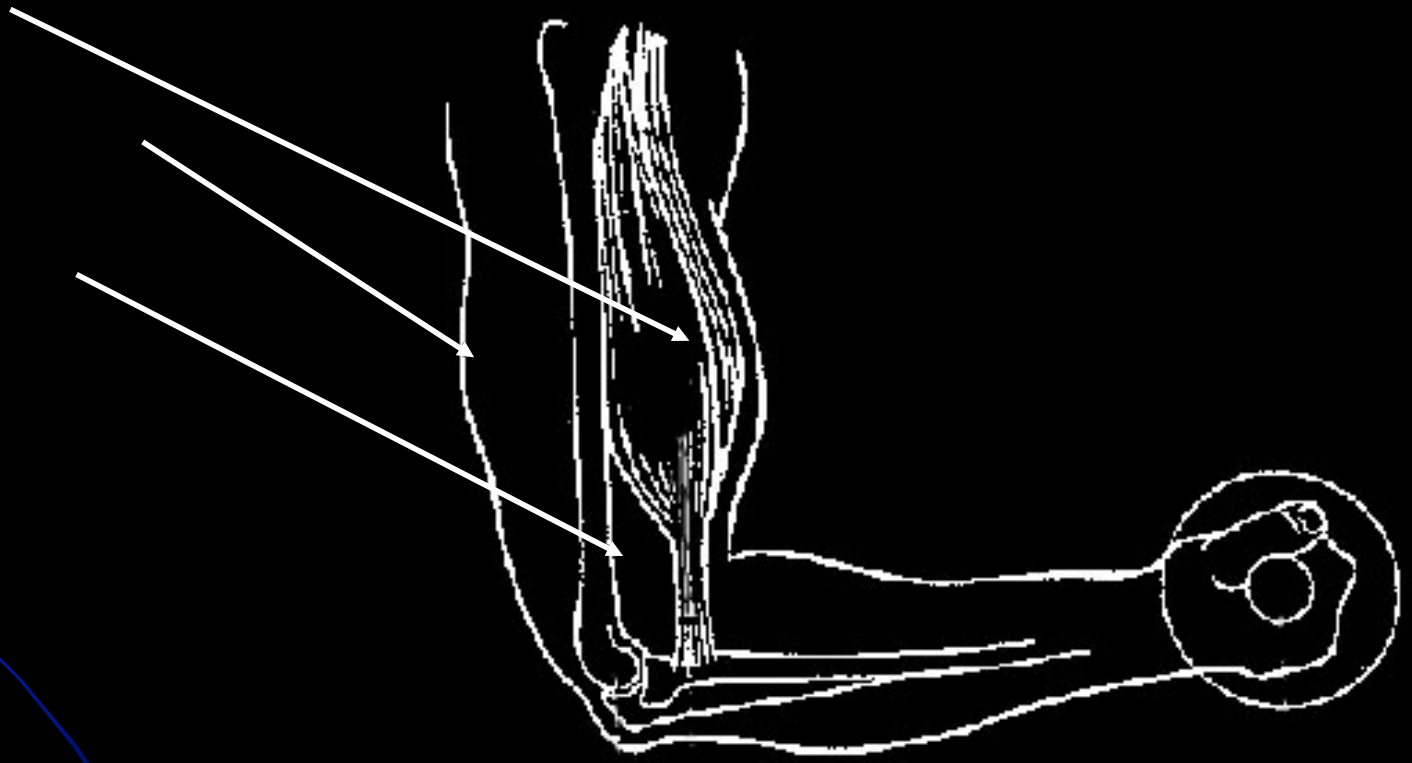
(Distal Attachment)

Roles of Muscles

- Agonist- prime mover
- Antagonist- provides a braking force
- Synergist- assists indirectly in the movement

Musculoskeletal System

- Agonist
- Antagonist
- Synergist



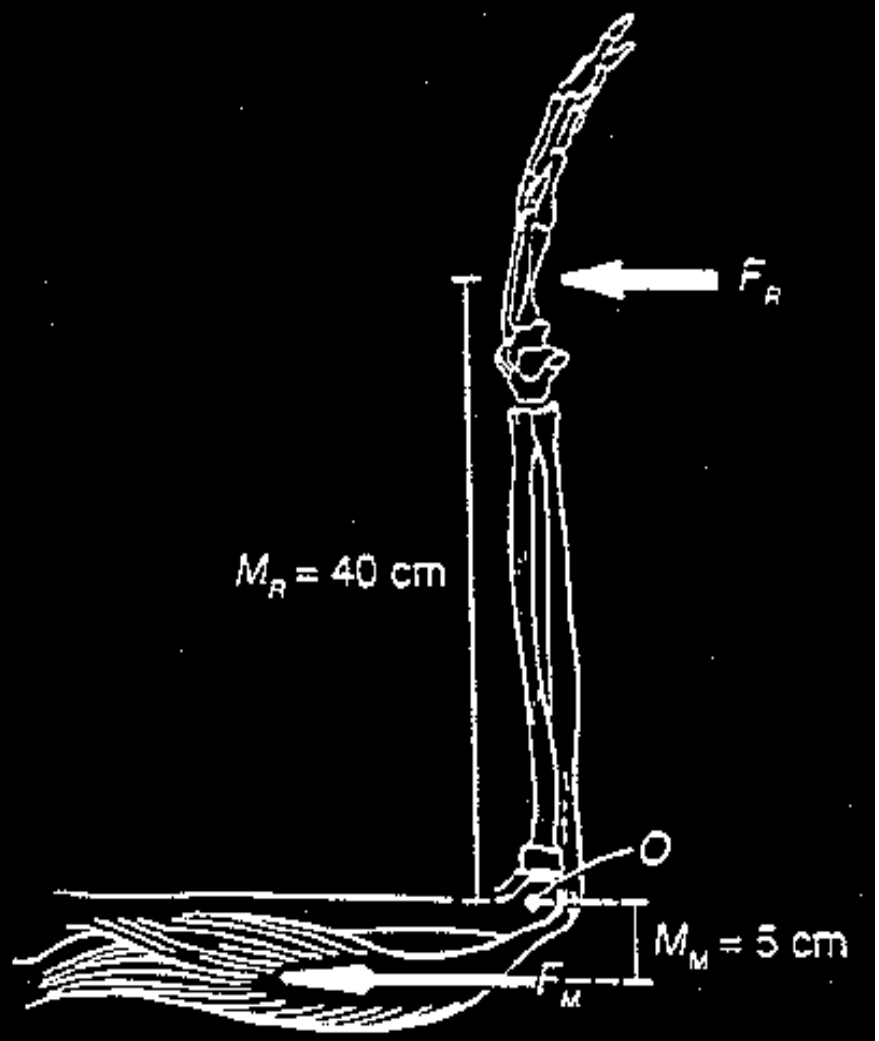
Levers in the Human Body

- Lever is a rigid bar rotating on an axis
- Fulcrum (axis)- point of support, axis of rotation
- Moment arm- perpendicular distance from line of action of a force to the axis of rotation
- Torque (moment)

First Class Lever

- A lever in which the muscular force and resistance force act on *opposite* sides of the fulcrum

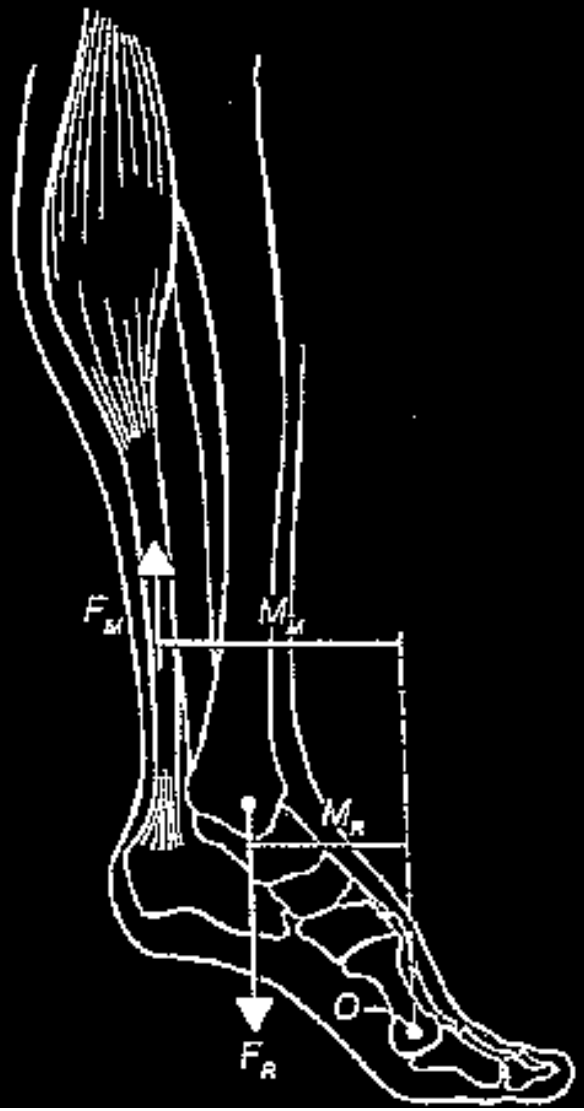
(Force-Axis-Resistance)



Second Class Lever

- A lever in which the muscle force and resistance force act on the *same* side of the fulcrum, but the resistance force acts at a point *closer* to the fulcrum than the muscle force

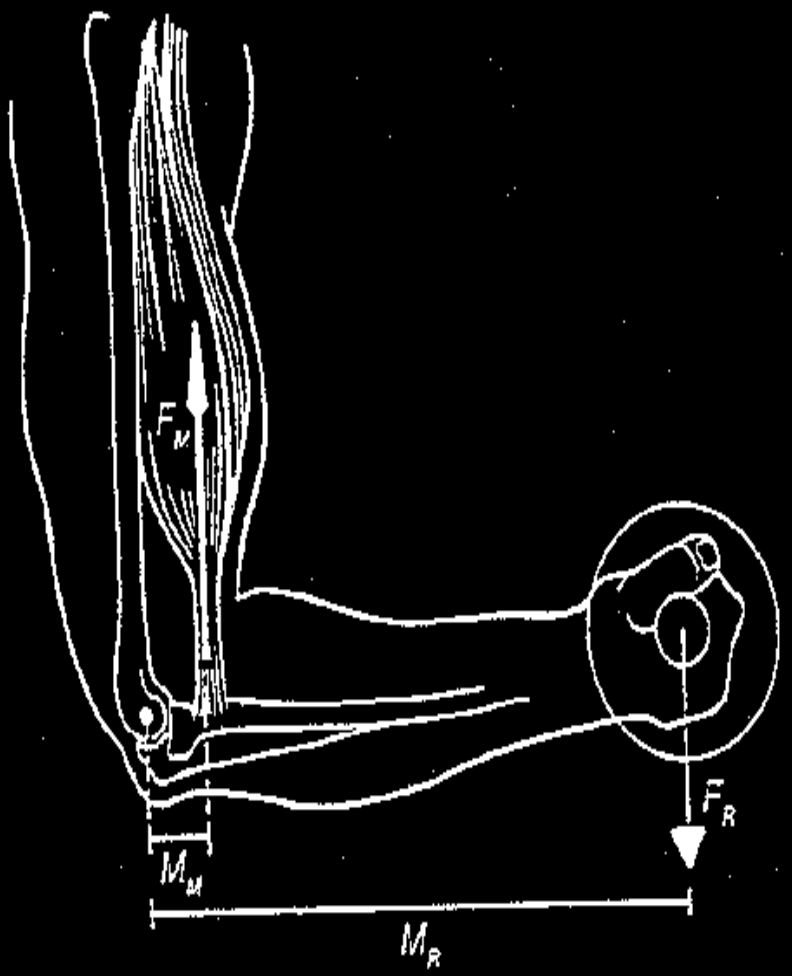
(Force-Resistance-Axis)



Third Class Lever

- A lever in which the muscle force and resistance force act on the *same* side of the fulcrum, but the muscle force acts at a point *closer* to the fulcrum than the resistance force.

(Resistance-Force-Axis)



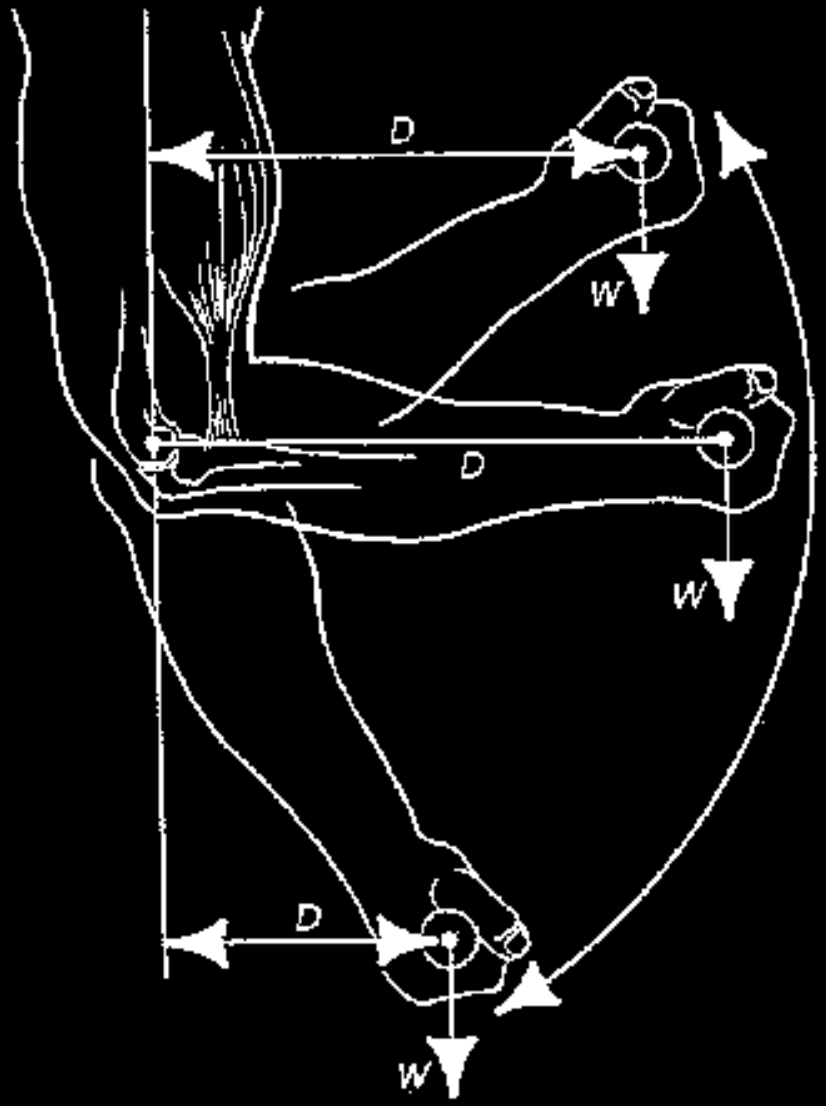
Musculoskeletal System

- Mechanical advantage
  - Force Arm ÷ Resistance Arm
  - Due the mechanical disadvantage, the body has to exert much higher internal forces to act against external objects
  - Force versus speed - body is made more for speed production and range of motion instead of force production

Musculoskeletal System

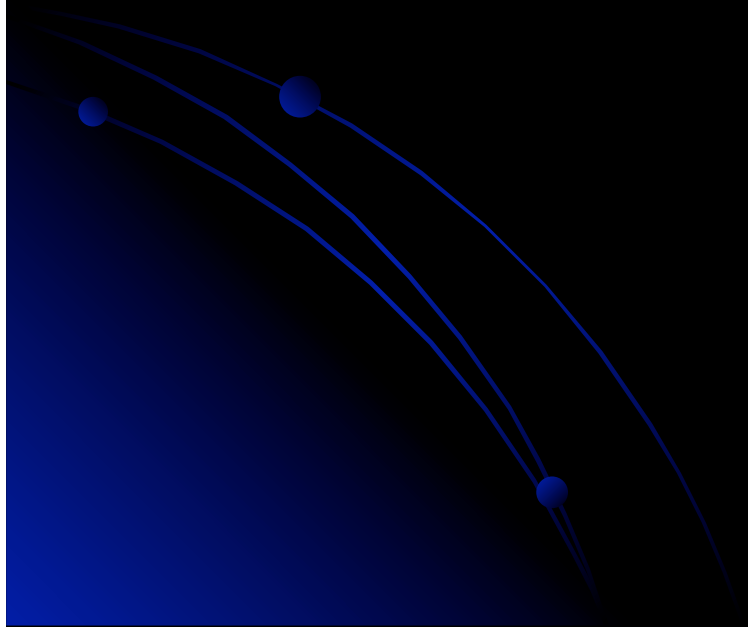
Elbow joint

- The mechanical advantage is the greatest at 90° elbow flexion



Human Strength and Power

- **Strength** -- the force a muscle or muscle group can generate under a given set of conditions



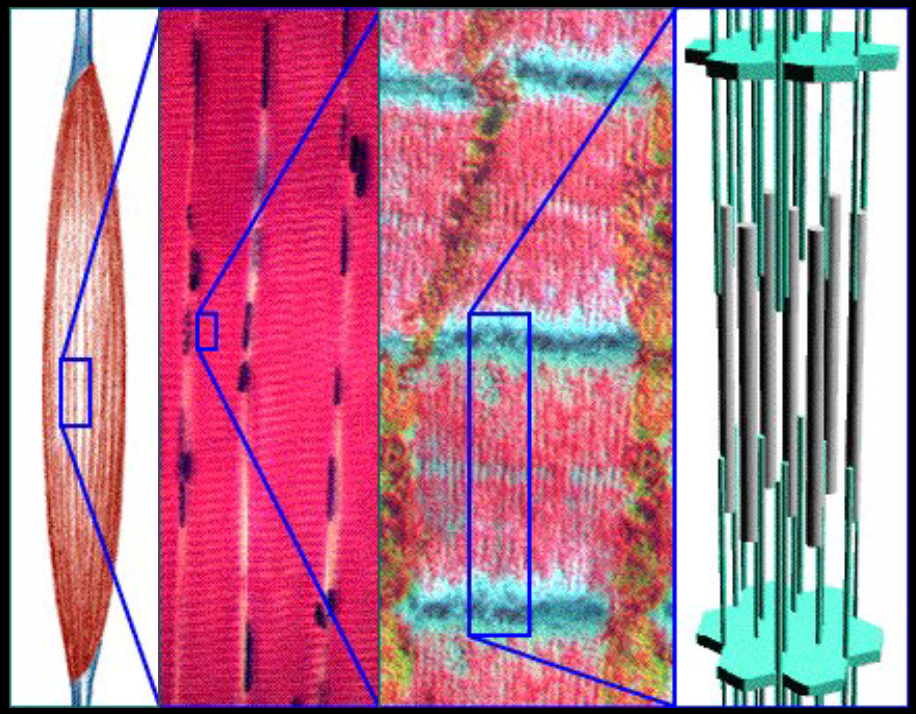
Biomechanical factors in strength production

- Neural factors- recruitment and rate coding
- Muscle cross-sectional area
- Arrangement of muscle fibers
- Muscle length
- Joint angle
- Point of tendon origin/insertion

Biomechanical Factors of Human Strength

- Neural control - muscle force increases when
  - More motor units are involved in a contraction
  - The motor units are greater in size
  - The rate of firing is faster

Muscle Structure



Muscle Fascicles Myofibers Sarcomeres

Length-Tension Relationship

- The tension a sarcomere can generate is a function of its length.
  - When the sarcomeres are very long, only a few of the myosin heads on each thick filament can reach a thin filament, so little force can be exerted.

Length-Tension Relationship

- At intermediate lengths, all of the myosin heads are within reach of the thin filaments, so maximum force can be exerted.

Length-Tension Relationship

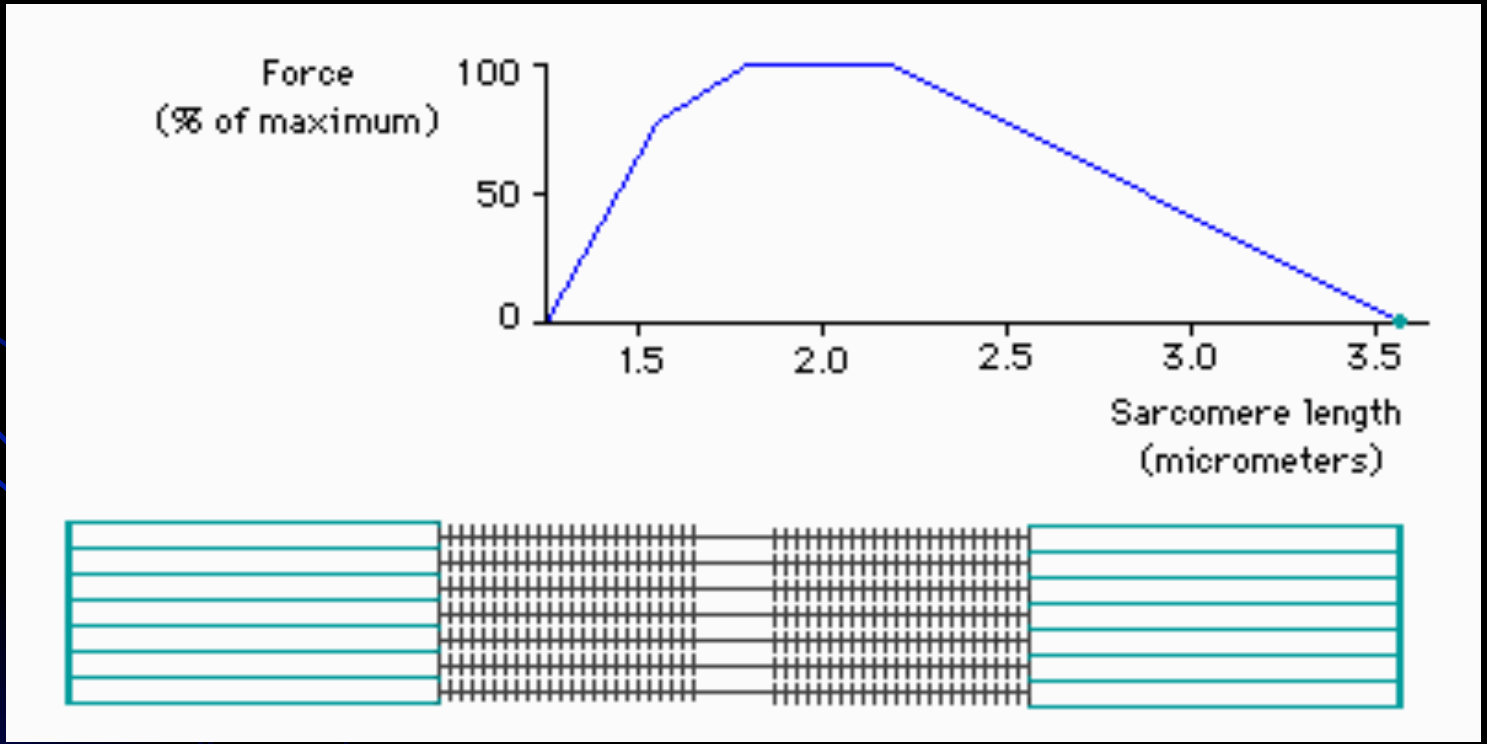
- With further shortening, the ends of the thin filaments reach beyond the mid-points of the thick ones, to myosin heads that face the wrong direction and push on them instead of pulling. This reduces the force that the muscle fiber can exert.

Length-Tension Relationship

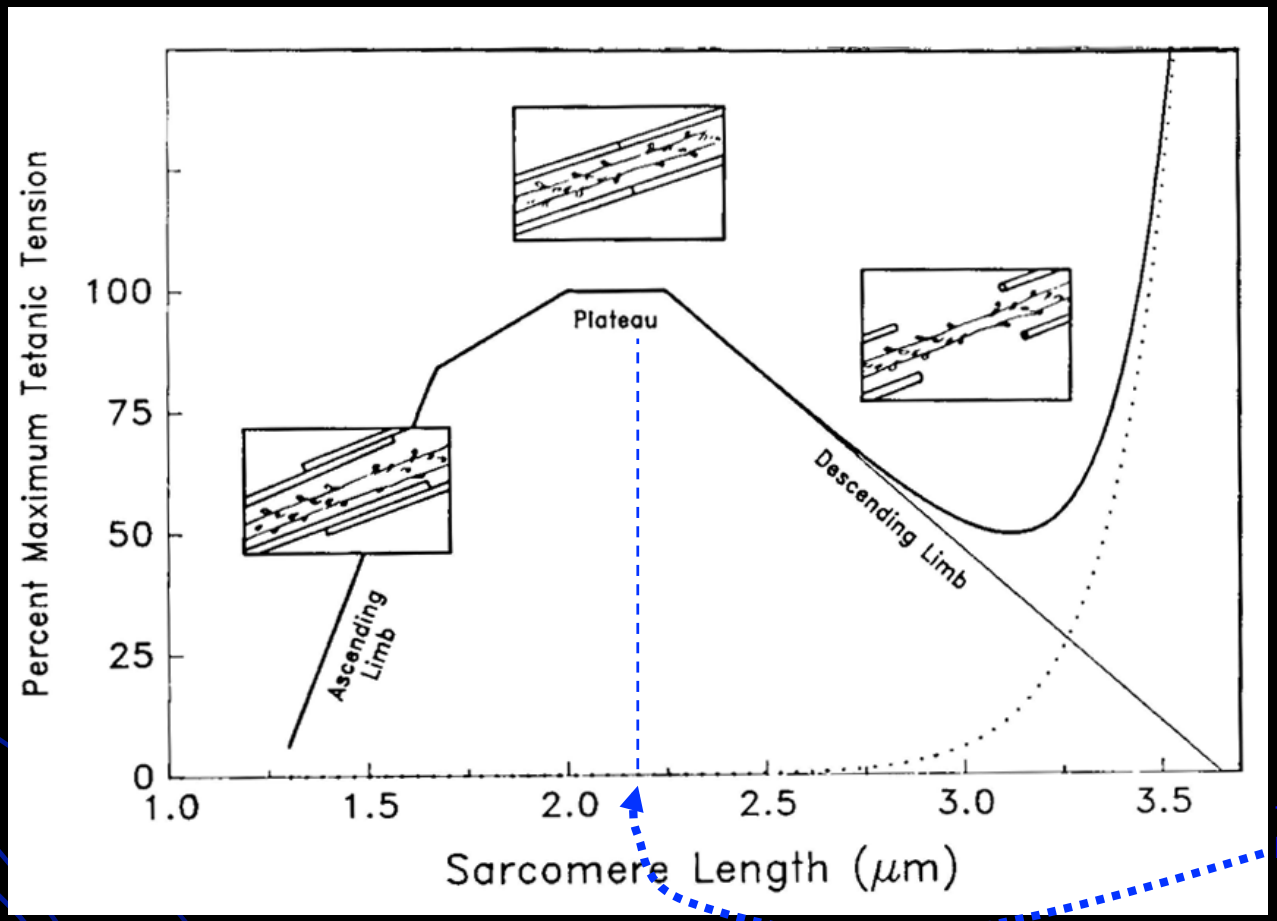
- Eventually, as shortening continues, the thick filaments collide with the Z-disks. Any further shortening distorts the filaments and the force falls rapidly.

Length-Tension Relationship

- The tension a sarcomere can generate is a function of its length.



Length-Tension Relationship



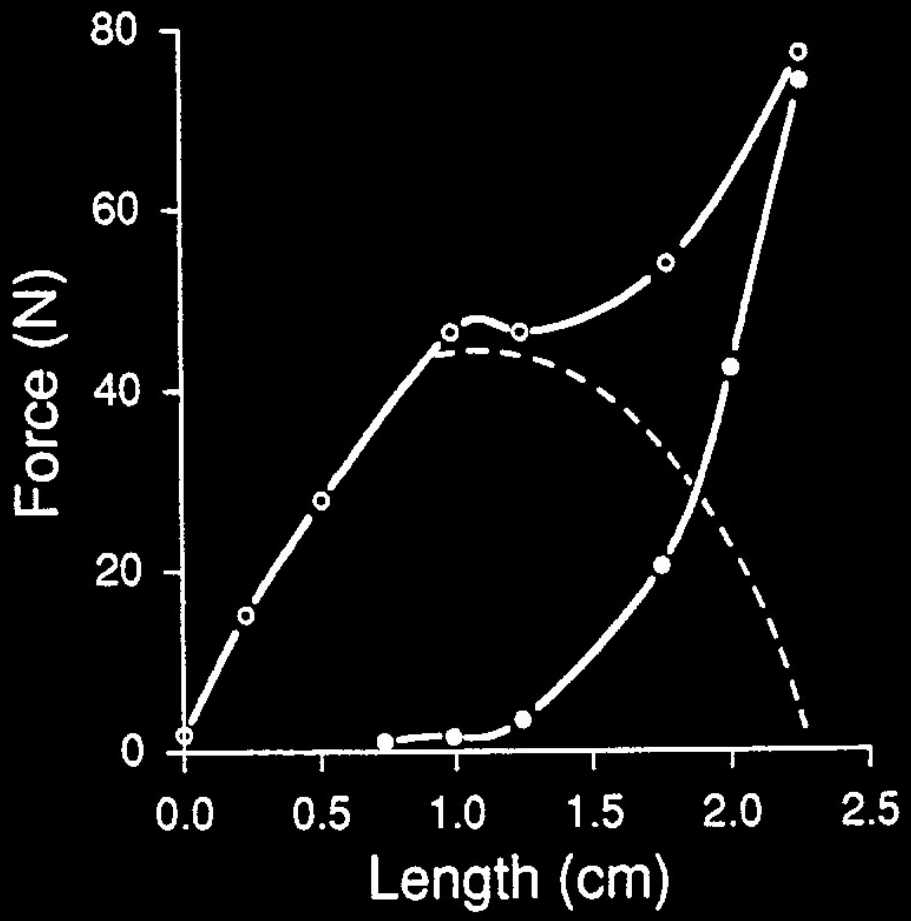
- There is an active and passive component to the L-T relationship.

Biomechanical Factors of Human Strength

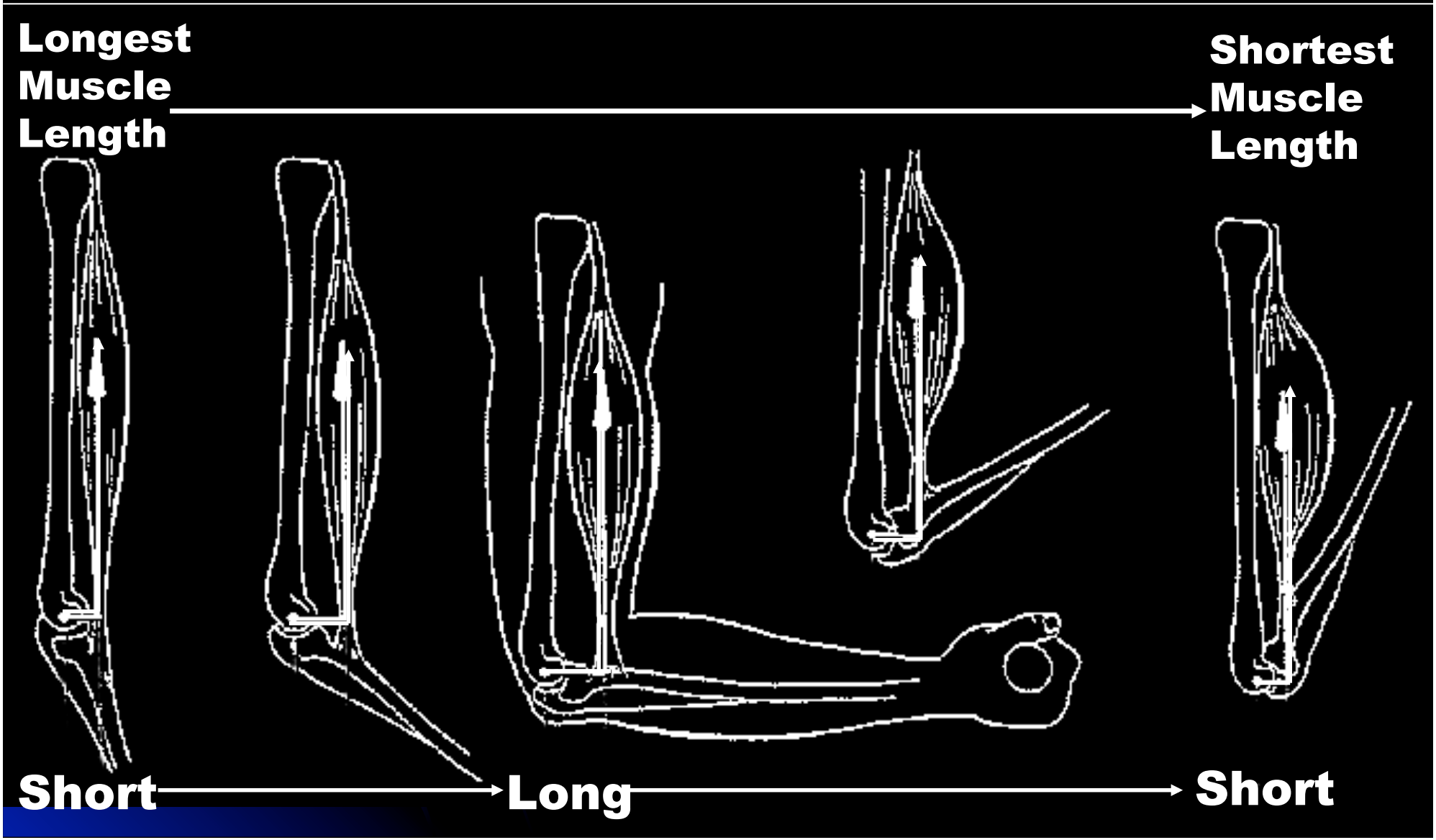
- Muscle cross-sectional area- with all else equal, the force a muscle can exert is related to its cross-sectional area rather than to its volume

Human Strength and Power

- Muscle length
  - Muscle can generate the most force at about its resting length, and less force when elongated or shortened
- Joint angle
  - Changes in strength throughout the joint range of motion affect force capability

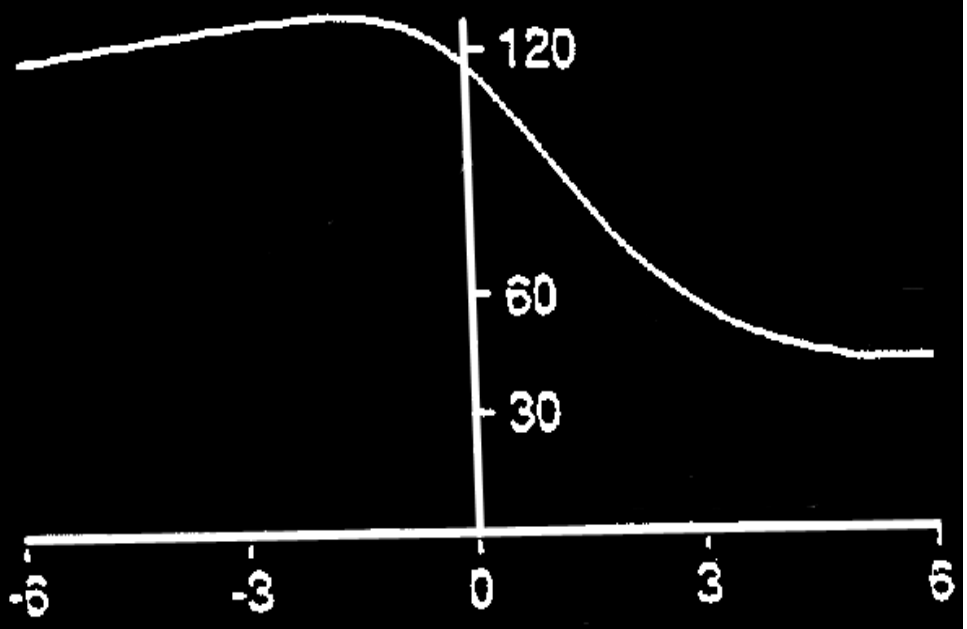


Human Strength and Power

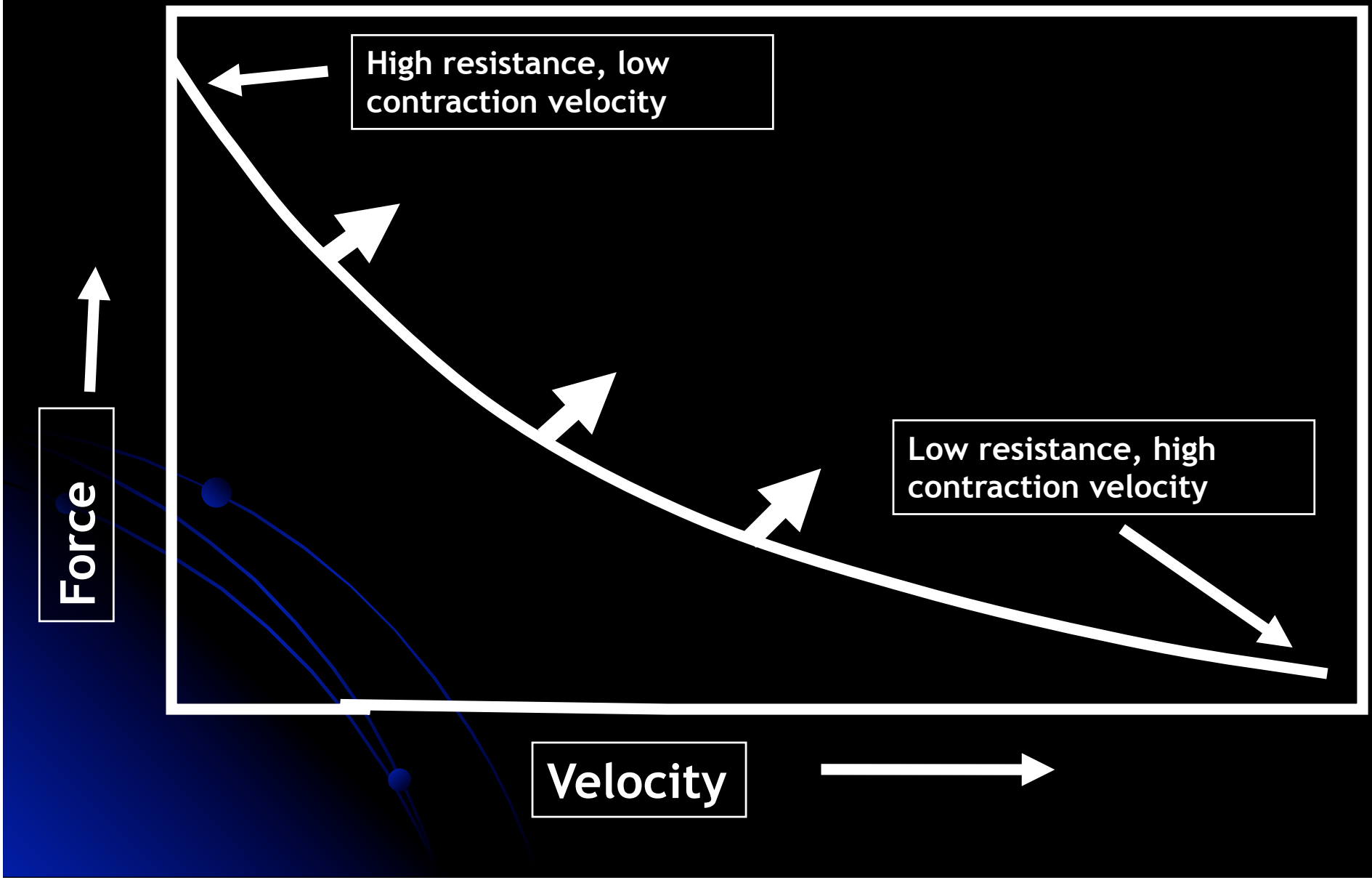


Human Strength and Power

- Force-velocity relationship
  - Greater velocity is generally associated with a lower force capability
    - Can exert more force eccentrically than isometrically or concentrically
    - Concentric muscle contraction velocity
      - The faster a muscle contracts, the less force it can exert



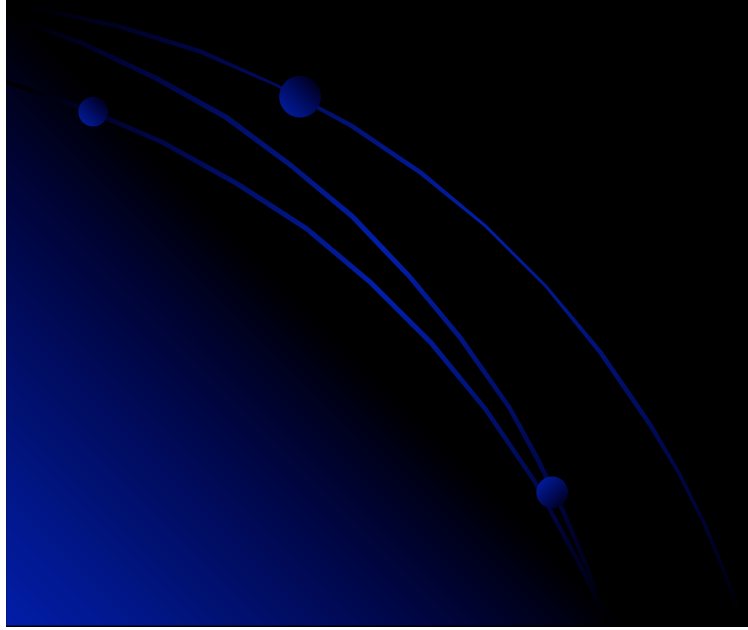
Force/Velocity Curve



Human Strength and Power

- **Power** - the rate of doing work, which equals force times velocity

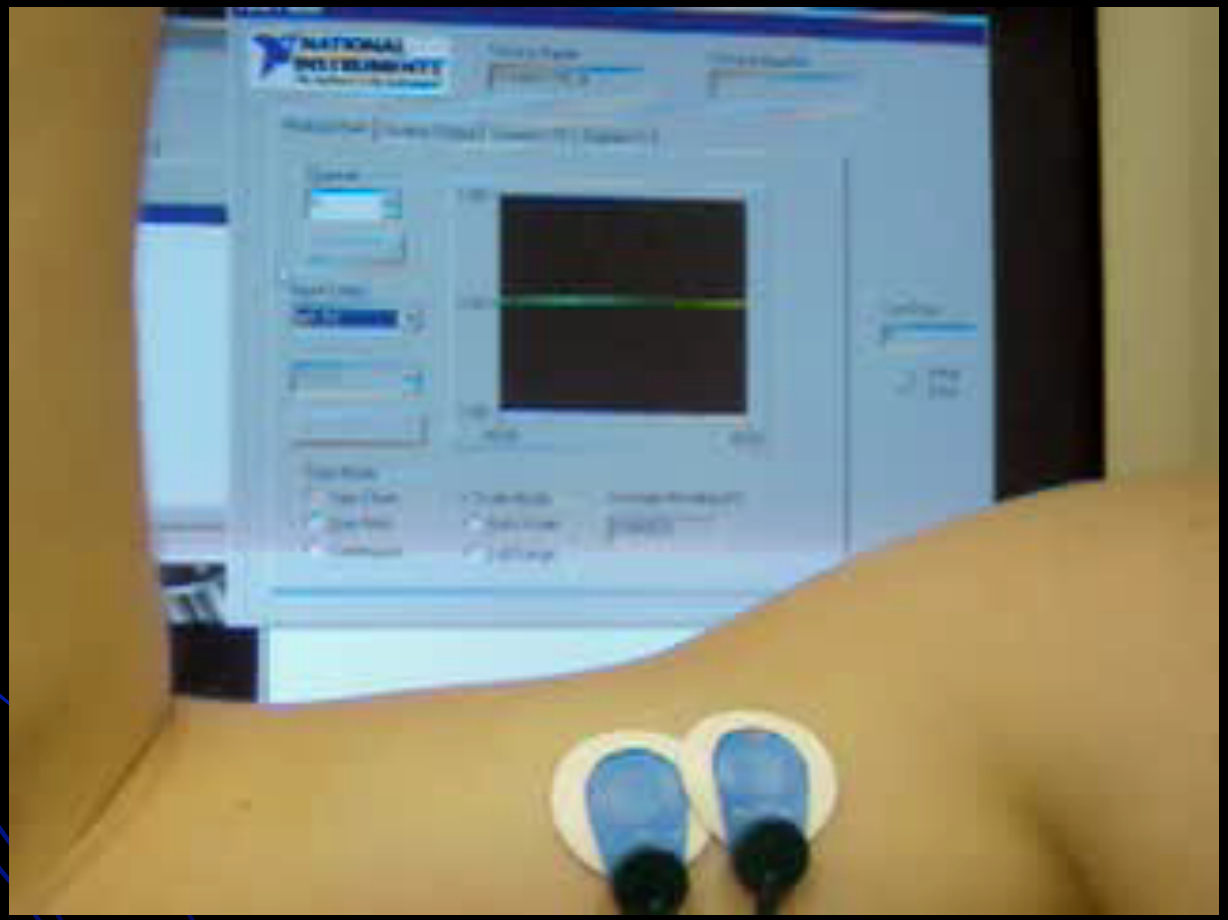
$$P = F \times V$$



Joint Moment

- We will measure joint moment using a Biodex Dynometer
  - Statically
  - Dynamically

EMG



EMG and Muscle Force

- EMG is related to muscle force
- The relationship is nonlinear
  - EMG to muscle activation
  - Muscle force-length relationship
  - Muscle force-velocity relationship
- Mathematical models describing this relationship are the topic of my research (in part)