Functional Anatomy

The structure and function of the “musculoskeletal machine”

- Skeletal & Neuromuscular aspects
- Not Cardio, Respiratory, Digestive Systems, etc.
Kinesiology

- Examines the mechanisms through which the components of the musculoskeletal system interact with each other and the external world to perform work and produce movement.

- The study of movement.
Anatomic Orientation

- Anatomical position
- Planes (figure 1)
  - **Sagittal** – left & right sections
    - Extremities: flexion & extension
    - Vertebral Column: flexion & extension
  - **Fontal** – front & back sections
    - Extremities: abduction & adduction
    - Vertebral Column: right & left sidebending
  - **Transverse/Horizontal**
    - Extremities: abduction & adduction AND transverse/horizontal abduction & adduction
    - Vertebral Column: right & left rotation
Neural System

Motor unit – a motor neuron and the muscle fibers it innervates (figure A1)
  - Innervation ratio and example (Eye vs. Quad)

Proprioceptors (“feedback system”) – detect stimuli and provide movement control
  - Example (fig. A2 and A3) – GTO, Spindles
Skeletal System

- **Axial skeleton**
  - Skull, vertebral column, sternum & ribs

- **Appendicular skeleton**
  - Shoulder girdle, pelvic girdle, upper extremity & lower extremity

- **Origin**
  - The proximal (towards the center of the body) connective tissue attachment of the muscle to the bone

- **Insertion**
  - The distal (away from the center of the body) connective tissue attachment to the bone
Skeletal System cont’

Functions (figure 4)

- **Agonist**
  - muscle most directly involved in creating a movement

- **Antagonist**
  - muscle that can slow down or stop a movement

- **Synergist**
  - muscle that assists indirectly in a movement

- **Stabilizer**
  - muscle that holds a bone in position so that the involved muscles can cause the desired movement
Functional Movement

- Triplanar movement (Example)
- Muscle function
Lever Systems
(figure 5)

- **Lever**
  - Rigid object (e.g., bone)
  - Point of rotation/axis/fulcrum (e.g., joint)

- **Force**
  - **Axis**
  - **Effort**
    - tends to create the desired movement
  - **Resistive**
    - tends to oppose the desired movement

- **Lever (Moment) arms**
  - **Effort**
    - perpendicular distance from the pivot to the effort force
  - **Resistive**
    - the perpendicular distance from the pivot to the resistive force
Lever Systems cont’

Lever classification

- **First class**
  - Muscle Force (MF) and Resistance Force (RF) act on *opposite* sides of fulcrum (figure 6)
    - Advantage
    - Disadvantage

- **Second class**
  - MF and RF act on *same* side of fulcrum; RF acts at point closer to fulcrum than MF (figure 7)
    - Advantage
    - Disadvantage

- **Third class**
  - MF and RF act on *same* side of fulcrum; MF acts at point closer to fulcrum than RF (figure 8)
    - Advantage
    - Disadvantage
Lever Systems cont’

- Torque (figure A4)
  - Tendency of a force to rotate an object around a fulcrum; quantitatively force times length of it’s moment arm

- Mechanical advantage (MA)
  - Ratio of the moment arm through which an applied force acts to the distance through which a resistance force acts
    - MA greater/less than one
  - Examples
    - Elbow (Figure 9)
    - Knee (Figure 10)
    - Exercise (Figure 11)
Strength

Contributory Factors

- Neural
  - Motor unit recruitment
  - Motor unit discharge rate

- Muscular
  - Length-tension relationship (Figure 12)
  - Force-velocity (Figure 13)
  - Muscle fiber architecture
    - Elasticity (Figure 14)
      - Contractile component (CC)
      - Series elastic component (SEC)
      - Parallel elastic component (PEC)
Strength cont’

- Role of stored elastic energy (tendons)
- Muscle pennation (Figure 15)
  - Pennation angle
  - Fennation angle and force generating capacity
  - Pannation angle examples

Cross sectional area

Joint angle (Figure 16)
Strength cont’

Types of Forces

- Gravity
  - Center of gravity
- Ground reaction force
- Tension
- Compression
  - Shoulder press, Squat
- Shear (side-to-side)
  - Leg extension, Squat
- Axial loading
  - Occurs w/ tensile and compressive forces
  - Important for decreasing the risk of osteoporosis
Power

- Defined as force times velocity; rate at which work is performed
- Force-velocity
- Power-time (figure 17)
- Rate of force development
Power cont’

Applications
  - Exercise mode
    - Plyometrics
      - Elasticity
      - Neural system
  - Weightlifting
  - Speed training
    - Speed of movement relies upon:
      - power & efficient movement patterns
    - Requires significant ground forces applied quickly to run faster
    - Stretch shortening cycle
    - Speed-strength
    - Application of maximal force at high velocities
    - Types of speed training (technique, sprint-assisted & resisted sprinting)
Kinetic Chain Terminology

- Closed kinetic chain – distal end of the “chain” of joints is fixed (figure 18)
  - Multi-joint doesn’t equal closed chain

- Open kinetic chain – proximal end of the “chain” of the joints is fixed (figure 19)
Biomechanics and Exercise Prescription

Free Weight and Exercise Prescription

Kinetic chain
- Closed chain
  - Increased joint approximation and joint stability
  - Not inherently more functional
- Open chain
  - Muscle/joint isolation
- “Specific adaptation to imposed demands” principle (SAID)
- ROM
- Speed of movement
- Exercise technique
Variable Resistance Exercise Machines

Developed in an attempt to match the muscular torque to the resistance of the exercise

- “Cam” variable resistance exercise machine concept (figure 20)
  - Variable resistance arm length
  - Designed to match effort torque

- “Universal” type exercise machines (figure 21)
  - Variable effort arm length
  - Decreased mechanical advantage

- “Strive” exercise machines
  - Exercise strength curve
Variable Resistance Exercise Machines cont’

Can exercise machines balance or equate to the human strength curves?

- Mismatch for most individuals
- Exercise machines were designed for the “average” person