Anatomy and physiology
ANATOMY (Upper Body) & PROGRAM DESIGN FOR MUSCULAR FITNESS

LEARNING OBJECTIVES

1. To know the origin, insertion and line of action for the muscles of the upper body.
2. To apply knowledge of anatomy to effective exercises and be able to distinguish between the agonists, antagonists, synergists and stabilizers.
3. To apply an understanding of the advantages and disadvantages of compound versus isolation exercises in the design of resistance training programs.
4. To understand the application of general strength training guidelines in the design of programs.
5. To apply an understanding of a variety of specific resistance training principles commonly used in the design of programs.
**MUSCLE ORIGIN, INSERTION & ACTION**

**ORIGIN**: muscle attachment that moves least, generally more proximal (towards mid-line of body).

**INSERTION**: muscle attachment that moves most, generally more distal (away from mid-line of body).

**LINE OF ACTION**: An imaginary line that connects the origin to insertion and denotes the joint action(s) caused by the muscle.
Muscular Classifications

**AGONIST (prime mover):** muscle most directly involved with the movement

**ANTAGONIST:** muscle opposite to the agonist that assists in joint stabilization and can slow down or stop the intended movement

**SYNERGIST:** muscle that assists the prime mover in a movement

**STABILIZER:** muscle that stabilizes a joint; usually contracts isometrically as a joint is moved
PECTORALIS MAJOR

CLAVICULAR HEAD
- **ORIGIN**
  Clavicle, medial half (Anterior)
- **INSERTION**
  Humerus (Proximal Anterior)
  Bicipital Groove (Outer Lip)

STERNAL HEAD
- **ORIGIN**
  Sternum (Anterior)
  Ribs (2nd to 6th), Costal Cartilages
- **INSERTION**
  Humerus (Proximal Anterior)
  Bicipital Groove (Outer Lip)

**ACTION**
Shoulder:
- Flexion
- Horizontal Adduction
- Internal Rotation
PECTORALIS MINOR

**ORIGIN**
Ribs (3rd to 5th), anterior surface

**INSERTION**
Scapula (Superior Anterior)
- Coracoid Process

**ACTION**
Scapular:
- Protraction/Abduction
- Downward Rotation (During Abduction)
- Depression
The serratus anterior holds the scapula against the thoracic wall. A winged scapula condition indicates a weakness of the serratus anterior.
The anterior deltoid is involved in shoulder abduction when the shoulder is externally rotated. The anterior deltoid is weak in strict horizontal flexion but assists the pectoralis major during shoulder horizontal flexion / shoulder flexion (elbow slightly inferior to shoulders).
The lateral deltoid is involved in shoulder abduction when the shoulder is internally rotated. It is involved in shoulder flexion when the shoulder is internally rotated. It is involved in shoulder transverse abduction (shoulder externally rotated).
The posterior deltoid is the primary shoulder hyperextensor, since the latissimus dorsi does not extend the shoulder beyond anatomical position (aka hyperextension).
TRICEPS BRACHII

**ORIGIN**
Long Head [1]: lower edge of glenoid cavity of scapula
Lateral Head [2]: lateral posterior surface of humerus
Medial Head [3]: posterior surface of humerus

**INSERTION**
Ulna (Proximal Posterior) [1, 2, 3]
- Olecranon Process

**ACTIONS**
Elbow:
- Extension [1, 2, 3]
Shoulder:
- Extension [1]
- Adduction [1]
ROTATOR CUFF MUSCLES

Muscles of the Rotator Cuff:
- Subscapularis
- Supraspinatus
- Infraspinatus
- Teres Minor
**SUPRASPINATUS**

**ORIGIN**
Scapula (Superior), Supraspinous fossa

**INSERTION**
Humerus, Greater Tubercle (Superior)

**ACTION**
Shoulder:
- Abduction (initiates)
- Stabilization

Most often injured rotator cuff muscle. Inability to smoothly abduct the arm against resistance may indicate a rotator cuff injury. Avoiding full ROM (i.e. not initiating deltoid exercises from fully adducted position) may not allow Supraspinatus to be fully strengthened since it is more fully activated at these initial degrees of shoulder abduction/flexion. Once injured ROM is typically restricted on the shoulder press.

Examples of affected exercises: **Shoulder Press, Upright Row, Lateral Raise**
Example preventative / corrective exercises: **Front Lateral Raise, Lying Lateral Raise**
INFRASPINATUS

**ORIGIN**
Scapula (Medial), Infraspinous fossa

**INSERTION**
Humerus, Greater Tuberosity (Posterior)

**ACTION**
Shoulder:
- External Rotation
- Transverse Abduction
- Posterior Stability

INFRASPINATUS WEAKNESS: Second most often injured rotator cuff muscle. Examples of affected exercises with suggestions for high risk individuals:
- **Bench Press**: Bring bar lower on chest, keeping elbows closer to sides.
- **Chest Press**: Elevate seat so elbows are closer to sides.
Range of motion may need to be limited so elbows do not go behind shoulders
Example preventative / corrective exercises: **Lying External Rotation**, **Rows**
TERES MINOR

**ORIGIN**
Scapula (Lateral)
  Lateral Border
    Posterior on upper and middle part

**INSERTION**
Humerus
  Greater Tubercle (Posterior)
  Inferior Facet

**ACTION**
Shoulder:
  • External Rotation
  • Transverse Abduction
  • Posterior Stability
ORIGIN
Scapula (Anterior)
  - Subscapularis Fossa

INSERTION
Humerus (Proximal Anterior)
  - Lesser Tubercle

ACTION
Shoulder:
  • Internal Rotation
  • Anterior Stability
  • Posterior Stability
TRAPEZIUS

UPPER FIBRES

**ORIGIN**
Skull (Posterior Inferior) [1]

**INSERTION**
Clavicle, Lateral Third (Posterior) [1, 2]

MIDDLE FIBRES

**ORIGIN**
Spine, Cervical Vertebrae (C7)
Spine, Thoracic Vertebrae (T1-3)

**INSERTION**
Scapula:
- Acromion Process (Medial Border)
- Spine (Superior Border)

LOWER FIBRES

**ORIGIN**
Spine, Thoracic Vertebrae (T4-12)

**INSERTION**
Scapula, Spine (Inferior Medial)

**ACTION**
- Scapular Elevation [1, 2]
- Cervical Extension [1]
- Neck Extension, Lateral Flexion, Rotation [1]

**ACTION**
Scapula:
- Adduction
- Elevation
- Upward Rotation

**ACTION**
Scapula:
- Upper Rotation
- Adduction
- Depression
- Spine (Thoracic), weak ext.
LEVATOR SCAPULAE

**ORIGIN**
Cervical Vertebrae (Upper 3 or 4)

**INSERTION**
Scapula, Medial Border (Superior part)

**ACTION**
Scapular:
- Elevation
- Downward Rotation
- Abduction

Spine (Cervical):
- Lateral flexion right [Right Levator Scapulae]
- Lateral flexion left [Left Levator Scapulae]
- Rotation right [Right Levator Scapulae]
- Rotation left [Left Levator Scapulae]

Stabilization: The Levator Scapulae holds the scapula against the trunk.
RHOMBOIDS

**Heads**
1. Rhomboids Minor
2. Rhomboids Major

**Origin**
Spine:
Cervical Vertebrae (C7) [1]
Thoracic Vertebrae (T1 [1], T2-T5 [2])

**Insertion**
Scapula: Medial Border (Below spine)
  - Superior [1]
  - Inferior [2]

**Action**
Scapular:
Adduction [1, 2]
Downward Rotation [1, 2]

Stabilization: The Rhomboids holds the scapula against the thoracic wall.
LATISSIMUS DORSI

**ORIGIN**
Ilium, Posterior Crest
Sacrum (Posterior)
Vertebral Column
  • Lumbar Vertebrae (L1-5)
  • Thoracic Vertebrae (T7-12)
Ribs (Posterior), Lower 3 or 4 ribs

**INSERTION**
Humerus (Proximal Anterior/Medial)

**ACTION**
**Shoulder**: Adduction, Extension, Internal Rotation, Transverse Extension
**Scapula (Assists)**: Depression, Downward, Rotation, Adduction

The latissimus dorsi does not extend the shoulder beyond **anatomical position** (shoulder hyperextension). In strict **transverse extension**, the latissimus dorsi is weak. Incidentally, the **posterior deltoid** is strongly involved in both shoulder hyperextension and transverse extension.
TERES MAJOR

**ORIGIN**
Scapula (Posterior, Inferior)
• Inferior Angle (Posterior, Lateral)

**INSERTION**
Humerus (Proximal Anterior/Medial)
• Medial Lip of Intertubercular Groove

**ACTIONS**
Shoulder:
• Extension
• Internal Rotation
• Adduction
**BICEPS BRACHII**

1. LONG HEAD (Outer)
2. SHORT HEAD (Inner)

**ORIGIN**
Scapula:
- Supraglenoid Tuberosity [1]
- Coracoid Process [2]

**INSERTION**
Radius
- tubercle [1, 2]
Fascia of forearm
- Bicipital Aponeurosis [1, 2]

**ACTION**
Elbow flexion [1, 2]
Forearm supination [1, 2]
Shoulder:
- Flexion (Weak) [2]
- Transverse Flexion (Weak) [2]

The biceps brachii is a stronger elbow flexor when the radioulnar joint (forearm) is **supinated**.

During elbow flexion, motor units in the lateral portion of the long head of the biceps are preferentially activated, whereas during forearm rotation, motor units in the medial portion are preferentially activated.
The brachioradialis is a stronger elbow flexor when the radioulnar joint (forearm) is in a midposition between supination and pronation. When the forearm is pronated, the brachioradialis is more active during elbow flexion since the biceps brachii is in a mechanical disadvantage.
The brachialis becomes more readily activated during isometric elbow flexion. During a dynamic elbow flexion, the biceps is more readily activated than the brachialis.
3. FLEXOR CARPI RADIALIS

**ORIGIN:** Humerus, Medial Epicondyle

**INSERTION:** 2<sup>nd</sup> & 3<sup>rd</sup> Metacarpals

**ACTION:** Wrist Flexion & Abduction; Weak elbow flexion

4. FLEXOR CARPI ULNARIS

**ORIGIN:** Humerus on Medial Epicondyle, Ulna (Proximal Posterior)

**INSERTION:** 5th Metacarpals, Carpals (Medial)

**ACTION:** Wrist Flexion & Adduction; Weak elbow flexion

5. PALMARIS LONGUS

**ORIGIN:** Humerus, Medial Epicondyle

**INSERTION:** 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> Metacarpals

**ACTION:** Wrist Flexion; Weak elbow flexion

The Palmaris Longus is absent on one or both sides in about 21% of people.
FOREARM EXTENSORS

2. EXTENSOR CARPI RADIALIS LONGUS

**ORIGIN:** Humerus on Lateral Epicondyle

**INSERTION:** Second Metacarpal

**ACTION:** Wrist extension & abduction; Weak elbow extension

3. EXTENSOR CARPI RADIALIS BREVIS

**ORIGIN:** Humerus on Lateral Epicondyle

**INSERTION:** Third Metacarpal

**ACTION:** Wrist extension & abduction; Weak elbow extension

4. EXTENSOR CARPI ULNARIS

**ORIGIN:** Humerus on Lateral Epicondyle

**INSERTION:** Fifth Metacarpal

**ACTION:** Wrist extension & adduction; Weak elbow extension
Exercise Classifications

Primary/compound (multi-joint)
Usually involves more coordination and recruitment of many muscle groups, using heavier weight loads
Example: Bench Press

Isolation (single-joint)
Involves isolating single muscle groups, and using lower weight loads
Example: Dumbbell Chest Fly
ISOLATION VS. COMPOUND EXERCISES

**ISOLATION EXERCISES**
+ Suitable for correcting muscle imbalances
+ Specific injury rehabilitation
+ Options for working around injuries
+ Adds greater variety

- Neglects stabilizers
- Requires more time

**Does not promote:**
- Sequential muscle action
- Muscle balance
- Coordination
- Positive motivation

**COMPOUND EXERCISES**
+ Sequential muscle action
+ Muscle balance
+ Coordination
+ Positive motivation
+ Saves time

- Limited by weaker muscles
Exercise Sequence

• Exercises spaced throughout program so as to rest one area while working another

• Compound exercises precede isolation exercises requiring the same muscle

• Exercises requiring larger muscles precede exercises requiring smaller muscles

• Exercises requiring muscles closer to the mid-line precede exercises requiring muscles further from the midline

• Exercises requiring less developed muscles precede exercises requiring more developed muscles
General Guidelines for Proper Technique

- Perform proper warm-up
- Maintain a neutral spine
- Avoid using momentum; Use controlled movements
- Use full range of motion
- Breath rhythmically (positive/concentric = exhale, negative/eccentric = inhale)
- Do not use *too much* or *too little* resistance
- Train muscle groups proportionately in a balanced manner
- Train larger muscle groups before smaller
Specific Strength Training Principles & Systems

- Muscle Confusion
- Muscle Priority
- Isolation
- Flushing
- Holistic
- Split System
- Pyramiding
- Supersets

CASE STUDY PARTNER ASSIGNMENT

Design one PRT program for your case study client in Appendix A utilizing 2 different principles/systems. Please indicate which principles/systems you chose and why.
PROGRAM DESIGN FOR FLEXIBILITY

LEARNING OBJECTIVES

1. To differentiate between BALLISTIC, DYNAMIC, STATIC and PNF stretching and understand their different applications in program design.

2. To apply an understanding of flexibility training guidelines using the O.F.I.T.T. principle.

3. To understand the application of O.F.I.T.T. in the flexibility training continuum (improvement vs. maintenance vs. over-training vs. detraining)

4. To explore controversies in the application and benefits of stretching for flexibility and injury prevention.
TYPES OF STRETCHING

BALLISTIC, DYNAMIC, STATIC, PNF
TYPES OF STRETCHING
BALLISTIC, DYNAMIC, STATIC, PNF

Muscle Spindle
Monitors changes in muscle length. When spindle fibers are rapidly stretched, a stretch reflex is elicited, causing muscle to contract.

Golgi Tendon Organ (PNF Application)
Monitors changes in muscle tension. When tension in muscle becomes too great, further contraction is inhibited, and muscle relaxes.
O.F.I.T.T.
General Guidelines for Stretching

- **Objective?**
  Dependent on client’s motivation for improving ROM…specific to a certain performance, fitness and/or health standard.

- **Frequency?**
  No upper limits on number of flexibility training components per week.

- **Intensity?**
  Dependent upon 1) degree of discomfort during stretch, and 2) holding time. “Comfortably uncomfortable”

- **Time?**
  Dependent upon 4 factors: # of stretches, holding time, # of sets per stretch, rest between sets/stretch.

- **Type?**
  Only static or PNF; Stretches for each joint.
ANATOMY (Lower Body) & PROGRAM DESIGN

LEARNING OBJECTIVES

1. To know the origin, insertion and line of action for the muscles of the lower body including the GLUTES, ABDUCTORS, ADDUCTORS, QUADRICEPS, HAMSTRINGS, and CALVES.

2. To apply knowledge of anatomy to effective exercises and be able to distinguish between the agonists, antagonists, synergists and stabilizers.

3. To learn proper exercise and spotting technique and practice exercise instruction using the Seven Step Process.

4. To apply the Principles of Training and specific program design methods in the instruction and performance of mini exercise routines for different muscle groups.
Rectus abdominus controls the tilt of the pelvis and curvature of the lower spine. It also tilts pelvis forward improving the mechanical positioning of the erector spinae.
OBLIQUES

ORIGIN
External Oblique:
- Outer surface of lower ribs (8-10)
Internal Oblique:
- Iliac crest & Lumbar fascia

INSERTION
External Oblique:
- Linea alba & Iliac crest
Internal Oblique:
- Costal cartilage of ribs 8-10, xiphoid process & Linea alba

ACTION
External Oblique:
- Trunk Flexion, Twists trunk to opposite side
Internal Oblique:
- Trunk Flexion, Twists trunk to same side

1. External Oblique
2. Internal Oblique
TRANSVERSE OBDOMINUS

**ORIGIN**
Iliac Crest, Lumbar Fascia, Inguinal Ligament
Costal Cartilages of ribs 6-12

**INSERTION**
Xiphoid Process of Sternum
Linea alba
Pubic Crest via the conjoint tendon

**ACTION**
Compresses abdomen (assists with forced expiration)
Intra-abdominal pressure

The Obliques and the Transverse Abdominus increase the intra-abdominal pressure necessary for the support of the vertebral column in some exercises. With the assistance of the Rectus Abdominus and Obliques, the Tranverse Abdominus hold the abdomen flat.
**ERECTOR SPINAES**

**Heads**
1. *Iliocastalis* (Lumborum, Thoracis, Cervicis)
2. *Longissimus* (Thoracis, Cervicis, Capitis)
3. *Spinalis* (Thoracis, Cervicis, Capitis)

**ORIGIN**
Crest of Ilium, Lumbar and Thoracic vertebrae

**INSERTION**
Angles of ribs 6-12, all thoracic vertebrae, cervical vertebrae, temporal bone (mastoid process)

**ACTION**
Extension of spine
Extension of head
Hyperextension
Lateral Flexion
QUADRICEPS

Heads
1. Rectus Femoris
2. Vastus Lateralis (Externus)
3. Vastus Intermedius
4. Vastus Medialis (Internus)

ORIGIN
Ilium: Illiac Spine (Anterior Inferior)
[1]  
Femur:
   Lateral Surface [2 ]
   Anterior Surface [3 ]
   Medial Surface [4 ]

INSERTION
Tibia: Tibial Tuberosity, Patellar
Tendon [1, 2, 3, 4 ]

ACTION
Knee Extension [1, 2, 3, 4 ]
Hip Flexion [1 ]
HAMSTRINGS

**ORIGIN**
Ischium: Ischial Tuberosity [1, 3, 4]
Femur (posterior): [2]
  Linea Aspera, Lateral Condyloid Ridge

**INSERTION**
Tibia: Lateral Condyle [1, 2], Medial Condyle [3, 4]
Fibula: Head [1, 2]

**ACTION**
Knee:
Flexion [1, 2, 3, 4]
External Rotation [1, 2]
Internal Rotation [3, 4]
Hip:
Extension [1, 3, 4]

**Heads**
1. Biceps Femoris, Long Head
2. Biceps Femoris, Short Head
3. Semitendinosus
4. Semimembranosus
GLUTEUS MAXIMUS

**ORIGIN**
- Ilium, Crest (Posterior)
- Sacrum (Posterior)
- Fascia of the Lumbar Area

**INSERTION**
- Femur, Gluteal Line
- Tibia, Lateral Condyle & Iliotibial Tract

**ACTION**
- Hip:
  - Extension [1, 2]
  - External Rotation [1, 2]
  - Transverse Abduction [1, 2]
  - Adduction [2]
GLUTEUS MEDIUS

**ORIGIN**
Ilium, External Surface just below crest:
  (Anterior) [1]
  (Posterior) [2]

**INSERTION**
Femur, Greater Trochanter
  (Posterior and Lateral Surface) [1, 2]

**ACTION**
Hip:
  Abduction [1, 2]
  Transverse Abduction [1, 2]
  Internal Rotation [1]
  External Rotation (during Abduction) [2]

Steadies pelvis so it does not sag when opposite side is not supported with leg.

Heads
  1. Anterior Fibers
  2. Posterior Fibers
ORIGIN
Ilium: External Surface
(Below the origin of the Gluteus Medius)

INSERTION
Femur: Greater Trochanter (Anterior Surface)

ACTIONS
Hip:
Abduction
Transverse Abduction
Internal Rotation (during Abduction)

Assists the Gluteus Medius with pelvic stability so it does not sag when opposite side is not supported with leg.
ILIOPSOAS

**ORIGIN**
- Ilium [1]: Inner Surface
- Sacrum [1]: Base
- Vertebral Column (Lateral Surface) [2]:
  - Thoracic Vertebrae (T-12)
  - Lumbar Vertebrae (L1-5)
  - Intervertebral Discs

**INSERTION**
- Femur:
  - Lesser Trochanter [2]
    - Shaft below Lesser Trochanter [1]
- Tendon of Psoas Major & Femur [1]

**ACTION**
- Hip Flexion [1, 2]
- Spine (Thoracic & Lumbar) Rotation [2]

**Heads**
- 1. Iliacus
- 2. Psoas (Major & Minor)
SARTORIUS

**ORIGIN**
Ilium: Iliac Spine (Anterior Superior)

**INSERTION**
Tibia: Medial Condyle (Anterior)

**ACTIONS**
Hip:
- Flexion
- Abduction
- External Rotation
Knee:
- Flexion
**ORIGIN**
Pubis

**INSERTION**
Tibia (Superior), Medial surface

**ACTIONS**
Hip:
• Adduction
• Transverse Adduction
Knee:
• Flexion
ADDUCTOR BREVIS, MAGNUS, LONGUS

**ORIGIN**
Pubis [1, 2, 3]
Ischium [3]

**INSERTION**
Femur (medial):
• Lesser Trochanter [1]
• Linea Aspera [1, 2, 3]
• Medial Condyle Ridge [3]

**ACTION**
Hip:
• Adduction [1, 2, 3]
• Transverse Adduction [1, 2, 3]
• Flexion (initial) [1, 2]
• Extension [3]
• External Rotation (during adduction) [1, 3]
GASTROCNEMIUS

**ORIGIN**
Femur:
- Medial Condyle (Posterior) [1]
- Lateral Condyle (Posterior) [2]

**INSERTION**
Calcaneous, Achilles Tendon [1, 2]

**ACTION**
Ankle: Plantar Flexion [1, 2]
Knee: Flexion [1, 2]

In moderate force, *soleus* is preferentially activated in the **concentric** phase, whereas gastrocnemius is preferentially activated in the **eccentric** phase. Gastrocnemius becomes even more activated at higher lengthening velocities. During hopping, the gastrocnemius, with its greater proportion of FT motor units, is preferentially activated over soleus. During stationary cycling, gastrocnemius is also preferentially activated at higher pedaling speeds.

Although involvement of the lateral and medial heads would not seem to be altered by **medial** or **lateral rotation of the hip**, MRI research suggests "toes in" activates both heads and "toes out" activates medial head to a higher degree.
SOLEUS

ORIGIN
Tibia (Upper Posterior)
Fibula (Upper Posterior)

INSERTION
Calcaneous, Achilles Tendon

ACTION
Ankle: Plantar Flexion

In the seated calf raise (knees flexed to 90º), the gastrocs are virtually inactive while the load is borne almost entirely by the soleus.

In moderate force, the soleus is preferentially activated in the concentric phase, whereas the gastrocnemius is preferentially activated in the eccentric phase.
**TIBIALIS ANTERIOR**

**ORIGIN**
Tibia (Lateral)

**INSERTION**
Tarsal: Cuneiform (Medial)
Metatarsal (First)

**ACTION**
Ankle:
- Dorsal Flexion
- Inversion (Supination)
LEARNING OBJECTIVES

1. To understand the application of Newton’s laws of motion (i.e. inertia, acceleration, reaction) in exercise performance.
2. To understand force production relative to muscle length and position of muscle attachment.
3. To understand the factors which influence efficiency of movement.
4. To understand lever lengths relative to rotation and force production.
The Essentials of Biomechanical Concepts

- **Motion Analysis**
  (movement pattern/muscle sequence, forces, lever arms, acceleration)

- **Force** (magnitude, direction, internal, external)

- **Torque**

- **Levers**

- **Stability**
Planes of Motion

Movements occur in one of three planes of motion.

**PARTNER EXERCISE:** Determine the plane of movement for each of the exercises in Chapter 5.
LEVERS

A lever is a rigid bar that rotates about an axis.

- Rotation is caused as force is applied to the lever.
- Two types of force act upon human levers, they are:
  - Muscular force
  - Resistive force
The Lever

- **Fulcrum** is the pivot point of a lever (joint).
- **Lever Arm** is the segment of the body (arm or leg) which is being moved about the fulcrum.
- **Moment Arm** is the perpendicular distance from the applied force to the fulcrum.

<table>
<thead>
<tr>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
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<tbody>
<tr>
<td><img src="image1" alt="Image of Class 1 lever" /></td>
<td><img src="image2" alt="Image of Class 2 lever" /></td>
<td><img src="image3" alt="Image of Class 3 lever" /></td>
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</table>

lever attached to fulcrum
LEVER SYSTEMS

(a) Class I lever
(b) Class II lever
(c) Class III lever
Torque

Is the degree to which a force tends to rotate a lever about a fulcrum.

Torque = F (rotational) x D (moment arm or force arm)

**PARTNER EXERCISE:**

1. Rank the following exercises in order according to which one produces the least amount of torque about the spine to the greatest.

   BB Squat
   BB Front Squat
   Good Mornings
   Stiff-Legged Deadlift

2. In what ways could proper technique reduce torque about the spine when squatting?
FORCE APPLICATIONS

GROUP EXERCISE: Provide an example for each of the following where the force either a) contributes to the intention of the exercise/movement, or b) works against the intention of the exercise/movement.

1. Static Friction
2. Kinetic Friction
3. Elastic Force
4. Air Resistance
5. Water Resistance
PARTNER EXERCISE: Based upon the magnitude and direction of forces acting through the knee joint, rank the following versions of the lunge from the least stressful to the most stressful on the knees.

- Reverse Lunge
- Forward Lunge
- Stationary Lunge
INTERNAL FORCES

BIOMECHANICAL FACTORS AFFECTING MUSCLE FORCE

1. Length of Muscle (Optimal = 1.2x resting length)
2. Velocity of Muscle Contraction
   - Concentrically: force decreases as velocity increases
   - Eccentrically: force increases as velocity increases
3. Tendon Insertion
4. Changing Joint Angle
PARTNER EXERCISE: Choosing one body part, provide a specific exercise example for manipulating each of the following factors in order to increase force generation in the muscle:

a) Stabilizing body segments  
b) Increasing the range of motion of a particular exercise  
c) Varying the speed of muscular contraction  
d) Utilizing sequential movement  
e) Increasing distance force is applied in selection of an exercise  
f) Using strongest muscles available for a task  
g) Using all the muscles that can contribute to a task  
h) Pre-stretching a muscle just prior to contraction  
i) Pre-loading the muscle prior to the task