“It is important when learning about how the body moves (kinesiology) to also learn about the forces placed on the body that cause the movement.”

Lippert, p93
NEWTON’S LAWS OF MOTION

1. The Law of Inertia
   - An object at rest tends to stay at rest and an object in motion tends to stay in motion

2. The Law of Acceleration
   - The amount of acceleration depends on the strength of the force applied to an object.
   - Acceleration is inversely proportional to the mass of an object.
     (mass is the amount of matter that an object contains)

1. The Law of Action-Reaction
   - for every action there is an equal and opposite reaction.

http://www.youtube.com/watch?v=QffUhiX2uSg&feature=related

Lippert, p94
FORCE

• To create a force, one object must act on another.
• Force can be either a push, which creates compression, or a pull, which creates tension.
• Movement occurs if one side pushes or pulls harder than the other.
• Therefore, force is any action or influence that moves an object.
FORCE...CONTINUED

- Kinetics is the effect of forces on the human body
- Force is any action or influence that moves the body or influences the movement of the body
- Forces “control” movement of the body and can be internal or external

<table>
<thead>
<tr>
<th>Internal Forces</th>
<th>External Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle contraction</td>
<td>Gravity</td>
</tr>
<tr>
<td>Ligamentous restraint</td>
<td>Weight</td>
</tr>
<tr>
<td>Bony support</td>
<td>Friction</td>
</tr>
</tbody>
</table>

Lippert, p94
FORCE COUPLE

• A force couple occurs when two or more forces act in different directions, resulting in a turning effect.

• Example: the upper trapezius pulls superiorly and medially, the lower trapezius pulls inferiorly, and the serratus anterior pulls anteriorly. The combined effect is that the scapula rotates.

Lippert, p97
TORQUE

• Torque is the ability of force to produce rotation around an axis
• Therefore, torque can be thought of as rotary force
• The amount of torque a lever has depends on two things:
  • The amount of force exerted
  • The distance between the force and the axis of motion (this distance is called the moment arm)
• Everyday example: use of a wrench
• http://www.youtube.com/watch?v=TQT-013500w&feature=related
• Clinical Example: strengthening shoulder abductors

Lippert, p97 & Mansfield, p11
STABILITY

1. **State of Equilibrium**: when an object is balanced and all forces acting on it are even

2. **Gravity**: the mutual attraction between the earth and an object

3. **Gravitational Force**: always directed vertically downward, toward the center of the earth

4. **Center of Gravity (COG)**: the balance point of an object at which torque on all sides is equal. It is also the point at which the planes of the body intersect

5. **Base of Support (BOS)**: that part of the body that is in contact with the supporting surface

6. **Line of Gravity (LOG)**: an imaginary vertical line passing through the COG toward the center of the earth
STABILITY...CONTINUED

The following principles demonstrate the relationships between balance, stability, and motion:

1. The lower the COG, the more stable the object
2. The COG and LOG must remain within the BOS for an object to remain stable
3. The wider the BOS, the more stable the object
4. The greater the mass of an object, the greater the stability.
5. The greater the friction between the supporting surface and the BOS, the more stable the body will be.
6. People have better balance while moving if they focus on a stationary object rather than on a moving object.

http://www.youtube.com/watch?v=BYa8MwLmb3k

Lippert, p101
BIOMECHANICAL LEVERS

Levers

1. The interaction between internal and external forces ultimately controls our movement.

2. These forces interact through a system of bony levers, with the pivot point located at the axis of rotation of our joints.

3. Through these systems of levers, the internal and external forces are converted to internal and external torques, which ultimately cause movement (or rotation) of our joints.
Levers...continued

1. There are 3 classes of levers, each with a different purpose and mechanical advantage.
2. A lever will either favor power or distance (ROM), but not both.
3. Any advantage gained in power is lost in distance and vice versa.
BIOMECHANICAL LEVERS...CONTINUED

Levers...continued

1. To understand the structure and function of levers, you should be familiar with certain terms:

2. **Lever**: rigid and can rotate around a fixed point (axis) when a force is applied

3. **Axis (A)**: the fixed point around which the lever rotates (in the body, the joint is the axis)

4. **Force (F)**: causes the lever to move (usually a muscle)

5. **Resistance (R)**: the load that must be overcome for motion to occur (can include the weight of the body part being moved, the pull of gravity on that body part, or an external weight)

6. **Force Arm (FA)**: the distance between the force and the axis

7. **Resistance Arm (RA)**: the distance between the resistance and the axis

Lippert, p102-103
Levers...continued

1. The arrangement of the axis (A) in relation to the force (F) and the resistance ® determines the **TYPE** of lever.

2. The longer the FA, the easier it is to move the part.

3. The longer the RA, the harder it is to move the part.

4. Remember, there is always a trade-off.

5. With a longer FA, the part will be easier to move, but the FA will have to move a greater distance.

6. With a longer RA, it won’t have to move as far, but it will be harder to move.
Classes of Levers:
1. First class lever
2. Second class lever
3. Third class lever
BIOMECHANICAL LEVERS...CONTINUED

First Class Levers

• The axis if located between the force and resistance
• Just like a seesaw!

Lippert, p103
BIOMECHANICAL LEVERS...CONTINUED

Second Class Levers

• The resistance is located between the axis and the force
• Just like a wheelbarrow!

Lippert, p104
BIOMECHANICAL LEVERS...CONTINUED

Third Class Levers

- The force is located between the axis and resistance
- Imagine someone moving one end of a boat away from a dock while the front of the boat is tied to the dock!

Lippert, p104
BIOMECHANICAL LEVERS...CONTINUED

First Class Lever

Second Class Lever

Third Class Lever
There are many applications of leverage in rehabilitation and exercise science. Can you think of one (or two)??
PULLEYS

1. A pulley consists of a grooved wheel that turns on an axle with a rope or cable riding in the groove

2. Its purpose is to either change the direction of force or to change the magnitude of the force

3. Everyday Example:

4. Clinical Example:
LINE OF PULL

• A muscle’s line of pull, sometimes called the line of force, describes the direction of muscular force

• The relationship between a muscle’s line of pull and the axis of rotation of a joint determines the action that the muscle produces

• This knowledge allows you to figure out the various actions of any muscle in the body, instead of relying on memorization
LINE OF PULL...CONTINUED

Line of pull about a medial-lateral axis of rotation

1. Muscles with a line of pull anterior to the medial-lateral axis of rotation of a joint will produce flexion in the sagittal plane (anterior deltoid).

2. A line of pull that courses posterior to the medial-lateral axis of rotation, such as the posterior deltoid, produces extension in the sagittal plane.
LINE OF PULL ABOUT A MEDIAL-LATERAL AXIS OF ROTATION

Figure 1-30 Lines of pull about a medial-lateral axis of rotation producing the sagittal plane motions of (A) flexion and (B) extension.
LINE OF PULL...CONTINUED

Line of pull about an anterior-posterior axis of rotation

1. Muscles with a line of pull passing superior or lateral to the anterior-posterior axis of rotation at a joint will produce abduction in the frontal plane (middle deltoid)

2. A muscle such as the teres major has a line of pull that courses inferior and medially relative to the anterior-posterior axis of rotation. This line of pull produces adduction in the frontal plane.

Mansfield, p15
LINE OF PULL ABOUT AN ANTERIOR-POSTERIOR AXIS OF ROTATION

Figure 1-31 Lines of pull about an anterior-posterior axis of rotation producing the frontal plane motions of (A) abduction and (B) adduction.

Mansfield, p16-17
LINE OF PULL...CONTINUED

Line of pull about a vertical axis of rotation

1. The anterior deltoid produces internal rotation about a vertical axis.

2. The posterior deltoid has a line of pull that produces external rotation of the shoulder.
LINE OF PULL ABOUT A VERTICAL AXIS OF ROTATION

Figure 1-32 Lines of pull about a vertical axis of rotation producing the horizontal plane motions of (A) internal rotation and (B) external rotation.
REFERENCES
