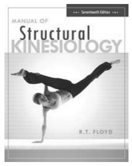

Chapter 3
Basic Biomechanical Factors & Concepts

Manual of Structural Kinesiology

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Biomechanics

- *Biomechanics* - study of the mechanics as it relates to the functional and anatomical analysis of biological systems and especially humans
  - Necessary to study the body's mechanical characteristics & principles to understand its movements

Biomechanics

- *Mechanics* - study of physical actions of forces
- Mechanics is divided into
  - *Statics*
  - *Dynamics*

Biomechanics

- Statics - study of systems that are in a constant state of motion, whether at rest with no motion or moving at a constant velocity without acceleration
  - Statics involves all forces acting on the body being in balance resulting in the body being in equilibrium

Biomechanics

- Dynamics - study of systems in motion with acceleration
  - A system in acceleration is unbalanced due to unequal forces acting on the body

Biomechanics

- *Kinematics* & *kinetics*
  - Kinematics - description of motion and includes consideration of time, displacement, velocity, acceleration, and space factors of a system's motion
  - Kinetics - study of forces associated with the motion of a body

Types of machines found in the body

- Mechanical advantage
  - Load/effort or load divided by effort
  - Ideally using a relatively small force, or effort to move a much greater resistance
- Musculoskeletal system may be thought of as a series of simple machines
  - Machines - used to increase mechanical advantage
  - Consider mechanical aspect of each component in analysis with respect to components' machine-like function

Types of machines found in the body

- Machines function in four ways
  - balance multiple forces
  - enhance force in an attempt to reduce total force needed to overcome a resistance
  - enhance range of motion & speed of movement so that resistance may be moved further or faster than applied force
  - alter resulting direction of the applied force

Types of machines found in the body

- Musculoskeletel system arrangement provides for 3 types of machines in producing movement
  - Levers (most common)
  - Wheel-axles
  - Pulleys
- Machine types not found in the body
  - Inclined plane
  - Screw
  - Wedge

Levers

- Humans moves through a system of levers
- Levers cannot be changed, but they can be utilized more efficiently
  - lever - a rigid bar that turns about an *axis* of rotation or a fulcrum
  - axis - point of rotation about which lever moves

Levers

- Levers rotate about an axis as a result of *force* (effort, *E)* being applied to cause its movement against a *resistance* or weight
- In the body
  - bones represent the bars
  - joints are the axes
  - muscles contract to apply force

Levers

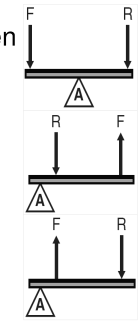
- Resistance can vary from maximal to minimal
  - May be only the bones or weight of body segment
- All lever systems have each of these three components in one of three possible arrangements

Levers

- Three points determine type of lever & for which kind of motion it is best suited
  - Axis *(A)*- fulcrum - the point of rotation
  - Point *(F)* of force application (usually muscle insertion) - effort
  - Point *(R)* of resistance application (center of gravity of lever) or (location of an external resistance)

Levers

- 1st class lever – axis *(A)* between force *(F)* & resistance *(R)*
- 2nd class lever – resistance *(R)* between axis *(A)* & force *(F)*
- 3rd class lever – force *(F)* between axis *(A)* & resistance *(R)*



Levers

- *FAR 1st* — | Force Arm || Resistance Arm | — F, A, R
- *ARF 2nd* — | Resistance Arm | ; | Force Arm | — A, R, F
- *AFR 3rd* — | Force Arm | ; | Resistance Arm | — A, F, R

Levers

- The mechanical advantage of levers may be determined using the following equations:

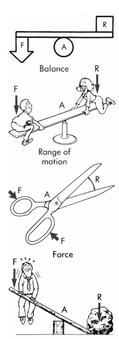
Mechanical advantage = $\frac{\text{Resistance}}{\text{Force}}$

or

Mechanical advantage = $\frac{\text{Length of force arm}}{\text{Length of resistance arm}}$

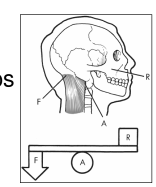
First-class Levers

- Produce balanced movements when axis is midway between force & resistance (e.g., seesaw)
- Produce speed & range of motion when axis is close to force, (triceps in elbow extension)
- Produce force motion when axis is close to resistance (crowbar)



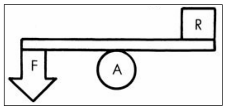
First-class Levers

- Head balanced on neck in flexing/extending
- Agonist & antagonist muscle groups are contracting simultaneously on either side of a joint axis
  - agonist produces force while antagonist supplies resistance



First-class Levers

- Elbow extension in triceps applying force to olecranon *(F)* in extending the non-supported forearm *(R)* at the elbow *(A)*



First-class Levers

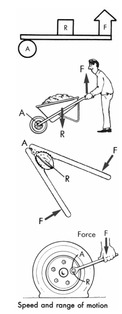
- Force is applied where muscle inserts in bone, not in belly of muscle
  - Ex. in elbow extension with shoulder fully flexed & arm beside the ear, the triceps applies force to the olecranon of ulna behind the axis of elbow joint
  - As the applied force exceeds the amount of forearm resistance, the elbow extends

First-class Levers

- Change example by placing the hand on the floor (as in a push-up) to push the body away from the floor, the same muscle action at this joint now changes the lever to 2nd class due to the axis being at the hand and the resistance is body weight at the elbow joint

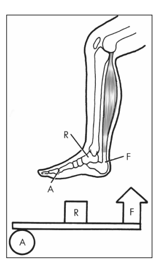
Second-class Levers

- Produces force movements, since a large resistance can be moved by a relatively small force
  - Wheelbarrow
  - Nutcracker
  - Loosening a lug nut
  - Raising the body up on the toes



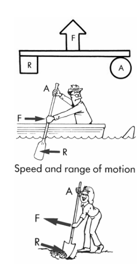
Second-class Levers

- Plantar flexion of foot to raise the body up on the toes where ball (A) of the foot serves as the axis as ankle plantar flexors apply force to the calcaneus (F) to lift the resistance of the body at the tibial articulation (R) with the foot
- Relatively few 2nd class levers in body



Third-class Levers

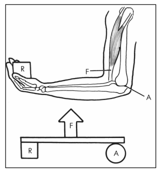
- Produce speed & range-of-motion movements
- Most common in human body
- Requires a great deal of force to move even a small resistance
  - Paddling a boat
  - Shoveling - application of lifting force to a shovel handle with lower hand while upper hand on shovel handle serves as axis of rotation



Third-class Levers

- Biceps brachii in elbow flexion

  Using the elbow joint (A) as the axis, the biceps brachii applies force at its insertion on radial tuberosity (F) to rotate forearm up, with its center of gravity (R) serving as the point of resistance application



Third-class Levers

- Brachialis - true 3rd class leverage
  - pulls on ulna just below elbow
  - pull is direct & true since ulna cannot rotate
- Biceps brachii supinates forearm as it flexes so its 3rd class leverage applies to flexion only
- Other examples
  - hamstrings contracting to flex leg at knee while in a standing position
  - using iliopsoas to flex thigh at hip

Factors in use of anatomical levers

- Anatomical leverage system can be used to gain a mechanical advantage
- Improve simple or complex physical movements
- Some habitually use human levers properly
- Some develop habits of improperly using human levers

Torque and length of lever arms

- *Torque* – (moment of force) the turning effect of an eccentric force
- *Eccentric force* - force applied in a direction not in line with the center of rotation of an object with a fixed axis
  - In objects without a fixed axis it is an applied force that is not in line with object's center of gravity
- For rotation to occur an eccentric force must be applied

Torque and length of lever arms

- In humans, contracting muscle applies an eccentric force (not to be confused with eccentric contraction) to bone upon which it attaches & causes the bone to rotate about an axis at the joint
- Amount of torque is determined by multiplying amount of force (*force magnitude*) by *force arm*

Torque and length of lever arms

- Force arm - perpendicular distance between location of force application & axis
  - a.k.a. moment arm or torque arm
  - shortest distance from axis of rotation to the line of action of the force
  - the greater the distance of force arm, the more torque produced by the force

Torque and length of lever arms

- Often, we purposely increase force arm length in order to increase torque so that we can more easily move a relatively large resistance (increasing our leverage)
- *Resistance arm* - distance between the axis and the point of resistance application

Torque and length of lever arms

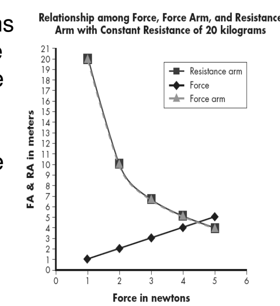
- Inverse relationship between length of the two lever arms
  - Between force & force arm
  - Between resistance & resistance arm
  - The longer the force arm, the less force required to move the lever if the resistance & resistance arm remain constant
  - Shortening the resistance arm allows a greater resistance to be moved if force & force arm remain constant

Torque and length of lever arms

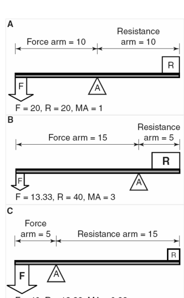
- Proportional relationship between force components & resistance components
  - If either of the resistance components increase, there must be an increase in one or both of force components
  - Greater resistance or resistance arm requires greater force or longer force arm
  - Greater force or force arm allows a greater amount of resistance to be moved or a longer resistance arm to be used

Torque and length of lever arms

- Even slight variations in the location of the force and resistance are important in determining the effective force of the muscle

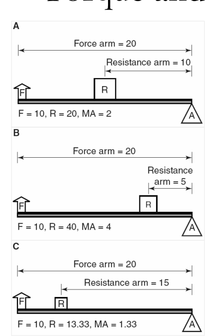


Torque and length of lever arms



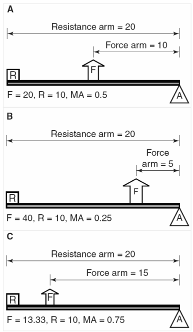
First class levers
A, If the force arm & resistance arm are equal in length, a force equal to the resistance is required to balance it; **B,** As the force arm becomes longer, a decreasing amount of force is required to move a relatively larger resistance; **C,** As the force arm becomes shorter, an increasing amount of force is required to move a relatively smaller resistance

Torque and length of lever arms



Second class levers
A, Placing the resistance halfway between the axis & the point of force application provides a MA of 2; **B,** Moving the resistance closer to the axis increases the MA, but decreases the distance that the resistance is moved; **C,** the closer the resistance is positioned to the point of force application the less of a MA, but the greater the distance it is moved

Torque and length of lever arms

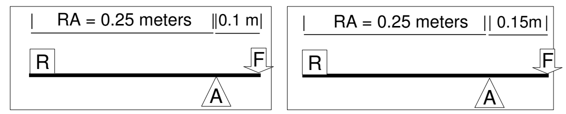


Third class levers
A, a force greater than the resistance, regardless of the point of force application, is required due to the resistance arm always being longer;
B, Moving the point of force application closer to the axis increases the range of motion & speed;
C, Moving the point of force application closer to the resistance decreases the force needed

Torque and length of lever arms

A 0.05 meter increase in insertion results in a substantial reduction in the force necessary to move the resistance

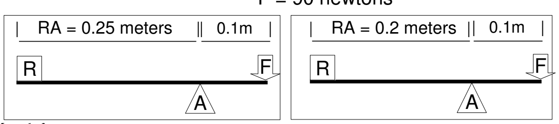
EXAMPLE: biceps curl
F x FA = R x RA
(force) x (force arm) = (resistance) x (resistance arm)
F x 0.1 meters = 45 newtons x 0.25 meters
F = 112.5 newtons
Increase insertion by 0.05 meters
F x 0.15 meters = 45 newtons x 0.25 meters
F x 0.15 meters = 11.25 newton-meters
F = 75 newtons



Torque and length of lever arms

A 0.05 meter reduction in resistance arm can reduce the force necessary to move the resistance

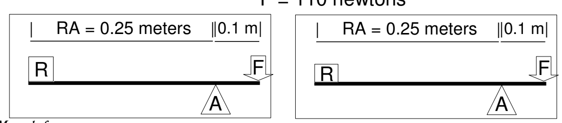
EXAMPLE: biceps curl
F x FA = R x RA
(force) x (force arm) = (resistance) x (resistance arm)
F x 0.1 meters = 45 newtons x 0.25 meters
F = 112.5 newtons
Decrease resistance arm by 0.05 meters
F x 0.1 meters = 45 newtons x 0.2 meters
F x 0.1 meters = 9 newton-meters
F = 90 newtons



Torque and length of lever arms

Reducing resistance reduces the amount of force needed to move the lever

EXAMPLE: biceps curl
F x FA = R x RA
(force) x (force arm) = (resistance) x (resistance arm)
F x 0.1 meters = 45 newtons x 0.25 meters
F = 112.5 newtons
Decrease resistance by 1 Newton
F x 0.1 meters = 44 newtons x 0.25 meter
F x 0.1 meters = 11 newton-meters
F = 110 newtons



Torque and length of lever arms

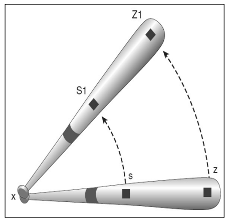
- Human leverage system is built for speed & range of movement at expense of force
- Short force arms & long resistance arms require great muscular strength to produce movement
- Ex. biceps & triceps attachments
  - biceps force arm is 1 to 2 inches
  - triceps force arm less than 1 inch

Torque and length of lever arms

- Human leverage for sport skills requires several levers
  - throwing a ball involves levers at shoulder, elbow & wrist joints
- The longer the lever, the more effective it is in imparting velocity
  - A tennis player can hit a tennis ball harder with a straight-arm drive than with a bent elbow because the lever (including the racket) is longer & moves at a faster speed

Torque and length of lever arms

- Long levers produce more linear force and thus better performance in some sports such as baseball, hockey, golf, field hockey, etc.



Torque and length of lever arms

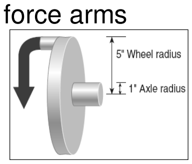
- For quickness, it is desirable to have a short lever arm
  - baseball catcher brings his hand back to his ear to secure a quick throw
  - sprinter shortens his knee lever through flexion that he almost catches his spikes in his gluteal muscles

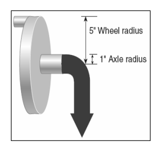
Wheels and axles

- Used primarily to enhance range of motion & speed of movement in the musculoskeletal system
  - function essentially as a form of a lever
- When either the wheel or axle turn, the other must turn as well
  - Both complete one turn at the same time

Wheels and axles

- Center of the wheel & the axle both correspond to the fulcrum
- Both the radius of the wheel & the radius of the axle correspond to the force arms





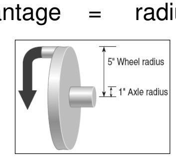
Wheels and axles

- If the wheel radius is greater than the radius of the axle, then, due to the longer force arm, the wheel has a mechanical advantage over the axle
  - a relatively smaller force may be applied to the wheel to move a relatively greater resistance applied to the axle
  - if the radius of the wheel is 5 times the radius of the axle, then the wheel has a 5 to 1 mechanical advantage over the axle

Wheels and axles

- calculate mechanical advantage of a wheel & axle by considering the radius of the wheel over the axle

$$\text{Mechanical advantage} = \frac{\text{radius of the wheel}}{\text{radius of the axle}}$$



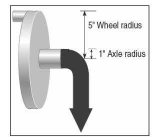
Wheels and axles

- If application of force is reversed and applied to the axle, then the mechanical advantage results from the wheel turning a greater distance & speed
  - if the radius of the wheel is 5 times the radius of the axle, then outside of the wheel will turn at a speed 5 times that of the axle
  - the distance that the outside of the wheel turns will be 5 times that of the outside of the axle

Wheels and axles

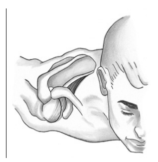
- Calculate the mechanical advantage for this example by considering the radius of the wheel over the axle

$$\text{Mechanical advantage} = \frac{\text{radius of the axle}}{\text{radius of the wheel}}$$



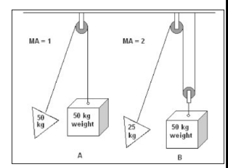
Wheels and axles

- Ex. resulting in greater range of motion & speed is with upper extremity in internal rotators attaching to humerus
  - humerus acts as the axle
  - hand & wrist are located at the outside of the wheel when elbow is flexed 90 degrees
  - with minimal humerus rotation, the hand & wrist travel a great distance
  - allows us significantly increase the speed at which we can throw objects



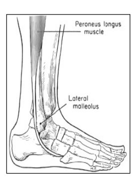
Pulleys

- Single pulleys function to change effective direction of force application
  - Mechanical advantage = 1
- Pulleys may be combined to form compound pulleys to increase mechanical advantage
  - Each additional rope increases mechanical advantage by 1



Pulleys

- Ex. lateral malleolus acting as a pulley around which tendon of peroneus longus runs
  - As peroneus longus contracts, it pulls toward it belly (toward the knee)
  - Using the lateral malleolus as a pulley, force is transmitted to plantar aspect of foot resulting in eversion/plantarflexion



Laws of motion and physical activities

- Body motion is produced or started by some action of muscular system
- Motion cannot occur without a force
- Muscular system is source of force in humans
- Two types of motion
  - *linear motion*
  - *angular motion*

Laws of motion and physical activities

- Linear motion (translatory motion) - motion along a line
  - *rectilinear* motion - motion along a straight line
  - *curvilinear* motion - motion along a curved line
- *Linear displacement* - distance that a system moves in a straight line

Laws of motion and physical activities

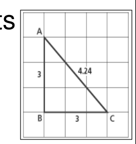
- Angular motion (rotary motion) - rotation around an axis
  - In the body, the axis of rotation is provided by the various joints
- Linear & angular motion are related
  - angular motion of the joints produces the linear motion of walking

Laws of motion and physical activities

- Sports ex. - cumulative angular motion of the joints imparts linear motion to a thrown object (ball, shot) or to an object struck with an instrument (bat, racket)

Laws of motion and physical activities

- *Displacement* - actual distance that the object has been displaced from its original point of reference
- *Distance* - actual sum length of measurement traveled
  - object may have traveled a distance of 10 meters along a linear path in two or more directions but only be displaced from its original reference point by 6 meters



Laws of motion and physical activities

- *Angular displacement* - change in location of a rotating body
- *Linear displacement* - distance that a system moves in a straight line
- *Speed* - how fast an object is moving or distance that an object moves in a specific amount of time
- *Velocity* - includes the direction & describes the rate of displacement

Laws of motion and physical activities

- Newton's laws of motion have many applications to physical education activities and sports

Law of Inertia

- **A body in motion tends to remain in motion at the same speed in a straight line unless acted on by a force; a body at rest tends to remain at rest unless acted on by a force**
- Muscles produce force to start, stop, accelerate, decelerate & change the direction of motion

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Law of Inertia

- *Inertia* - resistance to action or change
  - In human movement, inertia refers to resistance to acceleration or deceleration
  - tendency for the current state of motion to be maintained, regardless of whether the body segment is moving at a particular velocity or is motionless
  - the reluctance to change status; only force can change status

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Law of Inertia

- The greater an object's mass, the greater its inertia
  - the greater the mass, the more force needed to significantly change an object's inertia
- Examples
  - Sprinter in starting blocks must apply considerable force to overcome his resting inertia
  - Runner on an indoor track must apply considerable force to overcome moving inertia & stop before hitting the wall
  - Thrown or struck balls require force to stop them

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Law of Inertia

- Force is required to change inertia
  - Any activity carried out at a steady pace in a consistent direction will conserve energy
  - Any irregularly paced or directed activity will be very costly to energy reserves
  - Ex. handball & basketball are so much more fatiguing than jogging or dancing

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Law of Acceleration

- **A change in the acceleration of a body occurs in the same direction as the force that caused it. The change in acceleration is directly proportional to the force causing it and inversely proportional to the mass of the body.**

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Law of Acceleration

- *Acceleration* - the rate of change in velocity
  - To attain speed in moving the body, a strong muscular force is generally necessary
- Mass - the amount of matter in the body
  - affects the speed & acceleration in physical movements

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Law of Acceleration

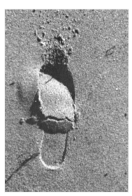
- A much greater force is required from the muscles to accelerate a 230-pound man than than to accelerate a 130-pound man to the same running speed
- A baseball maybe accelerated faster than a shot because of the difference in weight
- The force required to run at half speed is less than the force required to run at top speed
- To impart speed to a ball or an object, the body part holding the object must be rapidly accelerated

Law of Reaction

- **For every action there is an opposite and equal reaction.**
  - As we place force on a surface by walking over it, the surface provides an equal resistance back in the opposite direction to the soles of our feet
  - Our feet push down & back, while the surface pushes up & forward
- Force of the surface reacting to the force we place on it is *ground reaction force*

Law of Reaction

- We provide the action force while the surface provides the reaction force
  - easier to run on a hard track than on a sandy beach due to the difference in the ground reaction forces of the two surfaces
  - track resists the runner's propulsion force, and the reaction drives the runner ahead



Law of Reaction

- sand dissipates the runner's force reducing the reaction force with the apparent loss in forward force & speed
- sprinter applies a force in excess of 300 pounds on his starting blocks, which resist with an equal force
- in flight, movement of one part of the body produces a reaction in another part because there is no resistive surface to supply a reaction force

Friction

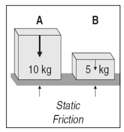
- *Friction* - force that results from the resistance between surfaces of two objects from moving upon one another
  - Depending increased or decreased friction may be desired
  - To run, we depend upon friction forces between our feet & the ground so that we may exert force against the ground & propel ourselves forward

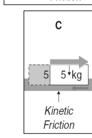
Friction

- With slick ground or shoe surface friction is reduced & we are more likely to slip
- In skating, we desire decreased friction so that we may slide across the ice with less resistance

Friction

- Static friction or kinetic friction
  - *Static friction* - the amount of friction between two objects that have not yet begun to move
  - *Kinetic friction* - friction occurring between two objects that are sliding upon one another





Friction

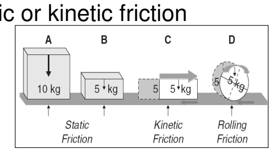
- Static friction is always greater than kinetic friction
  - It is always more difficult to initiate dragging an object across a surface than to continue dragging
  - Static friction may be increased by increasing the normal or perpendicular forces pressing the two objects together such as in adding more weight to one object sitting on the other object

Friction

- To determine the amount of friction forces consider both forces pressing the two objects together & the *coefficient of friction*
  - depends upon the hardness & roughness of the surface textures
- Coefficient of friction - ratio between force needed to overcome the friction over the force holding the surfaces together

Friction

- *Rolling friction* - resistance to an object rolling across a surface such as a ball rolling across a court or a tire rolling across the ground
  - Rolling friction is always much less than static or kinetic friction



Balance, equilibrium, & stability

- *Balance* - ability to control equilibrium, either static or dynamic
- *Equilibrium* - state of zero acceleration where there is no change in the speed or direction of the body
  - static or dynamic
- *Static equilibrium* - body is at rest or completely motionless

Balance, equilibrium, & stability

- *Dynamic equilibrium* - all applied & inertial forces acting on the moving body are in balance, resulting in movement with unchanging speed or direction
- To control equilibrium & achieve balance, *stability* needs to be maximized
- Stability is the resistance to a
  - change in the body's acceleration
  - disturbance of the body's equilibrium

Balance, equilibrium, & stability

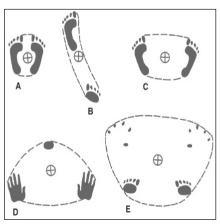
- Stability is enhanced by determining body's *center of gravity* & appropriately changing it
- Center of gravity - point at which all of body's mass & weight are equally balanced or equally distributed in all directions
- Balance - important in resting & moving bodies

Balance, equilibrium, & stability

- Generally, balance is desired
- Some circumstances exist where movement is improved when the body tends to be unbalance

Balance, equilibrium, & stability

- General factors applicable to enhancing equilibrium, maximizing stability, & ultimately achieving balance:
  1. A person has balance when the center of gravity falls within the base of support



Balance, equilibrium, & stability

2. A person has balance in the direct proportion to the size of the base
   - The larger the base of support, the more balance
3. A person has balance depending on the weight (mass)
   - The greater the weight, the more balance
4. A person has balance, depending on the height of the center of gravity
   - The lower the center of gravity, the more balance

Balance, equilibrium, & stability

5. A person has balance, depending on where the center of gravity is in relation to the base of support
   - Balance is less if the center of gravity is near the edge of the base
   - When anticipating an oncoming force, stability may be improved by placing the center of gravity nearer the side of the base of support expected to receive the force

Balance, equilibrium, & stability

6. In anticipation of an oncoming force, stability may be increased by enlarging the size of the base of support in the direction of the anticipated force
7. Equilibrium may be enhanced by increasing the friction between the body & the surfaces it contacts
8. Rotation about an axis aids balance
   A moving bike is easier to balance than a stationary bike

Balance, equilibrium, & stability

9. Kinesthetic physiological functions contribute to balance
   - The semicircular canals of the inner ear, vision, touch (pressure) & kinesthetic sense all provide balance information to the performer
   - Balance and its components of equilibrium and stability are essential in all movements and are all affected by the constant force of gravity as well as by inertia

Balance, equilibrium, & stability

- In walking a person throws the body in and out of balance with each step
- In rapid running movements where moving inertia is high, the center of gravity has to be lowered to maintain balance when stopping or changing direction
- In jumping activities the center of gravity needs to be raised as high as possible

Force

- Muscles are the main source of force that produces or changes movement of a body segment, the entire body, or some object thrown, struck, or stopped
- Strong muscles are able to produce more force than weak muscles
  - both maximum and sustained exertion over a period of time

Force

- *Forces* either push or pull on an object in an attempt to affect motion or shape
- Without forces acting on an object there would be no motion
- Force - product of mass times acceleration
- Mass - amount of matter in a body

Force

- The weight of a body segment or the entire body X the speed of acceleration determines the force
  - Important in football
  - Also important in activities using only a part of the body
  - In throwing a ball, the force applied to the ball is equal to the weight of the arm times the speed of acceleration of the arm
  - Leverage factors are also important

Force

Force = mass x acceleration

F = M x A

- *Momentum (*quantity of motion) - equal to mass times velocity
- The greater the momentum, the greater the resistance to change in the inertia or state of motion
- Momentum may be altered by *impulse*, which is the product of force and time

Force

- Many activities, particularly upper extremity, require a summation of forces from the beginning of movement in the lower segment of the body to the twisting of the trunk and movement at the shoulder, elbow, and wrist joints
- Ex. golf drive, shot-putting, discus and javelin throwing

Mechanical loading basics

- Significant mechanical loads are generated & absorbed by the tissues of the body
- Internal or external forces may cause these loads
- Only muscles can actively generate internal force, but tension in tendons, connective tissues, ligaments and joints capsules may generate passive internal forces

Mechanical loading basics

- External forces are produced from outside the body & originate from gravity, inertia or direct contact
- All tissues, in varying degrees, resist changes in their shape
- Tissue deformation may result from external forces, but can result from internally generated forces

Mechanical loading basics

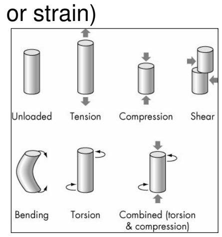
- Internal forces can
  - fracture bones
  - dislocate joints
  - disrupt muscles & connective tissues
- To prevent injury or damage from tissue deformation the body must be used to absorb energy from both internal & external forces

Mechanical loading basics

- It is advantageous to absorb force over larger aspects of our body rather than smaller and to spread the absorption rate over a greater period of time
- Stronger & healthier tissues are more likely to withstand excessive mechanical loading & the resultant excessive tissue deformation

Mechanical loading basics

- Excessive tissue deformation due to mechanical loading may result from
  - Tension (stretching or strain)
  - Compression
  - Shear
  - Bending
  - Torsion (twisting)



Functional application

- In the performance of various sport skills such as throwing, many applications of the laws of leverage, motion and balance may be found
- In throwing, the angular motion of the levers (bones) of the body (trunk, shoulder, elbow and wrist) is used to give linear motion to the ball when it is released

Functional application

- In throwing, the individual's inertia & the ball's inertia must be overcome by the application of force *(Law of inertia)*
- Muscles of the body provide the force to move the body parts & the ball
- *Law of acceleration* is in effect with the muscular force necessary to accelerate the arm, wrist, & hand

Functional application

- The greater the force (mass X acceleration) that a person can produce, the faster the arm will move, and thus the greater the speed that will be imparted to the ball
- The reaction of the feet against the surface on which the subject stands applies the *law of reaction*

Functional application

- The longer the lever, the greater the speed that can be imparted to the ball
  - The body from the feet to the fingers can be considered as one long lever
  - The longer the lever, from natural body length or the body movements to the extended backward position, the greater will be the arc through which it accelerates and thus the greater the speed imparted to the thrown object

Functional application

- Short levers are advantageous in taking less total time to release the ball
- Balance or equilibrium is a factor in throwing when the body is rotated posteriorly in the beginning of the throw
  - the body is moved nearly out of balance to the rear,
  - balance changes again with the forward movement
  - balance is reestablished with the follow-through when the feet are spread and the knees & trunk are flexed to lower the center of gravity

Web Sites

Biomechanics: The Magazine of Body Movement and Medicine
www.biomech.com/
Biomechanics World Wide
www.uni-essen.de/~qpd800/WSITECOPY.html
- This site enables the reader to search the biomechanics journals for recent information regarding mechanism of injury.

Kinesiology Biomechanics Classes
www.uoregon.edu/~karduna/biomechanics/kinesiology.htm
- A listing of numerous biomechanics and kinesiology class site on the web with many downloadable presentations and notes

Orthopaedic Biomechanics
www.orthobiomech.info/index.htm
- Numerous text and graphics on biomechanics in orthopaedics

Web Sites

The Physics Classroom

Http://www.glenbrook.k12.il.us/gbssci/phys/Class/BBoard.html

– Numerous topics including the laws of motion and other physics principles

Edquest

www.edquest.ca/pdf/sia84notes.pdf

– Text, pictures, and illustrations on simple and complex machines

COSI Hands-on science centers

www.cosi.org/files/Flash/simpMach/sm1.swf

A Flash site demonstrating simple machine explanations

EuclideanSpace - building a 3D world

www.euclideanspace.com

– Information on how to simulate physical objects with computer programs

Web Sites

Physics Homework Help

http://tutor4physics.com/index.htm

– Physics formulas, principles, tutorials

GRD Training Corporation

www.physchem.co.za/Motion

– Explanations of physics principles for in motion with quizzes

International Society of Biomechanics

www.isbweb.org/

– Software, data, information, resources, yellow pages, conferences.

James Madison Memorial High School

www.madison.k12.wi.us/jmm/isp/U7PDF08.pdf

– A pdf file explaining the six types of simple machines

Optusnet.com

www.members.optusnet.com.au/ncrick/converters/moment.html

– Conversion formulas for physics variables

Web Sites

Sports Coach—Levers

www.brianmac.demon.co.uk/levers.htm

– A basic review of levers with excellent links to the study of muscle training & function.

Integrated Publishing

www.tpub.com/content/engine/14037/index.htm

– Engine mechanics