

Balance, Equilibrium, & Stability

Kinesiology
RHS 341
Lecture **9**
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Definitions

- **Balance** = the ability to control equilibrium (either static or dynamic)
- **Equilibrium** = a state of zero acceleration where there is no change in the speed or direction of the body

Equilibrium

- **Static equilibrium** = when the body is at rest or completely *motionless*
- **Dynamic equilibrium** = when all the applied & inertial forces acting on the moving body are in balance, resulting in movement with unchanging *speed & direction*



Equilibrium

- An essential feature of all movement is the need to keep the body in stable ***equilibrium***, so that we do not fall over while the body is changing its position

Definitions

- **Stability** = the resistance to a change in the body's acceleration, or the resistance to a disturbance of the body's equilibrium

Stability

- Maximize ***stability*** 
control ***equilibrium*** 
achieve ***balance***
- Stability can be enhanced by determining the body's ***center of gravity*** and changing its position appropriately

Definitions

- **Gravity:**
 - Constant downward force
 - Acting at the center of a body segment
 - External force (acting outside the body)

Definitions

- **Center of gravity (COG)** = the point at which all of the body's mass (weight) is equally balanced

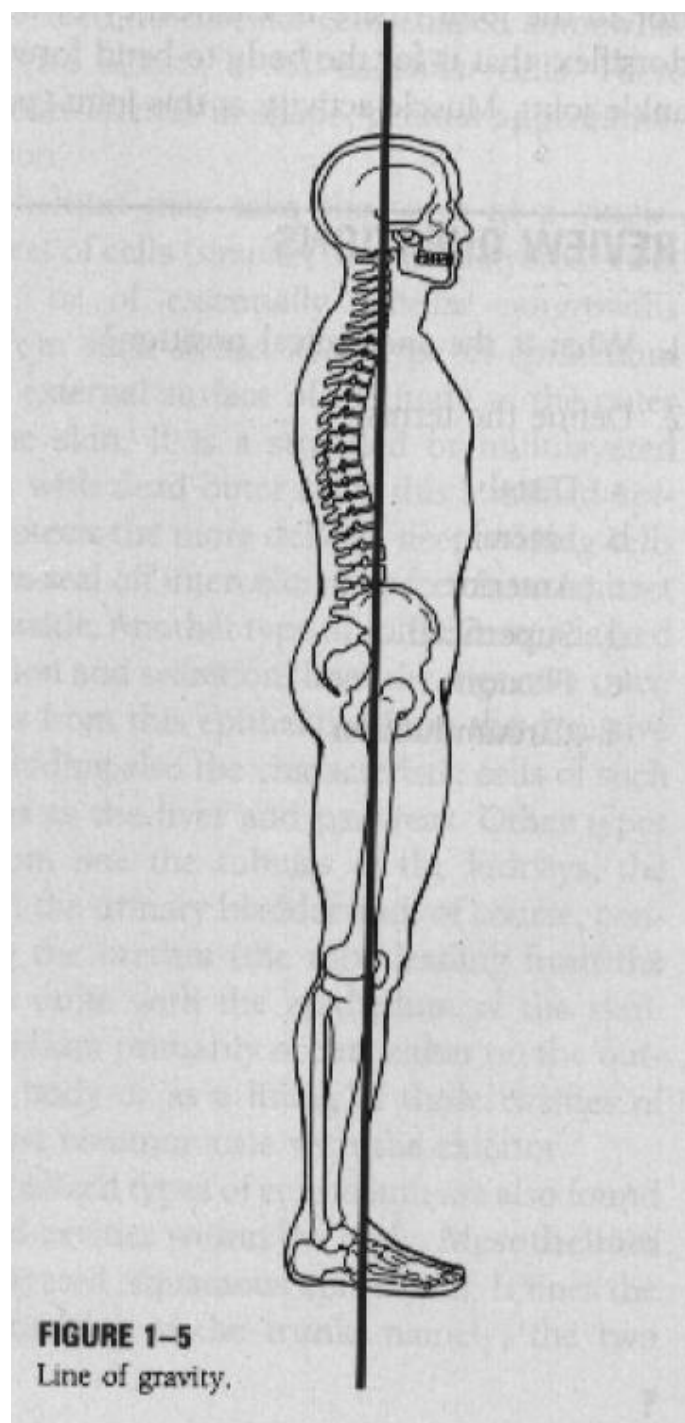
Center of gravity

- Imaginary balancing point
- The center around which the body may rotate freely in all directions
- = center of mass
- The summation of all **forces** at this point equal zero
- The summation of all **moments** at this point equal zero

Definitions

- **Line of gravity** = gravity's action line which is visualized as a vertical line projecting downwards from the center of gravity

Line of gravity



Line of gravity

- In the upright position, the line of gravity normally passes through the ***junctions*** of the various regions of the vertebral column:
 - the skull with the cervical vertebrae
 - the cervical with the thoracic vertebrae
 - the thoracic with the lumbar vertebrae
 - the lumbar vertebrae with the sacrum
 - posterior to hip & anterior to knee and ankle

Definitions

- **Base of support:**
 - the supporting area beneath the body
 - includes the points of contact with the supporting surface and the area between them
 - these points may be body parts (such as feet), or extensions of body parts (such as crutches or other walking aids)

Center of gravity (COG)

- The whole weight of the body, or body segment (such as the forearm), acts vertically downwards through the ***center of gravity*** of the body or body segment

Center of gravity (COG)

- **Location of the COG depends on:**
 - The proportion of body parts
 - The distribution of fat and muscle mass in the body
 - Posture
 - Structural deformities
 - External forces (e.g., carrying a shoulder bag)

Location of COG


- In case of square block or cylinder in which the mass is symmetrically distributed, the point is at the center of the object
- If the distribution of mass is asymmetrical, as in the limbs of the human body, the COG will be nearer to the larger and heavier end

Center of gravity (COG)

- In upright standing (in the average body): the COG is a point on the ***midline***, just anterior to the second sacral vertebra
- COG changes position during movement:
 - Lifting the arms raises COG
 - Bending the knees lowers COG

Factors affecting location of COG

Age:

- Age affects the location of COG because it affects body parts' mass proportion
- With advanced age, the COG becomes lower
- In newborn, the upper part of the body is heavier than the lower part 
the COG is higher than in adults

Factors affecting location of COG

Age

Location of COG:

- In newborn: above umbilicus
- At 2 years: at the level of umbilicus
- At 5 years: below the level of umbilicus
- In adults: anterior to the 2nd sacral vertebrae

Factors affecting location of COG

Gender

- The COG is higher in males than in females because of the muscular distribution (in males the upper body is heavier than lower body)
- The female pelvis is wider and heavier than the male pelvis...so?

Factors affecting location of COG

Addition of weight

If a person carries a backpack



the COG will move backward



as a compensatory mechanism, the person will move his trunk forward to prevent falling

Factors affecting location of COG

If a person carries weight in front of his body?



the COG will move forward



as a compensatory mechanism, the person will move his trunk backward to prevent falling forward

lordosis

Factors affecting location of COG

Subtraction of weight

- In amputation, the COG moves away from the amputated limb towards the healthy side
- E.g., in case of amputated left leg: the GOG will move upward & toward the right side

Factors affecting location of COG

Subtraction of weight

- When making an artificial limb, the weight of the artificial limb should be equal to the weight of the healthy limb
(avoid abnormal distribution of the segments weight)

Main factors contributing to stability

- **Position of the center of gravity:**
 - An object is in stable equilibrium when its center of gravity lies within its base of support
 - The upright body is only stable when the line of gravity lies within the foot base

Main factors contributing to stability

- **Base of support (BOS):**
 - The upright body is least stable when the feet are parallel and close together (because the BOS is small)
 - As the feet are moved further apart and the BOS increases, stability increases

Stability in carrying a weight at the side of the body



Unstable



Stable

Factors for achieving balance

- A person has balance when the COG falls within the base of support (BOS)
- A person has balance in direct proportion to the size of the BOS (the larger the base of support, the more balance)
- A person has balance depending on mass (the greater the mass, the more balance)

Factors for achieving balance

- A person has balance depending on the height of the COG
(the lower the COG, the more balance)
- A person has balance depending on where the COG is in relation to the base of support (balance is less if the COG is near the edge of the BOS)

Factors for achieving balance

- Balance is related to the functioning of the nervous system

Clinical applications

- If we bend to pick up a child or a box, the knees should be bent and the trunk flexed to move the COG down and over the feet
- In standing up from sitting, stability can be increased by moving the feet back and leaning the trunk forward in preparation for standing

Clinical applications

- Walking aids, such as canes and crutches, increase the size of the base of support and therefore allow more swaying of the body without falling
- A therapist should stand with feet apart and knees bent to be in a stable position to resist the added weight of the patient