

Equilibrium and Stability

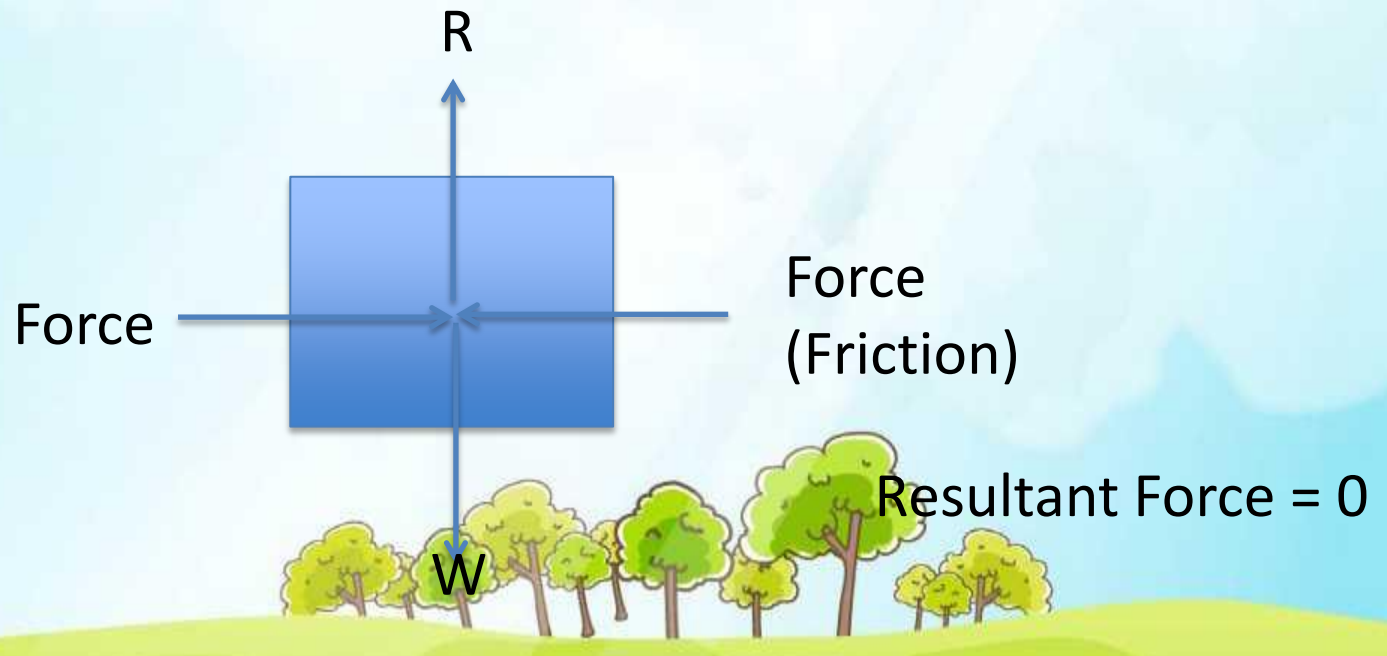


संतुलन और स्थिरता

Equilibrium: A body or object is said to be in equilibrium when

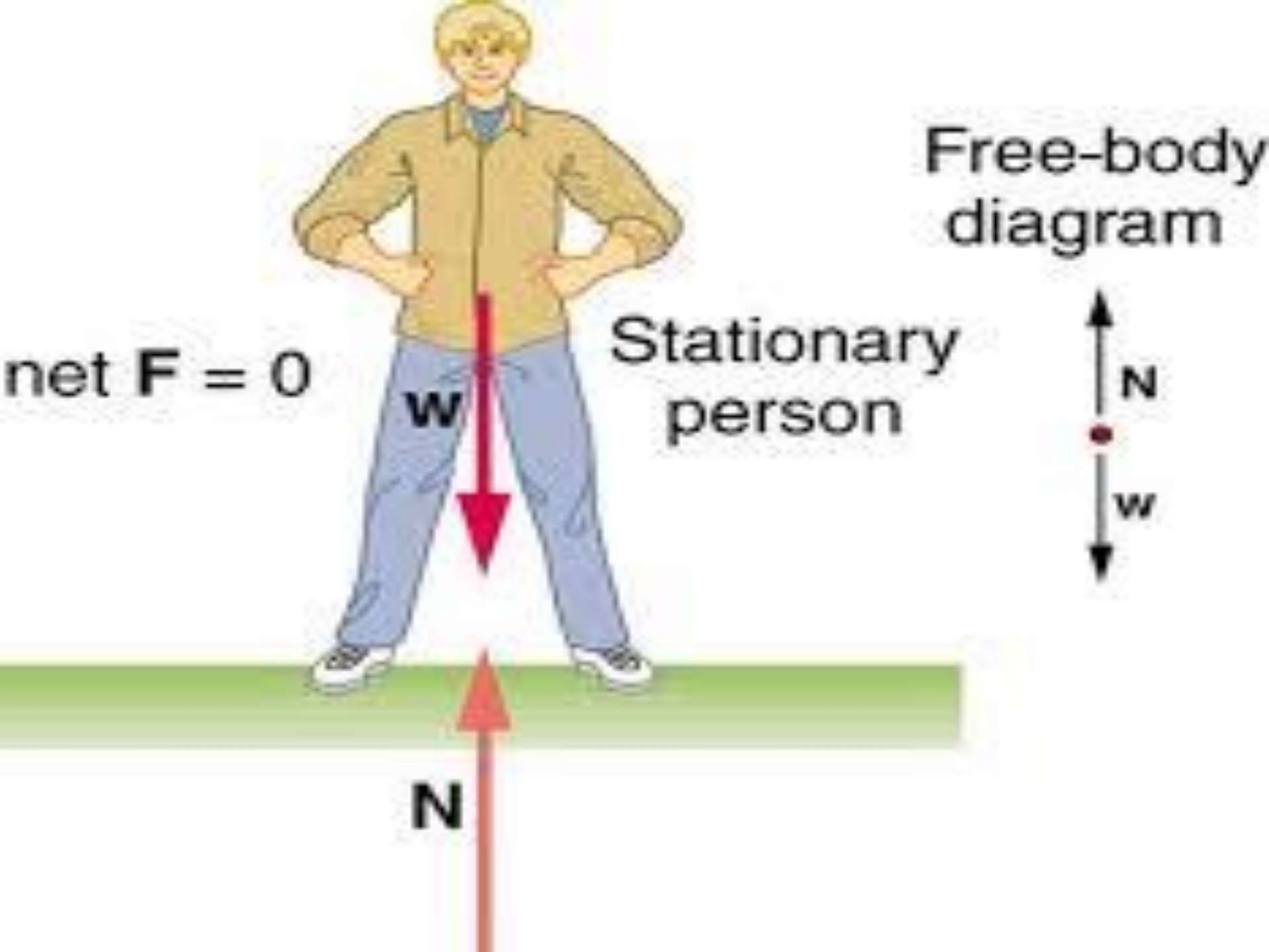
a) the sum of the forces acting on it is equal to zero and
b) the sum of the torques acting on it is equal to zero. In other words, there are no unbalancing forces or torques.

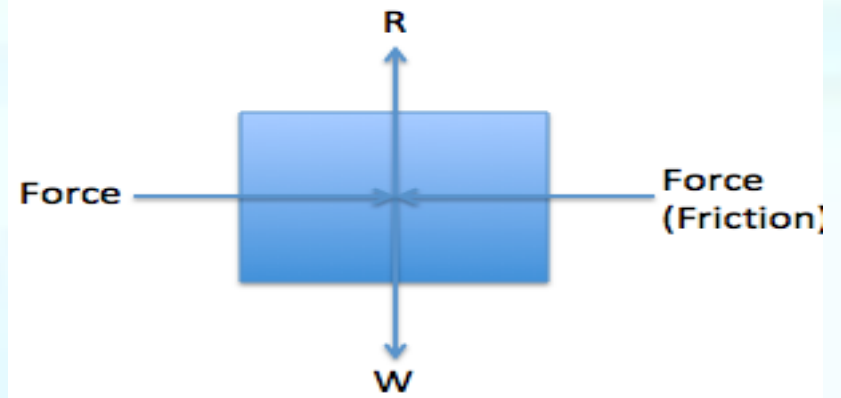
- Our body is constantly subjected to forces, even when there is no motion.



- Equilibrium of a body is defined as the state when all the forces and actions acting on the body nullify each other resulting in a stable, balanced and unchanging position.
- It is the stage when the body is either in a state of rest or moving with a constant velocity.

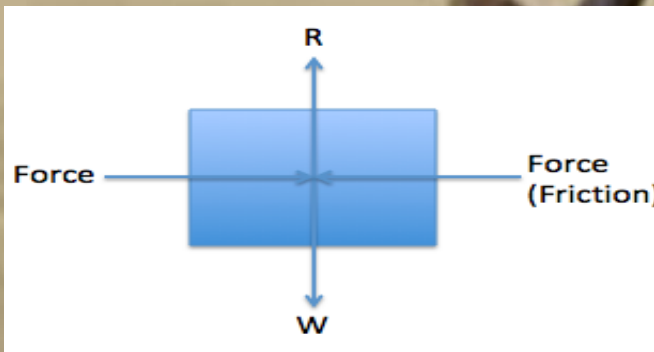






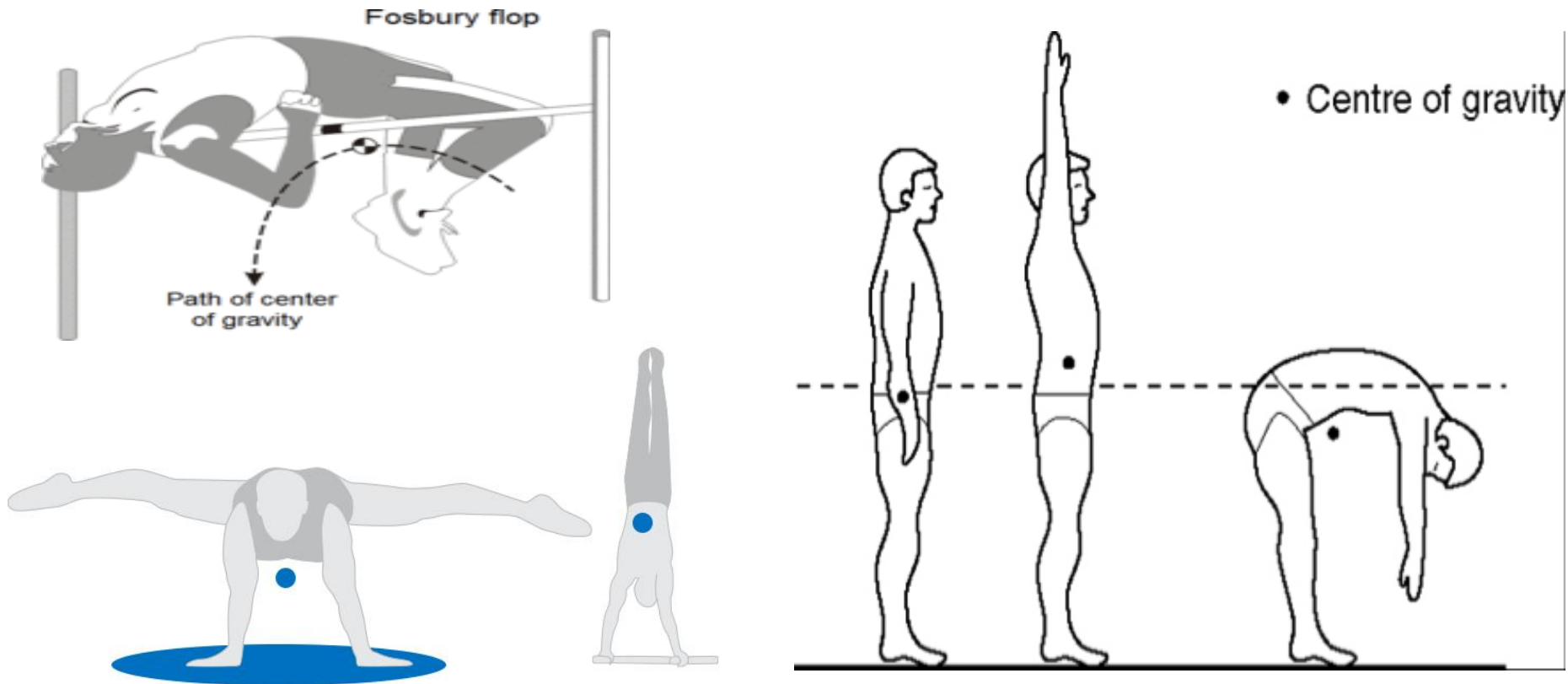
- The sum of all the horizontal force = 0
- The sum of all the vertical force = 0
- The sum of all the moments that cause rotation = 0

- When this condition exists, the body is said to be in equilibrium
- In sports, it is called balance, position or Stance.



Center of Gravity

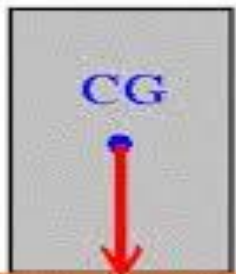
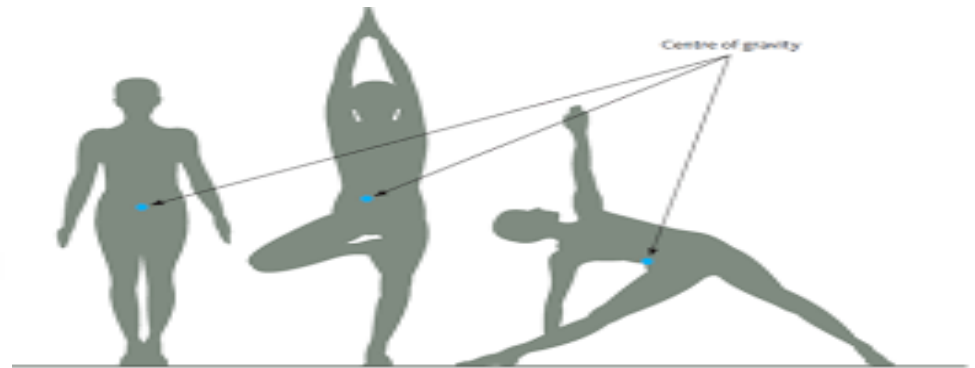
- The CG is a point in the human body where whole weight of the body is considered to be concentrated.
- It is the point in the human body which marks the intersection of three primary planes and their axis.



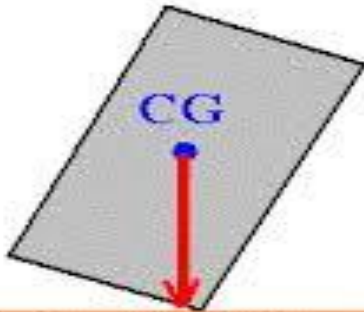
- In a rigid body of homogenous mass the CG is at the geometric center of the body.
- As the density of the body changes the CG shifts towards more weighted section.



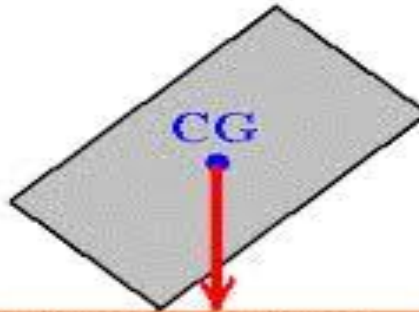
<http://myconnection.com/articles/ask-the-editor-is-my-center-of-gravity-better-than-yours/>



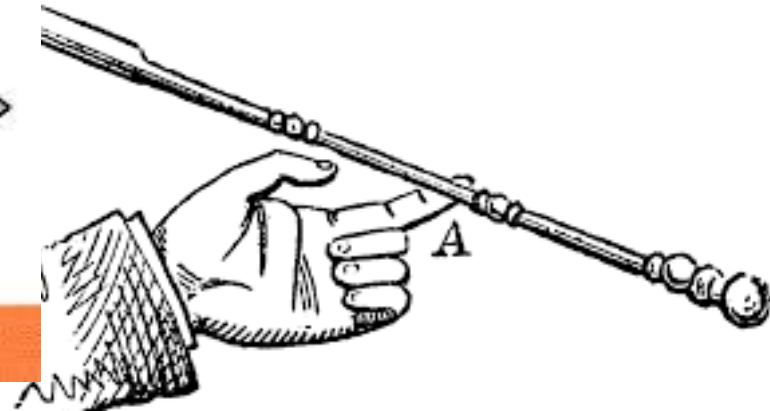
(a)



(b)

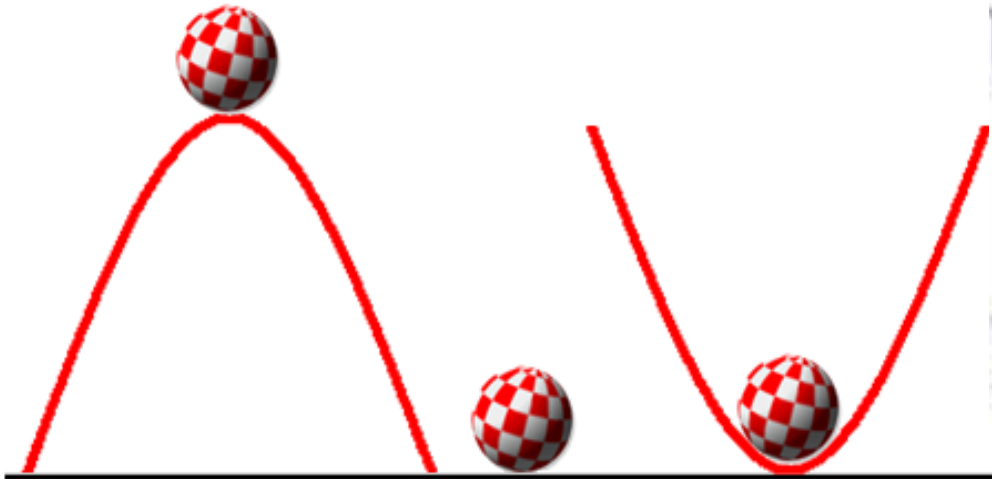


(c)



Types of Equilibrium

1. Stable equilibrium
2. Unstable equilibrium
3. Neutral equilibrium



Equilibrium types

Stable



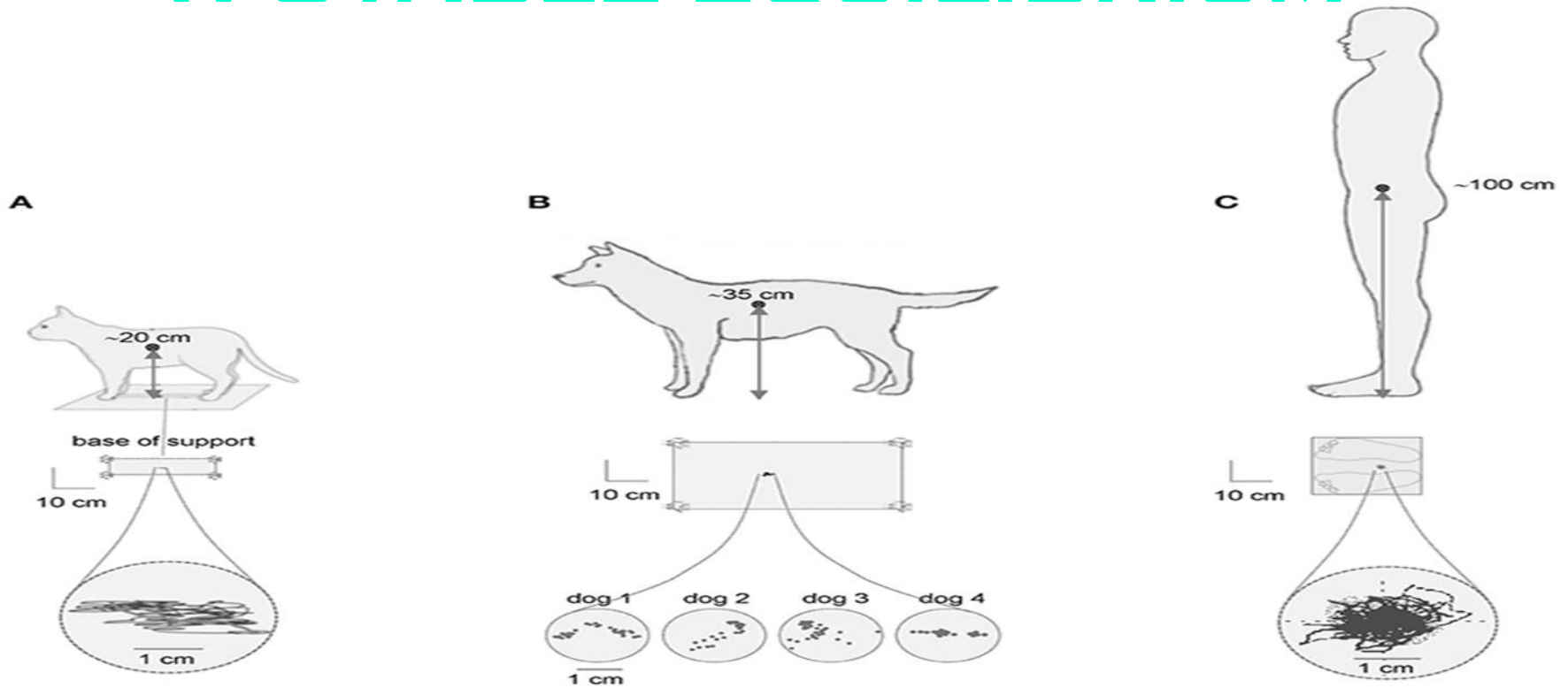
Unstable



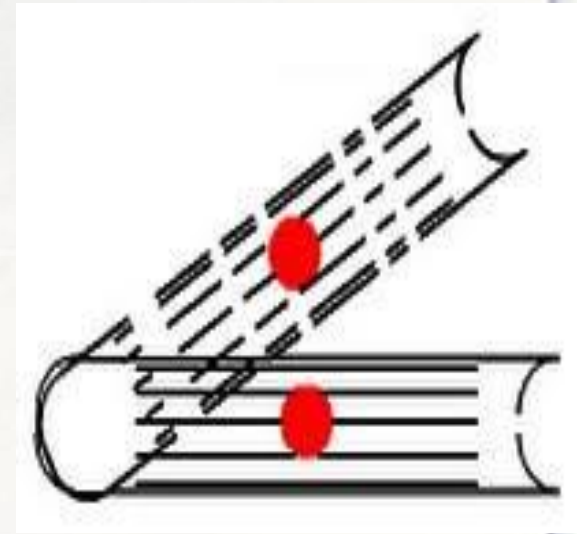
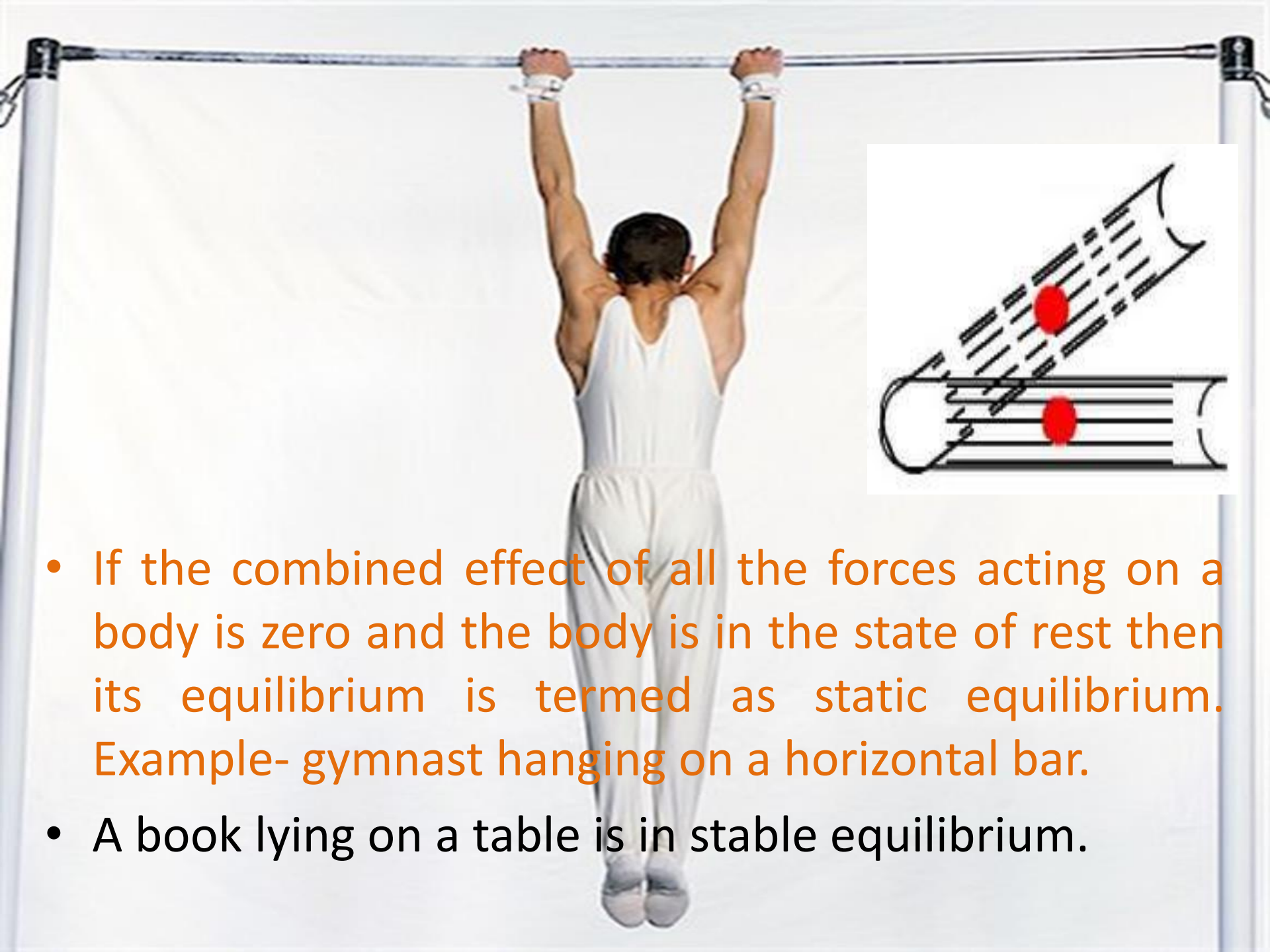
Neutral



1. STABLE EQUILIBRIUM

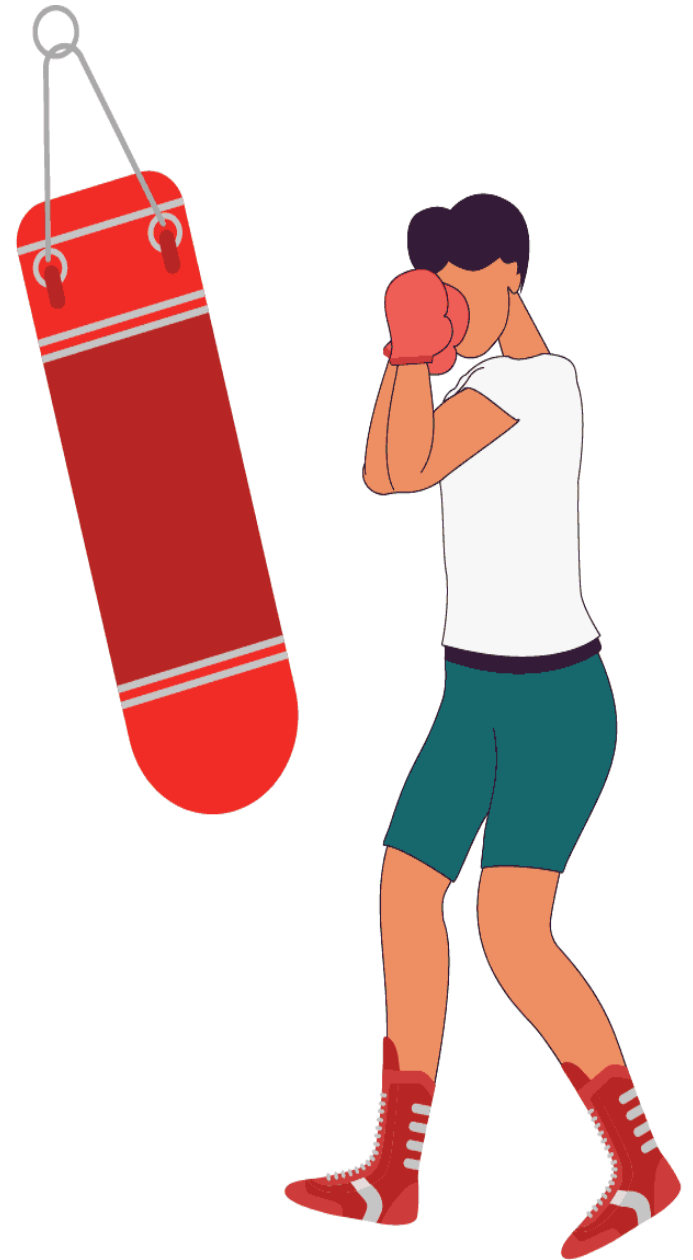


- When a body is in equilibrium and has a tendency to return to its original position when unbalancing forces are applied on it then the body is said to be in a state of stable equilibrium.



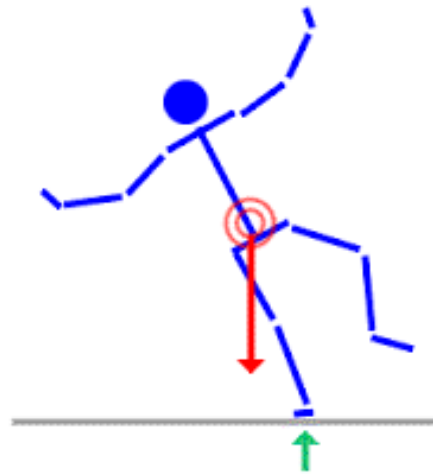
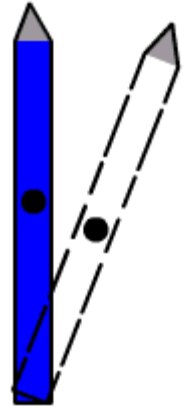
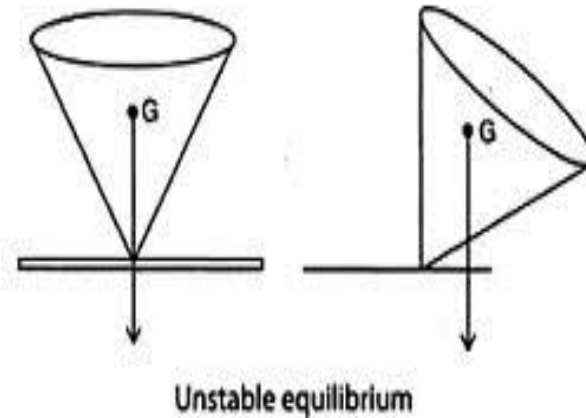
- If the combined effect of all the forces acting on a body is zero and the body is in the state of rest then its equilibrium is termed as static equilibrium. Example- gymnast hanging on a horizontal bar.
- A book lying on a table is in stable equilibrium.

- A body is said to be in stable equilibrium if it comes back to its original position when it is slightly displaced.
- When a body which is in stable equilibrium is disturbed its centre of gravity is raised.
- **Examples:**
 - Gymnast hanging on a horizontal bar
 - Punching bag in boxing
 - Pendulum



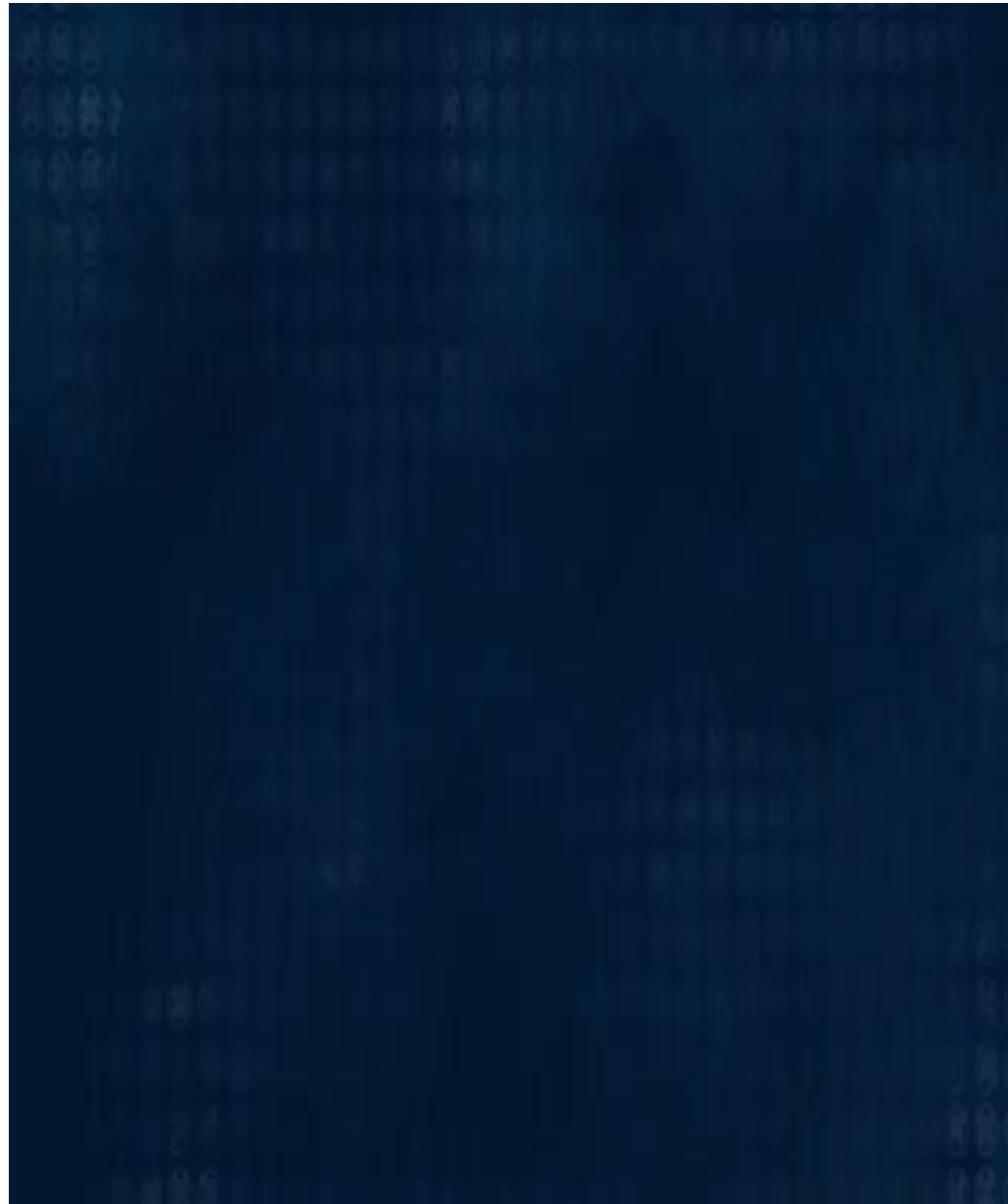
2. Unstable equilibrium

- A body is said to be in unstable equilibrium if it does not come back to its original position when it is slightly displaced.
- When a body which is in unstable equilibrium is disturbed its centre of gravity is lowered.
Example: pencil standing on its point or a stick in vertically standing position.

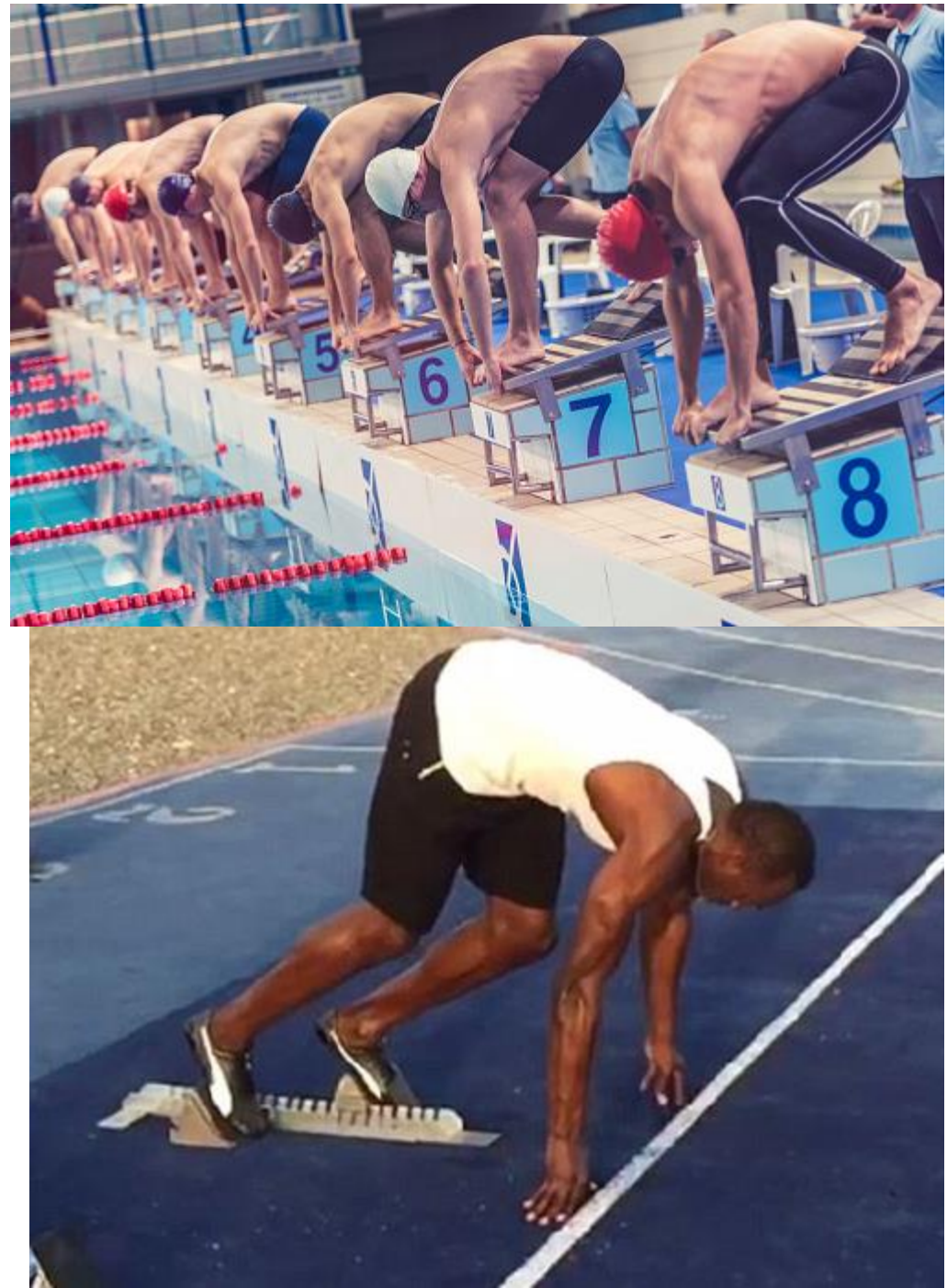


when forces or disturbing moment is applied on a body such that on removal of that force or moment the original position is **never restored** but rather continually moves to new positions is called unstable equilibrium.

- In such equilibrium the center of gravity of the body lies above the point from which it is suspended or supported. For example a pen standing on its point.



- Examples:
 - handstand on parallel bar.
 - A swimmer standing on a starting block, ready to take start.

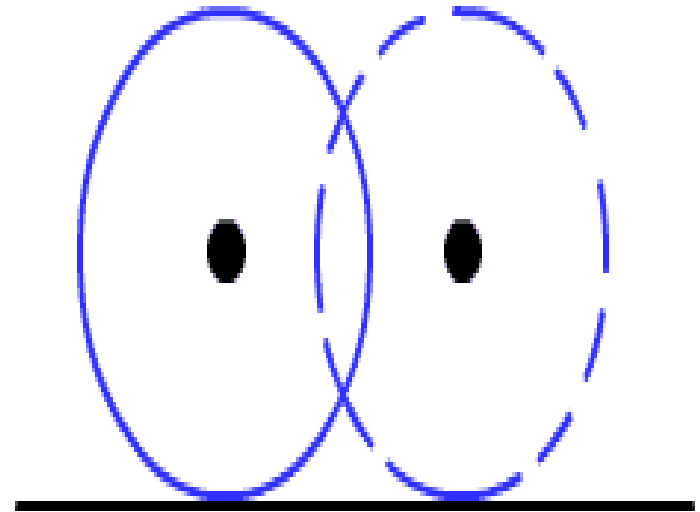


3. Neutral equilibrium

- When forces or disturbing moment is applied on a body such that on removal of that force or moment the body doesn't retain its original position but attains a new position is called neutral equilibrium.
- In such equilibrium the center of gravity of the body coincides with the point of support or suspension.
- For example bowling or a dice rolling on the game board .



- In this case the body has a tendency to change its position under the influence of an applied force but the new acquired position is similar to the original position
- An effort to disturb the body will neither raise nor lower the CG.
- The CG remains at the same point.
- Example
- A ball lying on a level surface.



Stability Factors



- Ability of a body to maintain balance under unfavorable condition.
- It is the measure of equilibrium.

1. Stability is directly proportional to the area of the base on which the body rests.

- A person standing on tip of toe with feet together is in equilibrium but of unstable degree.
- Standing feet apart.
- Position with both hands and feet on the ground in a four point American football stance

THE DEADLIFT

- Hip-width stance
- Hands just outside of hips
- Full grip on the bar



- *Wrestlers defensive down position. (more stability)*
- *Lie down with arms and feet spread.*





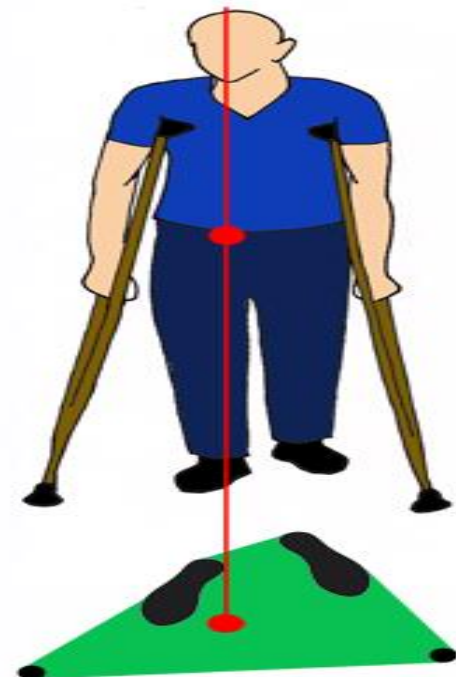
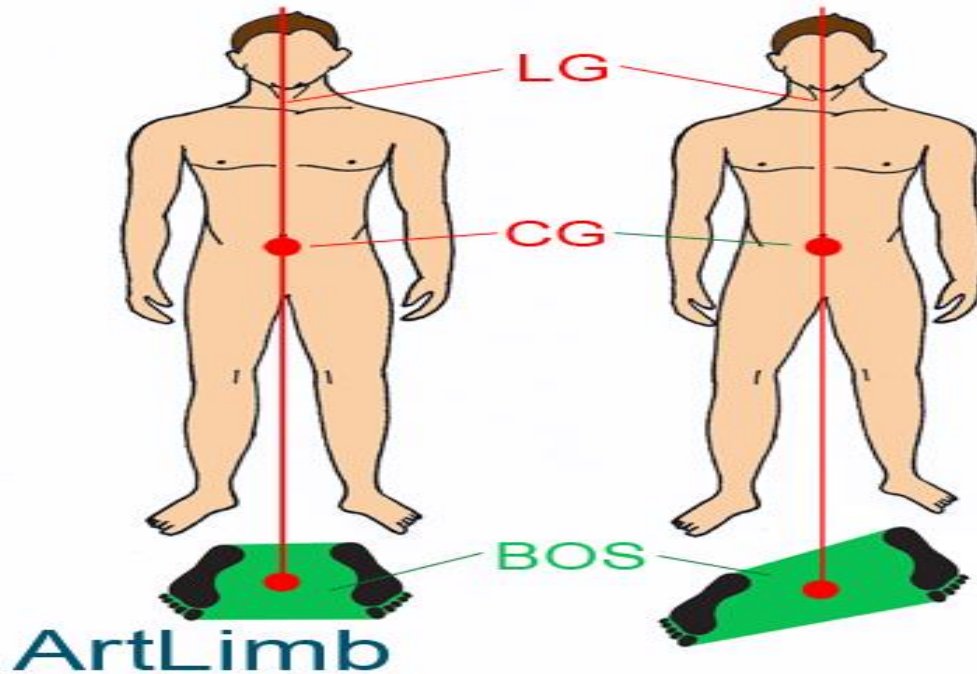
More stable

Less stable



Low COG
 Wide base of support – 4 point contact
 Line of gravity in middle of support

Higher COG
 Small base of support – 2 point contact
 Similar line of gravity



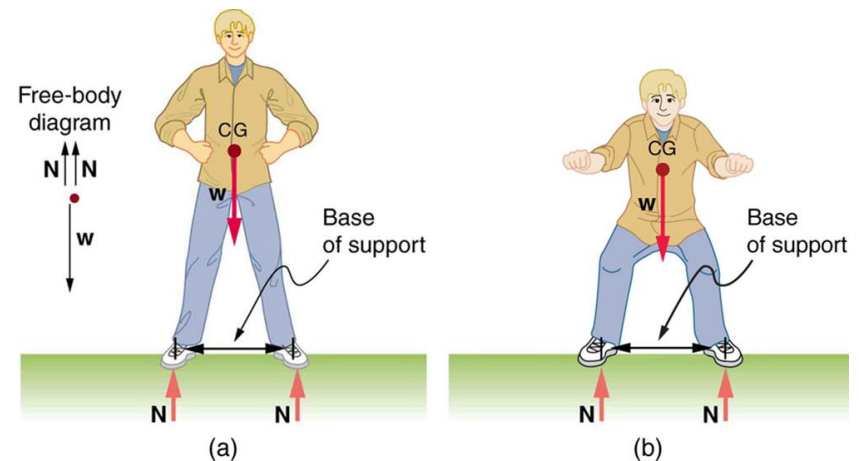
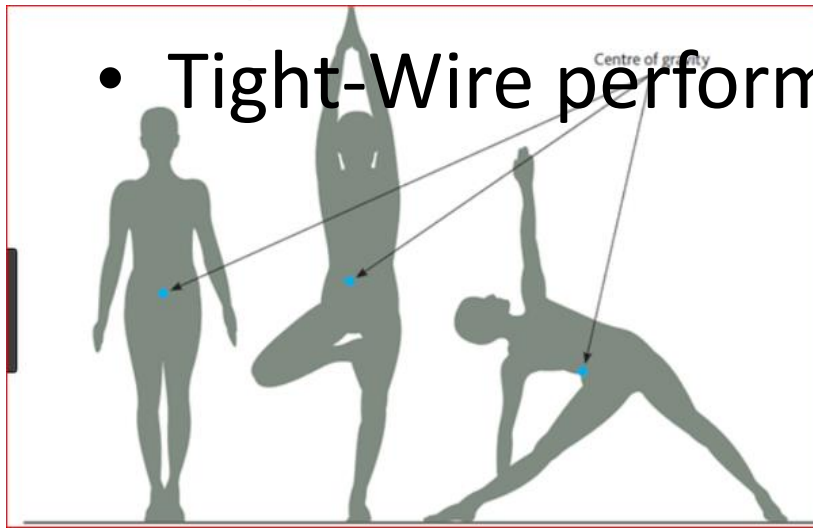
- *A body maintain its equilibrium only so long as its line of gravity falls within the base of support.*
- For this reason, a gymnast walking on balance beam keeps his arm stretched both ways.



2. Stability is indirectly proportional to the distance of the center of gravity of the body above the base. (Height of center of gravity)

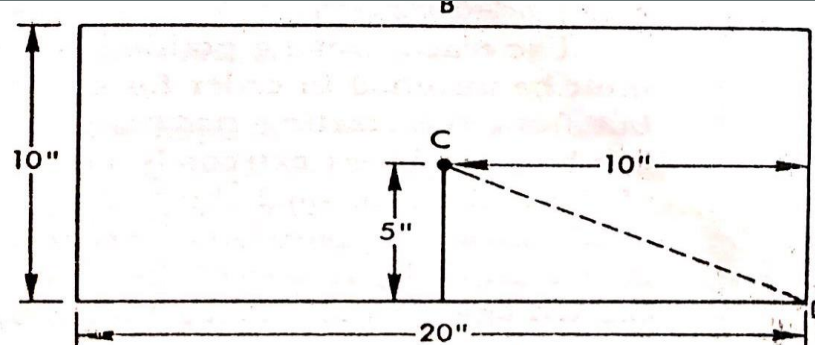
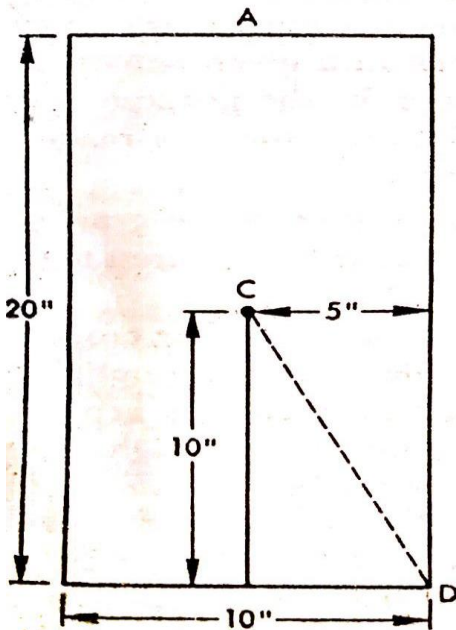
- Lower the CG, more is the stability.
- In Standing position at crest of ilium midway between the front and the back is CoG.
- If Arms are lifted CoG rise.
- E.g in supine position at see-saw.

• Tight-Wire performers.



3. For equilibrium to exist the centre of gravity of a body must fall within its base.

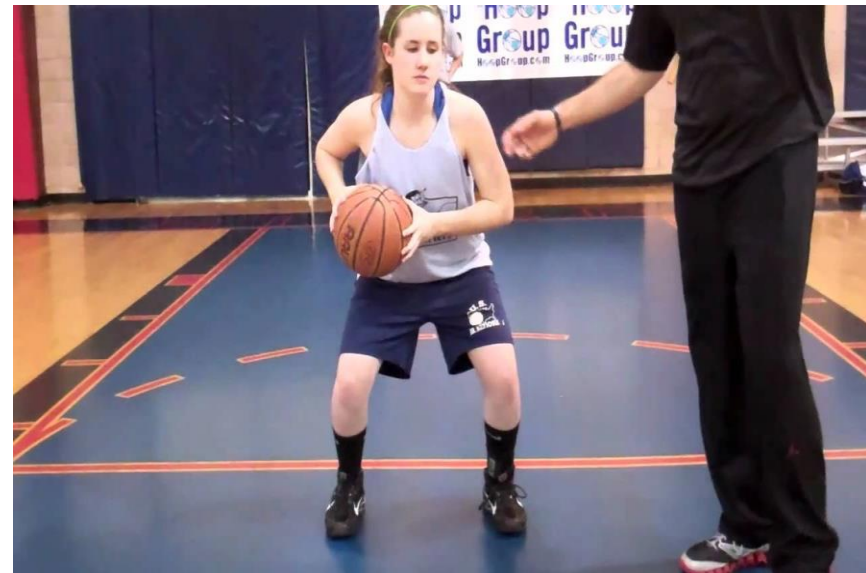
- In order to maintain handstand, the line of CoG between hands.
- E.g Block



- In **athletic** situations where objective is to start as quickly as possible, it will require less effort to upset ones equilibrium from high CoG.
- Throwing the CoG outside the base is a prime requisite to starting in motion.



- If it is desired to resist displacement by an outside force, such as in a charge in a football game or with an opponent in a wrestling bout.
- If a body is moving rapidly and one desires to stop instantaneously, he could accomplish his purpose more effectively by lowering CoG. (e.g Basketball player crouching)
- The low crouch creates a wide base, drops CoG close to the floor, and tends to keep it within base of support.



4. Stability in a given direction is directly proportional to the horizontal distance of the CoG from the edge of the base toward the given direction of movement.

- On the position “On Your Mark” lean forward so that CoG is above his hands.
- Basketball player running and rapidly stops , takes his CoG to rear foot.



5. Stability is the directly proportional to the weight of the body.

- It is more difficult to upset the equilibrium of the heavier person.



- **GUIDING PRINCIPLES**

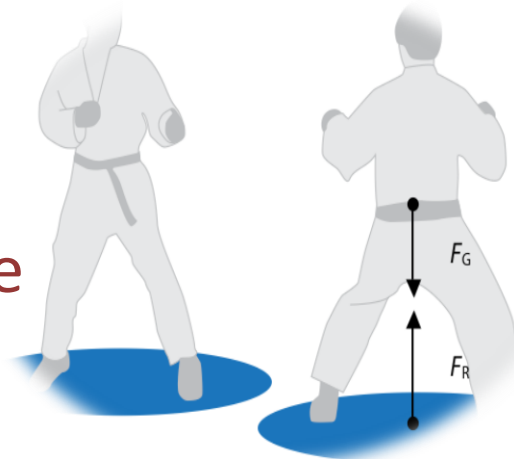
1. To start quickly in one direction, keep the CoG as high as possible to the edge of the base nearest to the direction of intended motion.

- Example: Sprinters in the "set" position shift their weight in the direction of the race.



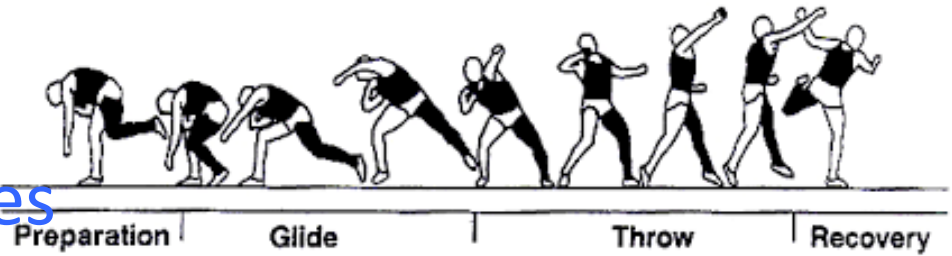
2. For greatest stability in all directions, the center of gravity should be over the center of the base of support.

- Example: Holding a handstand requires the hips to remain toward the center of the base formed by the hands.
- Greater the area of the base of support, easier is to keep the CoG within it.
- Equilibrium is upset if CoG goes outside base of support.

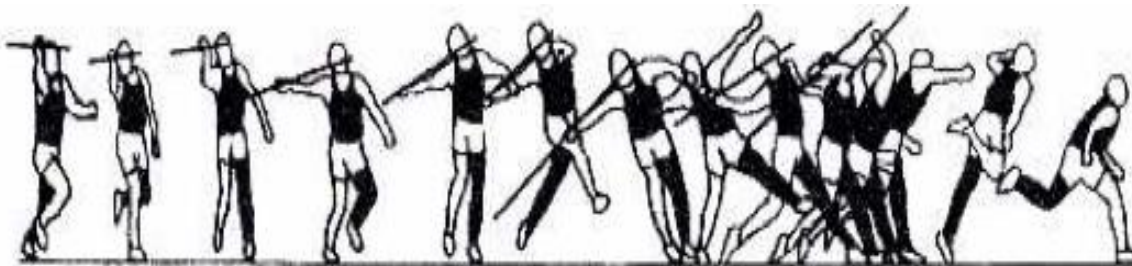


3. For greatest stability, increase the area of the base to a position where the CoG as much as is consistent with the activity involved.

- A shotput follow through involves bending the knees to prevent fouling.



- Wrestler sometimes lie flat in prone position, feet apart and forearms flat on the floor until he sees an opportunity to escape from his position.



4. Mass of the body शरीर का भार

- More the mass, more is the inertia and therefore more is the stability.
- It require more force to upset the heavy body.



5. To stop quickly when in a rapid motion, drop the CoG as low as possible, consistent with subsequent movements, create as an area of base as possible, and move the CoG away from the edge of the base i.e. nearest the direction of movement.

- Basketball players while stopping immediately spreads his feet at shoulder width, placing one foot in advance of the other and dropping the buttocks down as low as possible.



6. When an individual is airborne, height of CoG can be raised above floor cannot be affected by body movements, but the position of CoG within the body may be raised or lowered above the floor.

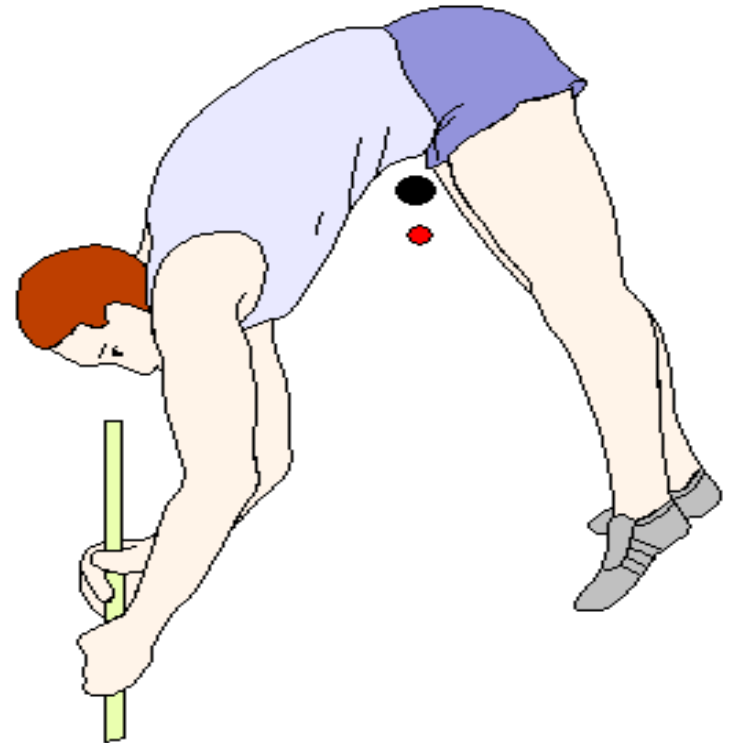
- In jumping high (heading in football)



7. When the body is free in air, if the head and feet move down, the hips move up, and vice versa. (Law of ends and middle)



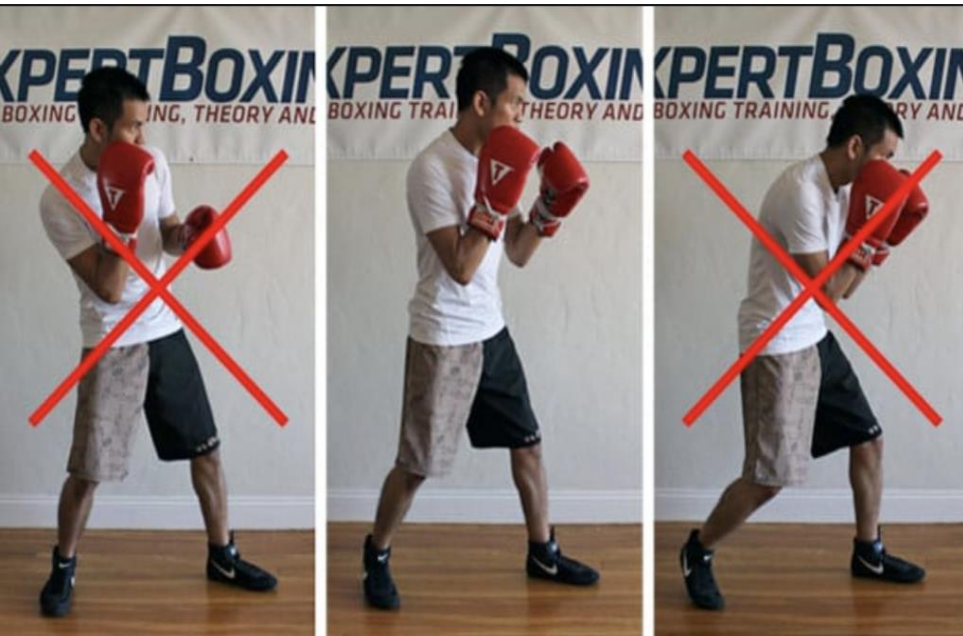
- In High Jump or pole vault while crossing bar .
- In long jump before landing athlete bring both hands and feet together to cover more distance.
- In hurdling also same principle is applied while crossing hurdle.





8. An opponent can be forced to lose balance if pushed or pulled in the direction where the center of gravity is closest to the edge of the base of support.

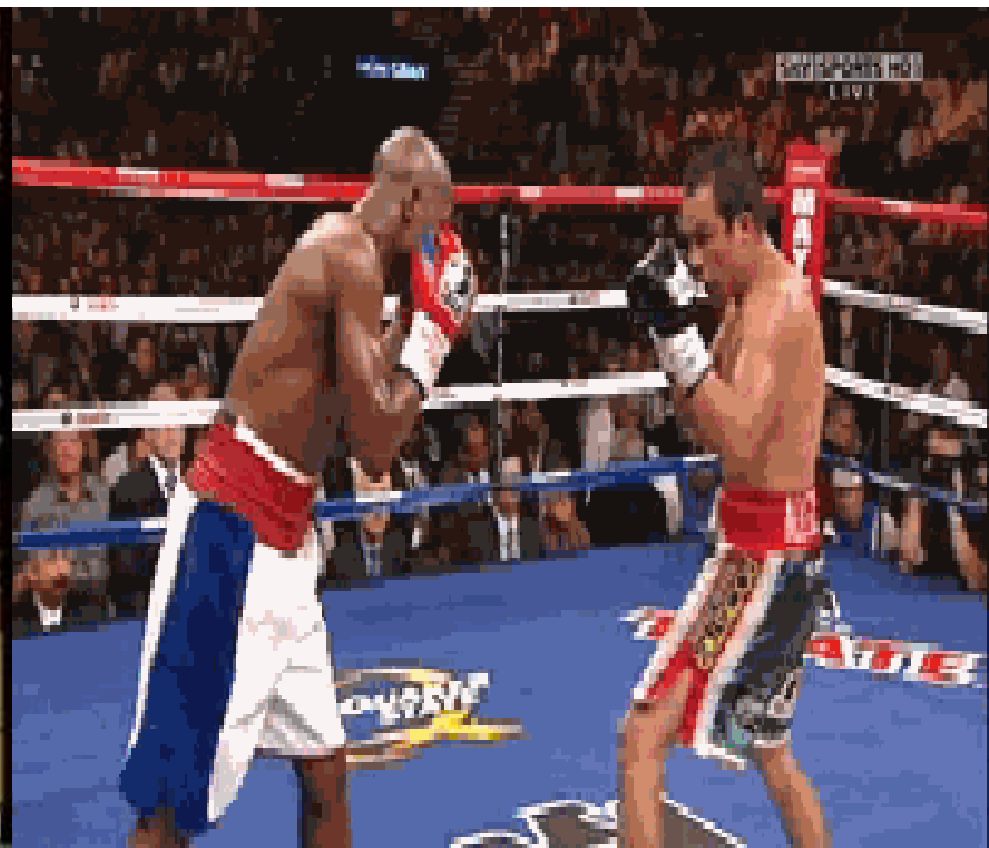
- Example: Boxers can lose balance when weight is shifted back on the heels.





9. Shifting the center of gravity toward an approaching force increases an athlete's ability to maintain balance.

- Example: A football lineman shifts weight toward the opposing line prior to the snap.



10. The greater the friction between the supporting surface and the athlete's body, the greater the ability to maintain balance.

- Example: Wearing shoes that prevent excessive sliding on a playing surface.



12. When lifting or carrying an object, shift the body weight in order to maintain balance.

- Example: Lean in the opposite direction when carrying a heavy equipment bag.



Thank You

