Unit 8 | Biomechanics and Sports

Biomechanics

Biomechanics is the science of movement of a living body, including how muscles, bones, tendons, and ligaments work together to produce movement.
Biomechanics is the combination of two words- bio and mechanics. Bio means, something pertaining to living beings or life, whereas Mechanics is the branch of physics which studies movement or motion of an object or body with the help of mechanical principles. Thus, when the study of mechanics is limited to living structures and their function, especially the human body, it is called biomechanics.

Newtons Law of Motion

1st law of Motion

According to Newton's first law of motion, a body at rest will continue to be at rest and a body in motion will continue to be in motion at the same speed and in the same direction unless any external force is applied on it, in order to change its state.

Also called Law of Interia

Example:
- A moving football first slows down and then stops. It comes to rest due to the friction between the ground and the ball.
- To take a start in sprint races.
- To lift the opponent in wrestling.
- To start hammer throw.

2nd law of Motion

According to this law, the rate of change in acceleration of an object is directly proportional to the force producing it and inversely proportional to its mass.
In case two unequal forces are applied to objects of equal masses, the object on which a greater force is applied will move faster.

Also called Law of Acceleration or momentum.

Example:
- A cricket player while catching a ball moves his hands backwards.
- In baseball, the player hits the ball hard to throw it far away.

3rd law of Motion

According to this law, every action has an equal and opposite reaction.

This implies that forces do not work alone they actually act in equal and opposite pairs between the bodies in contact. This law explains what happens to a body when it applies a force on another body.

Also called Law of Reaction.

Example:
- A cricket player while catching a ball moves his hands backwards.
- In baseball, the player hits the ball hard to throw it far away.

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Equilibrium

Equilibrium can be defined as a state of balance among forces acting within or upon a body. In other words, it is a state in which all influences, forces are cancelled or counterbalanced by each other i.e. the sum of all opposite forces acting on it is zero. Thus, it is a scientific term describing balance and stability.

Types of Equilibrium

Static Equilibrium

It is the balance of the body during its rest or objects that are not accelerating or moving. Static stability mainly depends upon the enlarged base of support, lowered center of gravity, direction of an acting force and body weight.

Stability in sports situations is quite unlike the stability of solid objects.

For e.g., Wrestlers positions, Stance of batsman in cricket, shooting, archery, etc.

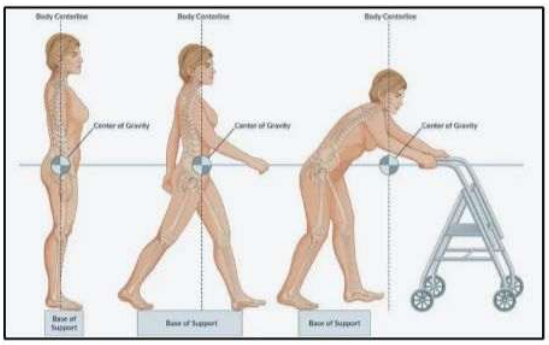
Dynamic Equilibrium

It is a balance of body during movement or actions. It frequently happens that the line of gravity of an athlete will fall outside the base of support for a moment.

For example in a sprint start, the body weight is well ahead of the supporting foot, but before the body can fall forward, the other foot moves ahead to provide support and the process repeats itself. Other examples are exercises on balancing beam, low dribble in basketball and all kinds of sports movements.

Centre of Gravity

It is the "balance point" of the body. The point where the weight of the body acts. The point where all forces acting on the body equal zero. Linear forces must be balanced. Torques must be balanced. Line of Gravity: It is an imaginary vertical line which passes through the center of the body. The location of the line of gravity will depend upon the location of the gravity which changes according to the body's position.



Application of Centre of Gravity

(a) The centre of gravity moves according to the athlete's body position. For example, the centre of gravity is lower & in front of athlete's body while he or she is running. Lower body is advantageous for acceleration.
(b) Low center of gravity also helps to increase stability because it needs to be lifted higher before it moves outside of the base of support. This becomes very useful in combat sports such as sumo wrestling. It is also used by in kabaddi, basketball etc.
(c) Lowering the centre of gravity increases balance & stability in sports. This is why you can change direction faster by bending your legs and getting lower to the ground. It increases your stability, allowing you to adjust to greater force by the legs.

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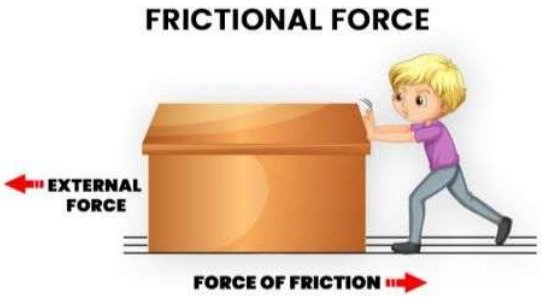
Friction

The force acting along two surfaces in contact, which opposes the motion of one body over the other is called the force of friction. It is important in sports. The larger the area of contact between the surfaces, the greater the force of friction. When both the surfaces are smooth, the force of friction reduces almost to zero. Generally, there are two causes of friction:
The roughness or irregularities of the surface
The strong atomic or molecular force of attraction between the two surfaces at the point of actual contact.



Types of Friction

Static

Static friction is when a force is applied to an object but does not cause it to move. Example: Pushing a wall. Static friction comes into play when a body is forced to move along a surface and movement does not start. The magnitude of static friction remains equal to the applied external forces and direction of motion. The magnitude of static friction depends upon coefficient of static friction and N (Net normal reaction of the body).

Dynamic

Sliding

Sliding friction is the divergent force that comes into action as the body slides over the surface of the other body.
For instance, ice skating and in pole vault, planting the pole.

Rolling

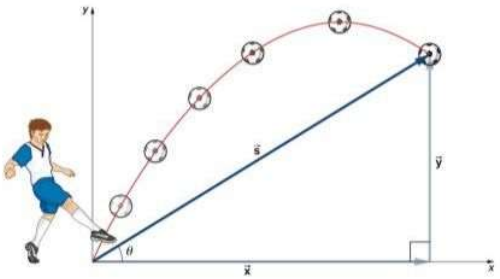
Rolling friction occurs when an object rolls over another (something with wheels or circular like a ball). Example: riding a motorcycle. Rolling frictional force is a force that slows down the motion of a rolling object.

Fluid

Fluid friction is defined as the friction that exists between the layers of the fluid when they are moving relative to each other.
Example:
A person swimming in the water.
A plane flying through the air.

Projectile in Sports

It checks with the motion of an object projected into the air at an angle. An object thrown into the space either horizontally or at oblique angle under the action of gravity is termed as a projectile. Within the field of games and sports, there are many samples of projectiles like putting the shot, throwing a hammer, discus, and javelin in athletics.



Application of Projectile in Sports

1. Bow and arrow/sling-shot: When an arrow is fired at an angle to the bottom, it follows a parabolic path of a projectile and then it hits the target.
2. In the baseball game, a ball is hit by the bat and then it starts moving in the air but the ball doesn't follow a standardised circular path. The trail is probably going to be parabolic in nature betting on the angle at which it's launched.
3. When a football is kicked then it travels a specific distance within the air & it falls at an angle to the base or ground, this can be an example of projectile motion.
4. When a basketball is thrown into the basket, the ball travels a parabolic trajectory and then goes into the basket.
5. In Gymnastics, plenty of stunts and jumps are performed by gymnasts. The motion of the gymnast as he jumps is parabolic.

Types of Levers & their Applications in Sports

Levers in our body are formed from bones, joints & muscles.
A lever consists of the following:
- A rigid structure (bone).
- A force is acting upon it (muscle) to produce a turning movement (angular motion).
- A fulcrum which is a fixed point (joint).
- A load or resistance that is placed on the rigid structure (weight of body part being moved and anything that it is carrying).

There are three types of lever:
First class lever: The fulcrum is in the middle of the effort & the load. This type of lever is found in the neck when raising your head to head a football. The neck muscles provide the effort, the neck is the fulcrum & the weight of the head is the load.

Second class lever: The load is in the middle between the fulcrum & the effort. This type of lever is found in the ankle area of the foot. When standing on tiptoe, the ball of the foot acts as the fulcrum, the weight of the body acts as the load & The contraction of the "gastrocnemius" muscle is what causes the effort. This second-class lever is used when taking off for a jump or pushing against the blocks in a sprint start.

Third class lever: The effort is in the middle between the fulcrum & the load. During a biceps curl, the fulcrum is the elbow joint; the effort comes from the biceps contracting, and the resistance is the weight of the forearm and any weight that it may be holding.