

PHYSICAL EDUCATION

CHAPTER 7: BIOMECHANICS & SPORTS



BIOMECHANICS & SPORTS

Meaning

Biomechanics is the science concerned with the analysis of the mechanics of human movement. It explains how and why the human body moves.

It is the study of the function and motion of the mechanical aspects of biological systems.

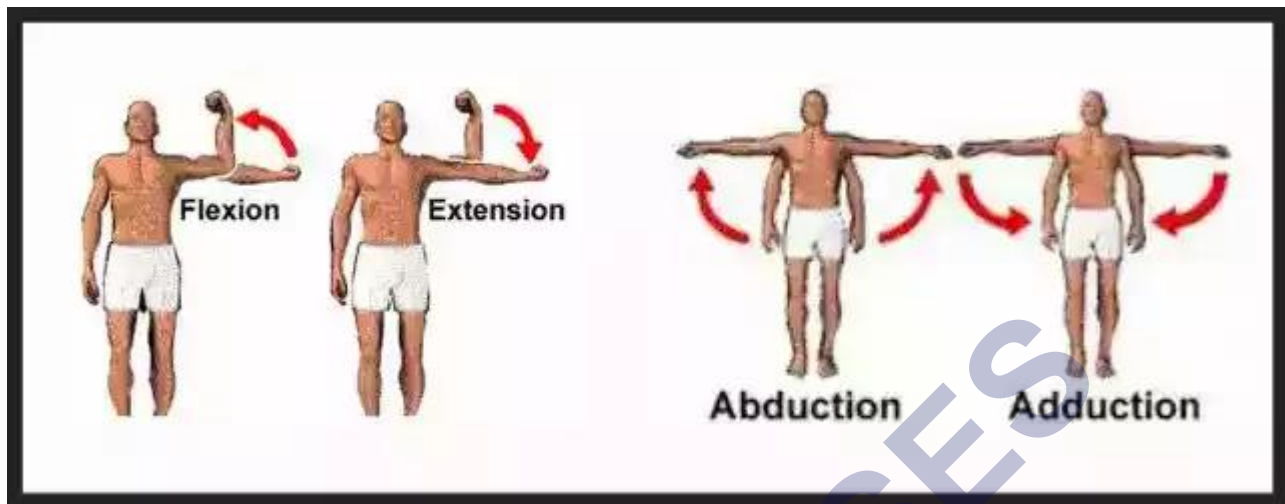
Biomechanics tells us how our muscles, bones, tendons, and ligaments work together to produce movement.

It gives us a detailed analysis of any sport movements, which helps to minimise the risk of injury and improve sports performance.

Importance Of Biomechanics In Sports:

- **Improves sports performance:** Biomechanics tell us the right techniques for effective and efficient results by using minimum muscular force and gets maximum results.
- **Improvement in technique:** Biomechanics helps to improve new techniques, which helps us to get more results.
- **Helps to develop best sports equipment:** Biomechanics helps us to make correct and scientifically proven equipment.
- **Improvement in training:** Coaches can give best training to athletes on the basis of scientific knowledge. He can analyse the player's movement in a better way.
- **Prevents injuries:** It helps us to know the forces that can lead to the injuries during the game situation.
- **Knowledge of safety principles:** Biomechanics gives the understanding to analyse different safety movements.
- **Helps in research work:** It helps to impart scientific teaching and learning processes.
- **Creates confidence in players:** Players come to know correct techniques to execute the movement. Thus, it improves the confidence of the player.

Types Of Movements



Flexion

It describes a bending movement that decreases the angle between two body parts, that is bones of the limb at a joint. Flexion refers to movement in the anterior direction.

It happens when muscles contract and move your bones and joints.

Example: Elbow flexion is decreasing the angle between the radius and the humerus. Knee flexion is decreasing the angle between the femur and tibia.

Flexion of the shoulder or hips refers to movement of arm or leg forward.

Extension

It is the opposite of flexion; it is a movement that increases the angle between two body parts.

Extension refers to movement in the posterior direction.

Extension at the elbow is to increase the angle between the ulna and the humerus. Extension of the knee is to increase the angle between the tibia and the femur.

Abduction

Abduction is a movement that pulls a structure or part away from the midline of the body. The muscles which create this type of motion is known as abductor.

Abduction of the wrist is also known as radial deviation.

Swinging the arms laterally from the side of the body up to the shoulder or moving the legs away from midline is abduction are some examples.

Adduction

It refers to the movement that pulls a part towards the midline. When the arms straight out at the shoulders brings down to their sides is adduction.

Arms closing towards the chest, bringing the knees together, bringing all the fingers or toes together, thumb back to the normal position are some of the examples of adduction.

Newton's Law of Motion

Application In Sports

Man is said to be the man of action. So, movements are involved everywhere. For every moment there is motion. Therefore, everything that moves is governed by the 'Laws of motion'.

These laws of motion formulated by Sir Isaac Newton in 1687. He explained and investigated that every motion is under the impact of following laws of motion



Less

expensive.

First Law of motion

First law is also named as Law of Inertia. This law states that an object at rest will remain at rest or an object in motion will remain at motion at constant velocity unless acted upon by external force.

In other word an object will remain in stationary position or remain in movement unless external force is applied to move or stop.

Application in Sports

A football placed at penalty point will remain at rest unless a player kicks the ball to score a goal, Or that same football will continue to move at a constant velocity unless a force acts on it to slow it down (e.g. wind resistance) or change its direction (e.g. gravity).

Second Law of Motion

Second Law of motion is also named as the 'Law of Acceleration'. According to this law the rate of change in velocity of an object is directly proportional to the force applied and inversely proportional to the mass of the body.

The greater the force applied the faster is the velocity and more is displacement. If less force is applied than the displacement and acceleration is also less

If unequal forces are applied to objects of equal mass the greater force will cause more acceleration. If equal forces are applied to objects on unequal mass, the object with mass, have less acceleration

Application in Sports

A Volleyball player pushes the ball slowly for a drop, whereas hits the ball hard for a smash.

Thus, drop is slow because there is less force applied, whereas smash is very fast as there is great force applied.

In the shot-put event a player who exerts more force and tosses the shot put at the correct angle has greater displacement.

Third Law of Motion

This law is also known as 'Law of Action and Reaction'

This law states that for every action there is an equal and opposite reaction.

Application in Sports:

In swimming if a swimmer pushes the water backward, in return he is pushed forward by the water.

When a person walks, he presses the ground in the backward direction and the ground pushes him in the forward direction with an equal force.

Friction & Sports

Friction is a force resisting the relative motion of solid surface, fluid layers and material elements sliding against each other. It generally creates obstruction to moving object.

It is created whenever two surfaces move or try to move across each other. It opposes the motion of one surface across another surface.

Friction depends on the texture of both surfaces and on the amount of contact force pushing the two surface together.

Types of Friction

There are two types of friction:

- i. **Static Friction:** It occurs when a body is forced to move along a surface but movement does not start. This friction is present between two or more solid objects that are not moving relative to each other.
Without static friction your feet would sleep out and it makes it difficult to walk.
- ii. **Dynamic/kinetic friction:** It occurs when two objects are moving relative to each other and work together. Further it is of two types
- iii. **Sliding Friction:** It is a kind of friction which acts on the object when it slides or rub over the surface. It is weaker than static friction. Sliding friction causes wear and tear
- iv. **Rolling friction:** It is a force that slows down the motion of a rolling object. It acts on objects when they are rolling over a surface.

Advantages of friction:

- **It helps to move:** Frictional force helps to move the object, e.g. running, walking with friction of feet and surface.
- **Stop the moving object:** It helps to stop the moving object by friction
- **Hold or grip object:** With the help of friction our fingers and palm enable us to grasp and hold objects.
- **Keep the objects at its position:** Friction can hold the object at its position.
- Disadvantages of friction
- **Makes movement difficult:** Friction can make the movement difficult. For example, excess friction can make a box difficult to slide on the floor.
- **Waste of energy:** Excess friction means extra energy, so extra energy is wasted because of friction.

Important Questions

➤ Multiple Choice Questions:

- Question 1. Biomechanics helps in _____
- a) Treating injuries to sports person
 - b) Improving performance of athletes

- c) Increasing friction between the athlete and the ground surface
- d) All of the above

Question 2. Abduction and adduction take place at which Axis

- a) Oblique
- b) Longitudinal or vertical
- c) Frontal or medio lateral
- d) Sagittal or anteroposterior

Question 3. Flexion and extension are

- a) Movements in the frontal plane about the said sagittal axis
- b) Movement in the sagittal plane about the frontal axis
- c) Movement in the horizontal plane about the vertical axis
- d) None of the above

Question 4. Biomechanics is a branch of

- a) Biology
- b) Kinesiology
- c) Science
- d) Physics

Question 5. _____ refers to the study of human movement including the interaction between the athlete Sports Equipment and the exercise environment

- a) Kinesiology
- b) Physical education
- c) Biomechanics
- d) Sports education

Question 6. Biomechanics can play a crucial role in

- a) Injury prevention
- b) Performance enhancement
- c) Physical movement
- d) Both a and b

Question 7. Which of the following is not a type of movement related to physical activity

- a) Extension
- b) Adduction
- c) Abduction
- d) None of this

Question 8. _____ takes place when the angle between two bones attached to a joint

- a) Flexion, increase
- b) Extension, decrease
- c) Adduction, increase

d) Extension, increase

Question 9. Understanding of proper sports and exercise movements will allow the participants to be more _____ for long-term development

- a) Efficient
- b) Technically sound
- c) Prone to good habits
- d) All of this

Question 10. Coaches should make use of the method of _____ biomechanical analysis in their everyday practice to produce changes in the techniques used by their students

- a) Quantitative
- b) Qualitative
- c) Effective
- d) None of these

Question 11. Which of Newton's Law of Motion deals with acceleration

- a) First
- b) Second
- c) Third
- d) None of these

Question 12. Why it is important to know biomechanics in sports

- a) Improve sports performance
- b) Prevent sports injuries
- c) Both a and b
- d) None of the above

Question 13. Sophisticated Sports Equipment gives advantage to _____ athletes

- a) Elite
- b) Recreational
- c) Both A and B
- d) None of the above

Question 14. This type of movement takes place when the angle decreases between the two bones attached to a joint. It is _____

- a) Adduction
- b) Abduction
- c) Extension
- d) Flexion

Question 15. Name the movement in which the angle decreases between the two bones attached to a joint

- a) Adduction
- b) Flexion

- c) Abduction
- d) Extension

➤ **Very Short Question:**

- Que 1. Define trajectory?
- Que 2. What do you mean by sport biomechanics?
- Que 3. What is power?
- Que 4. Define Work?
- Que 5. Explain Gravity?
- Que 6. What is Air-resistance?
- Que 7. Define velocity?

➤ **Short Questions:**

- Que 1. What is Friction? Discuss various types of Friction.
- Que 2. What is Energy? Explain about Kinetic & Potential Energy?
- Que 3. What is axis? What are its types?
- Que 4. What do you mean by plane? Explain its types.
- Que 5. Enumerate the laws of motion:
- Que 6. How Newton's second law and third law of motion can be applied in sports.
- Que 7. "Friction is a necessary evil." Justify your answer with suitable examples from sport.

➤ **Long Questions:**

- Que 1. Which muscles are used in jumping?
- Que 2. Which muscles do we use in throwing?
- Que 3. Define trajectory. Describe the factors affecting the trajectory of a projectile.
- Que 4. Elucidate the types of friction.
- Que 5. Describe different types of movements.

➤ **Assertion & Reason Questions:**

1. For two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

Assertion (A) Biomechanics is the study of force and its effects on the living system

Reason (R) In swimming third law of motion is utilized

- (a) Both A and R are true and R is the correct explanation of A
- (b) Both A and R are true and but R is not a correct explanation of A
- (c) A is true but R is false
- (d) A is false, but R is true.

2. For two statements are given-one labelled Assertion and the other labelled Reason. Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

Assertion (A) Abduction means moving the body parts away from the midline of the body

Reason (R) Adduction is another name for abduction

- (a) Both A and R are true and R is the correct explanation of A
- (b) Both A and R are true and but R is not a correct explanation of A
- (c) A is true but R is false
- (d) A is false, but R is true

✓ **Answer Key-**

➤ **Multiple Choice Answers:**

- 1. Answer: All of the above
- 2. Answer: Sagittal or anteroposterior
- 3. Answer: Movement in the sagittal plane about the frontal axis
- 4. Answer: Physics
- 5. Answer: Biomechanics
- 6. Answer: Both a and b
- 7. Answer: None of this
- 8. Answer: Extension, increase
- 9. Answer: All of this
- 10. Answer: Qualitative
- 11. Answer: Second
- 12. Answer: Both a and b
- 13. Answer: Both A and B
- 14. Answer: Flexion
- 15. Answer: Flexion

➤ **Very Short Answers:**

- 1. The flight path followed by a projectile is called it's trajectory.

2. Sport biomechanics is the study of forces and stresses of human movements & their effects, athletic performance and safety.
3. The rate of doing work or using energy is called Power.

$$\text{Power} = \frac{\text{Work done}}{\text{time taken to do work}}$$

4. Work refers to an activity involving a force and the movement in the direction of the force. It can also be defined as the work done by a constant force as the product of force and the distance moved in the direction of the force.

Work Done = Constant force × Distance moved in the direction of the force

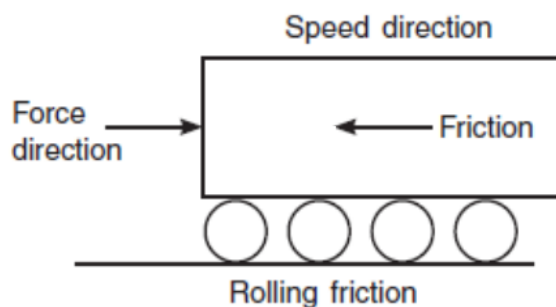
5. Gravity is the force of attraction exerted by the earth towards its centre on a body or an object.
6. When a projectile moves through the air, it is slow down by air-resistance.
7. The distance covered by an object per unit time is called velocity.

➤ Short Answer:

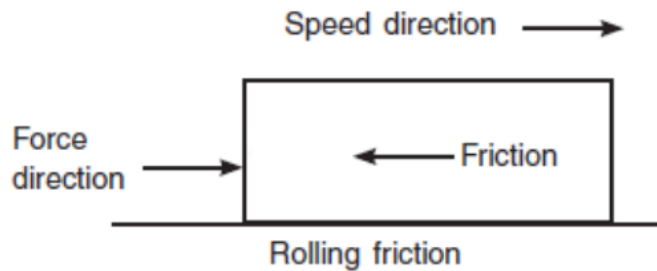
1. Friction is the force that combats relative motion between the two surfaces that come in contact. Friction always acts in the opposite direction of the applied force.

Friction can be of following types:-

- a) **Static friction:-** The opposite force that comes into play when one body tends to move over the surface of another, but the actual motion has not yet started.
- b) **Dynamic friction:-** The opposing force that comes into play when one body is actually moving over the surface of another body. Dynamic friction may be of two types.
- c) **Rolling friction:-** The opposing force that comes into play when body is actually rolling over the surface of another body. For example, hockey/ cricket ball is hit.



- d) **Sliding friction:-** The opposing force that comes into play when one body is actually sliding over the surface of the other body. For example- Ice skating.

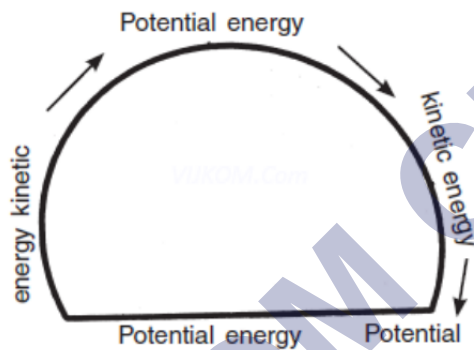


2. The Energy is the capacity to do work. There are various forms of energy.

Kinetic Energy:- It is defined as energy possessed by a body as a result of motion. It is called as—Kinetic energy = $\frac{1}{2}$ mass \times velocity² ($\frac{1}{2}mv^2$)

Potential Energy:- It is energy which is stored up in a body because of its position.

Potential Energy = mass \times gravitational force \times height of the body from ground (mgh)



3. An axis is an imaginary line about which the body (or limb) rotates. It can be divided in three parts

- a) Frontal Horizontal Axis Axis of the body that passes horizontally from side to side at right angles to the sagittal plane.
- b) Vertical Axis Axis of the body that passes from head to foot at right angles to the transverse plane.
- c) Sagittal Horizontal Axis Axis of the body that passes from front to rear lying at right angles to the frontal plane.

4. A plane is an imaginary flat surface along which a movement takes place.

It can be divided into three parts as follows:

- a) Sagittal Plane A vertical plane of the body which passes from front to rear dividing the body into two symmetrical halves.
- b) Transverse Plane Any horizontal plane of the body which is parallel to the diaphragm; also called the horizontal plane.
- c) Frontal Plane Plane of the body which passes from side to side at right angles to

the sagittal plane; also called the coronal plane.

5. The three laws of motion are:

a) Newton's First Law of Motion This law is also known as law of inertia. This law states that a body at rest will remain at rest and a body in motion will remain in motion at the same speed and in the same direction till any external force is applied on it to change that state.

b) Newton's Second Law of Motion This law states that the acceleration of an object is directly proportional to the force producing it and inversely proportional to its mass.

$$a = F/m \text{ where } a \propto F, a \propto 1/m$$

c) Newton's Third Law of Motion This law states that to every action there is always an equal and opposite reaction. This law describes what happens to a body when it exerts a force on another body.

6. Second Laws If a baseball player hits a ball with double the force the rate at which the ball will accelerate (speed up) will be doubled. Football players can slow down stop or reverse the direction of other players depending upon how much force they can generate and in which direction.

Third Law A swimmer propels herself through the water because the water offers enough counter force to oppose the action of her hands pushing allowing her to move. An athlete can jump higher off a solid surface because it opposes his body with as much force as he is able to generate in contrast to sand or another unstable surface.

7. Friction is usually called a necessary evil. It means that it is essential in games and sports. Without friction we cannot give a better performance in the field of sports. Examples are spikes used by athletes for running and studs used in football boots of the players. However, friction has disadvantages also. In cycling, there should not be more friction between road and the tyres of the cycle.

➤ **Long Answer:**

1. Following muscles are used in jumping:

a) Quadriceps The quadriceps rest on the front of the thighs and they have four components: the vastus medial vastus lateral rectus femoris and vastus intermedius. During a jump you perform hip flexion and knee extension which both activate the quadriceps. Hip flexion takes place when you move your thigh toward your stomach; knee extension takes place when you straighten your leg. A squat is a specific exercise that can help you gain more strength in the quads.

b) Hamstrings The hamstrings are opposing muscles to the quadriceps and have

an opposite function. You activate your hamstrings through hip extension and knee flexion. Hip extension takes place when you bend your knee and move your heel toward your butt. Hip extension also causes you to work the glutes. From an anatomical standpoint the hamstrings have three parts: the biceps femoris semimembranosus. All parts get activated during the lowering phase and the explosive phase of a jump. A squat works the hamstrings but you can place more emphasis on them by doing a lunge.

- c) Hip Flexors The hip flexors run from the lower stomach to the top of the thighs. They consist of the psoas major and iliacus and because of this they are often referred to as the iliopsoas. As the name implies these muscles get activated when you flex your hip in similar fashion to the quads.
- d) Although these muscles are small they are important for explosive motions like sprinting a jumping. A lying leg raise is a good exercise to strengthen the hip flexors.
- e) Calves The calves have two parts the gastrocnemius and soleus. The gastrocnemius has a lateral head and medial head and it is easily seen on the back of the leg right below the knee. The soleus sits anterior or in front of the gastrocnemius-. Both parts function to plantar-flex the foot. This motion occurs when you jump off the ground and point your toes downward.

Jumping rope is a good cardiovascular exercise to train these muscles because of the repetitive hopping you do on your toes. A tuck jump is a good exercise to work your calves because it is specific to jumping.

2. Following are the muscles which are used While throwing anything like ball football etc:

- a) Shoulder Muscles The deltoids are the muscles of your shoulder which play a crucial role in rotating your arm. Always warm up adequately by performing arm circles to avoid injuring your rotator cuff while performing shoulder exercises.
- b) Triceps Your triceps are located on the back of your upper arm and aid in the process of extending your arm at the elbow. This action helps you release the ball with force and push it in the desired direction. To strengthen your triceps efficiently perform exercises such as triceps pushdowns with a rope or pulley and close-grip bench presses.
- c) Latissimus Dorsi Your latissimus dorsi often referred to as your lats are located on either side of your spine. These large muscles help produce force for throwing and help transfer energy from your legs to your upper body. Among the best exercises for strengthening your lats are pull up seated cable rows and bent-over barbell rows.

- d) **Abdominals** While many people exercise their abdominal muscles in hopes of attaining a six-pack this muscle group is highly functional as well. A strong core facilitates the transfer of power from your lower body to your upper body enabling your throws to benefit from the strength of your legs. Among the best exercises for your abs are hanging leg raises and Swiss ball crunch.
- e) **Quadriceps** The quadriceps is the major muscle group located on the front of your thigh. This large group of muscle tissue helps you power the ball toward your intended target as you step into your throw. Among the most effective exercises for the quadriceps are the barbell step-up barbell lunge and barbell squats which also work your abdominal muscles.
3. A trajectory is a path described by a moving object or the path followed by a projectile. Examples are kicking a soccer ball a throw in cricket throwing a hammer etc.

Factors affecting projectile trajectory are:

- a) **Propelling Force:-** The propelling force produces certain effects depending upon its point and direction of application. If the application is directly through the projectile's centre of gravity only linear motion results from the force.

As the projecting force is moved further from the centre of gravity rotatory motion of the object increases at the expense of linear motion.

If the force is below the object's centre of gravity backspin results. Forward spin results when the force is above the centre of gravity. When the force is off centre to the left clockwise spin results and when it is off centre to right counter-clockwise spin occurs.

- b) **Force of Gravity:-** As soon as contact is broken with a projected object the force of gravity begins to diminish the upward velocity of the object. Finally gravity overcomes the effects of the upward component of the projectile's motion and the object begins to descend. The factors that determine how soon gravity will cause the object to descend are-

- weight (mass) of the object
- amount of force driving it upward
- the effects of air resistance on the object.

- c) **Effect of Air Resistance:-** As the speed of an object increases air resistance has a greater retarding effect. The more surface area an object presents in the direction of movement the greater will be the effect of air resistance.

4. 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 very important in sports. The

larger the area of contact between the surfaces, the greater is the force of friction. When both the surfaces are smooth, the force of friction reduces to almost zero.

Three types of friction are:

- a) Static Friction The opposing force that comes into play when one body tends to move over the another surface but the actual motion has not yet started.
 - b) Limiting Friction Limiting friction is the maximum opposing force that comes into play when one body is just on the verge of moving over the surface of another body.
 - c) Kinetic Friction Kinetic friction is the opposing force that comes into play when one body is actually moving over the surface of another body.
5. Physical activity is made possible by movements and motions. Every movement takes place in one plane and around one axis.

They are categorised by movement type as follows:

- a) Flexion It takes place when the angle decreases between the two bones attached to a joint.
- b) Extension It takes place when the angle between the two bones attached to a joint increase. Both flexion and extension occur in the sagittal plane about the frontal axis.
- c) Adduction It is a movement laterally toward the middle of the body.
- d) Abduction It is a movement laterally away from the middle of the body. Both adduction and abduction occur in the frontal plane about the sagittal axis.

➤ **Assertion and Reason Answers:**

1. (b) Both A and R are true and but R is not a correct explanation of A.
2. (c) A is true but R is false.