



# UNIT 8

# Biomechanics and Sports

## LEARNING OBJECTIVES

- 8.1 Meaning and importance of Biomechanics in Sports
- 8.2 Types of Movements (Flexion, Extension, Abduction and Adduction)
- 8.3 Newton's Law of Motion and its Application in Sports
- 8.4 Friction and Sports

## INTRODUCTION

From the moment we wake up in the morning to the moment our heads hit the pillow at night, we perform hundreds of different movements and engage in a wide array of physical activities. Human movement affects our personal health, wellness, and physical achievements in distinct ways, providing a unique opportunity to explore and interact with the world around us.

In a way, biomechanics has been around since the ancient Greek and Roman began dissecting animals and vivisectioning humans to discover the inner systems of our bodies. Many of the great philosophers and scientists of our past tried their hand at some form of biomechanics, from Aristotle, who wrote On the Motion of Animals in the 4th century BC, to Leonardo da Vinci, who studied human muscle and joint function in 15th century Italy. In the 19th century, scores of Europeans were incredibly fascinated, for some reason, with the gait of horses and extensively studied the biomechanics of a horse's galloping motion.



## 8.1 MEANING AND IMPORTANCE OF BIOMECHANICS IN SPORTS

Biomechanics word is a combination of two words i.e. 'Bio' and 'mechanics'. 'Bio' means living things and 'mechanics' means the field of physics i.e. the forces related to body movements. It can also be

said that **Biomechanics is the study of forces and their effects on living systems.** The study of biomechanics provides the knowledge of human body movements and the forces that act on human movements. Biomechanics helps to know about the correct movements and helps in better performance.

The principles of biomechanics can also be used or applied in many fields of study including biology, physical and occupational-therapy, physiology, engineering, aerospace engineering and medicine. Biomechanics plays an important role in physical education field especially in games and sports. It helps in the study of biological movements of the athletes and players based on the principles of physics. Essentially biomechanics in sport is focused on analysing the physiological mechanics of human movement. This includes analysis of how forces interact and the effects these forces have on and within the body. In other words biomechanics in sports examines and explains why and how the human body moves like it does. Biomechanical analysis is also helpful in reducing sports injuries and increasing safety. To be effective teachers of physical education, coaches and other sports professionals should have an understanding of the principles of biomechanics.

## **NEED AND IMPORTANCE OF BIOMECHANICS IN SPORTS**

- (i) **Improves performance in sports** : The major goal of biomechanics in sports and physical exercise is to improve performance in given sport or physical exercise. For example the correct biomechanics of running allows athletes to carry out regular physical exercise for long enough periods of time without being seriously limited by injuries and their consequences.
- (ii) **Improvements in techniques** : In many sporting events, technique is the major factor of performance. Sport technique is a physical action of an athlete which leads to the best possible execution of a physical motion in conformity with a required task of a given sporting event. Improvement of technique with the help of biomechanics can be used by teachers and coaches to correct motions of students or athletes.
- (iii) **Development of better sports equipment** : Use of biomechanics can also lead to a better look and better functioning of sport equipment. Sophisticated sport equipment gives advantage to both elite and recreational athletes. For example an introduction of the new vaulting equipment (vaulting table) after the 2000 Olympics represents the most substantial transition in the development of gymnastics equipment in the last decades. New vaulting equipment allows gymnasts to produce bigger angular momentum and thus to execute more complex vaults with multiple rotations around horizontal and vertical axes.
- (iv) **Improves training techniques** : Biomechanics can help improve training of athletes. By the analysis of technical imperfections of a given athlete, the coach identifies the type of training needed for the athlete to improve.
- (v) **Prevent sports injuries** : One of the goals of sports biomechanics is to provide recommendations for injury prevention and rehabilitation. A healthy athlete will perform better than an athlete plagued with frequent injuries.
- (vi) **Helps in understanding human body** : An athlete is limited by strength or endurance of certain muscle groups, by speed of motion, or by specific aspects of motion technique. In the case of certain sport skills the required abilities to execute a motor task are not easy to detect and quantitative biomechanics analysis must be used.

There are several "types" of movement in joints that are described in anatomical terms. These are:

- (i) Gliding Movement
- (ii) Angular Movement
- (iii) Rotation
- (iv) Circumduction.

1. **Gliding Movement:** It is the type of movement in which one surface moves or glides over another surface. It is the simplest type of movement in which there is no rotation or angular movement involved. It is common in all of the joints but it occurs in combination with the angular movements. However, in smaller joints such as hand and feet (carpal and tarsal joints), these are the only movements.

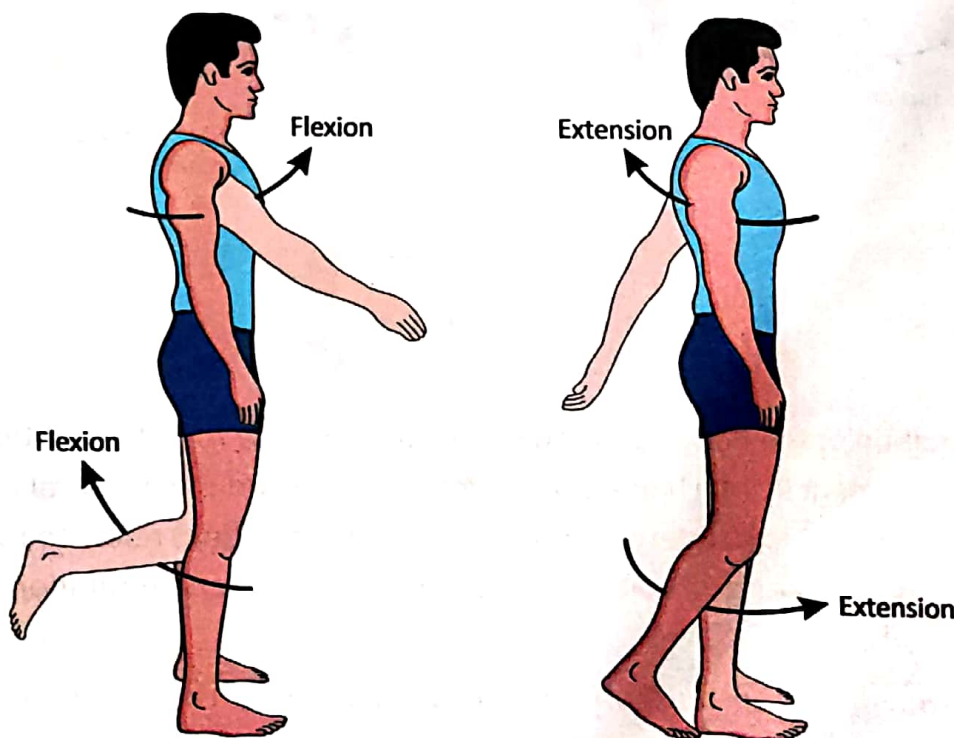
2. **Angular Movement:** This type of movement occurs between the long bones causing a change in the angle between the two bones. The angle either increases or decreases. Various angular movements are flexion, extension, abduction and adduction. These are explained in detail below:

## FLEXION AND EXTENSION

These movements occur in the sagittal plane and around a frontal horizontal axis. They refer to an increase or decrease in angle between two body parts.

**Flexion** takes place when the angle between the two bones attached to the joint being affected decreases. When you flex your knee, the angle between your femur (thigh bone) or upper leg and your tibia/fibula or lower leg decreases.

Examples of flexion include Tuck jump, Front dumbbell raise, Bicep curl.



**Extension** is the opposite of flexion. Extension occurs when the angle between the two bones increases. When you straighten or extend your knee joint the angle between your upper and lower leg increases.

Examples of extension include Straight leg dead lift, Triceps press down, Military press.

## ABDUCTION AND ADDUCTION

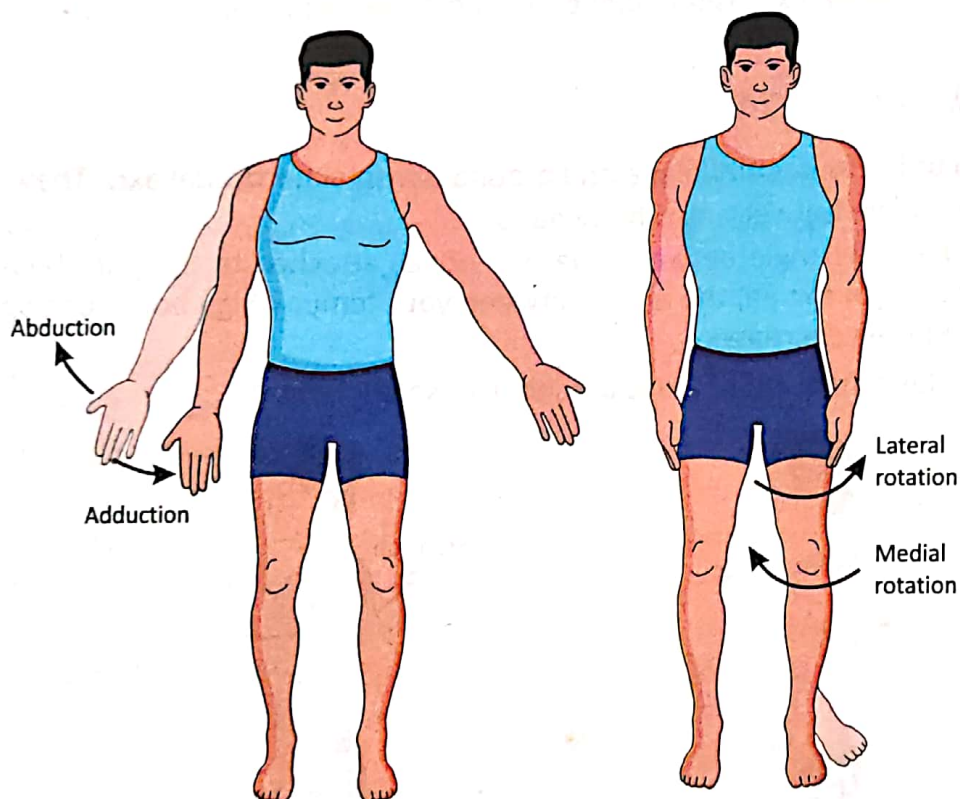
These two movements are in the frontal plane and around a sagittal horizontal axis.

**Abduction** is a movement laterally away from the midline or centre of your body. From a standing position, when you move your leg to the side away from the middle of your body you are abducting your leg.

Examples of abduction include Straight arm dumbbell side raise, Star jump, Hip abduction machine.

**Adduction** is a movement in the opposite direction and towards the centre of your body. When you return your leg from the abducted position back to a normal standing position you are adducting your leg.

Examples of adduction include Cable crossover pull down, Supine dumbbell flies, Hip adduction machine.



- 3. Rotation :** Rotation of the body parts can be towards or away from the center of the body. It is a form of movement in which the movement of bone is around a central axis without any displacement from the axis. Internal rotation (or medial rotation) refers to rotation towards the axis of the body. External rotation (or lateral rotation) refers to rotation away from the center of the body.
- 4. Circumduction :** Circumduction can be described as the movement of joints in a circular motion. It is the movement which takes place between the articular cavity and the head of a bone. It can also be visualized as a circular motion of the part being moved. It is a combination of Flexion, Extension, Abduction and Adduction. It is most prominently seen at shoulder and hip joints.

## 8.3 NEWTON'S LAW OF MOTION AND ITS APPLICATION IN SPORTS

There are 3 laws of motion as given by Sir Issac Newton. These are described below.

### 1. NEWTON'S FIRST LAW OF MOTION : LAW OF INERTIA

According to the first law of motion an object at rest will remain at rest or an object in motion will remain at motion at constant velocity unless acted upon by a force.

An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force.

In other words, a motionless object or body will remain motionless (in the same position) unless a net force (external force) disturbs it or acts on it. Similarly a body, moving with a constant speed along a straight path, will keep on moving unless some force acts upon it and alters its speed or direction of the motion.

Newton's first law can be applied to any sporting activity. It explains two fundamental concepts linked with motion and force:

- (i) It tells us that a stationary body will remain at rest until an external force is applied. For example, for a pass in basketball, the ball will remain in the player's hands until he applies a force to the ball to pass it to a teammate.
- (ii) It tells us that a moving body will continue to move with constant velocity until made to change its speed and/or direction by an external force. For example, A moving football slows down and then stops after some time. It comes to rest due to the friction between the ground and the ball.



### 2. NEWTON'S SECOND LAW : THE LAW OF ACCELERATION

Newton's second law of motion is an expression of the interrelationship among force, mass and acceleration. This law is known as the law of acceleration. The second law states that the

acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. As the force acting upon an object is increased, the acceleration of the object is increased. As the mass of an object is increased, the acceleration of the object is decreased.

- (i) In football, a forward player who has received the ball in a strong position close to the goal will only need to impart a relatively small amount of force in the direction of the goal. However, a forward player who has been forced



to the edge of the shooting circle before taking a kick will need to impart a larger amount of force in the direction of the goal as the ball will need a greater change in momentum to travel to the goal.

- (ii) A cricket player while catching a ball moves his hands backwards. Initially the ball is moving with a certain velocity. The player has to apply a retarding force to bring the ball at rest in his hands. However, in baseball, player hits the ball hard to throw it far away.

### 3. NEWTON'S THIRD LAW OF MOTION : THE LAW OF REACTION

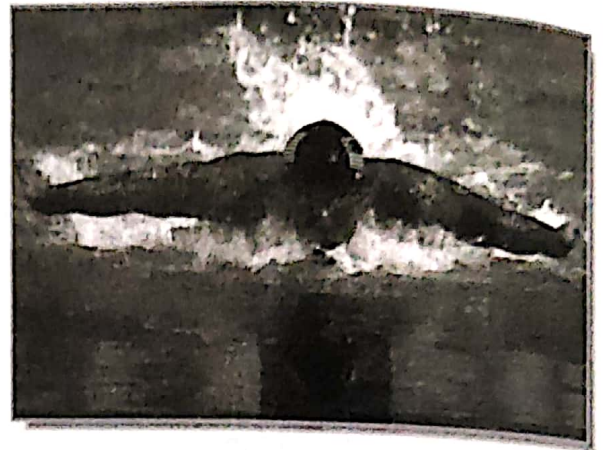
According to the Newton's third law of motion, to every action there is always an equal and opposite reaction.

The third law of motion is also called the law of reaction.

**Example 1 :** Springing from a diving board is an example of the law of action and reaction. The more force one exerts on the downward bounce, the higher he bounces into the air.

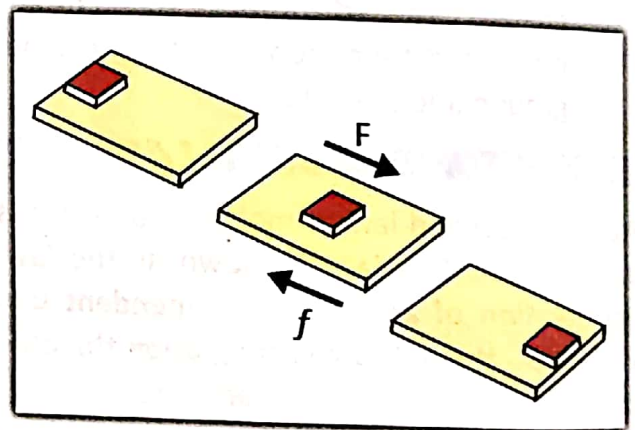
**Example 2 :** When a swimmer pushes the water backward (action), the water pushes the swimmer forward (reaction).

**Example 3 :** Walking, when a person walks, he presses the ground in backward direction by his feet (action) and the ground pushes him in forward direction (reaction)



### 8.4 FRICTION AND SPORTS

Friction is a force between two surfaces that are sliding, or trying to slide, across each other. The force that opposes the motion of an object is called friction. To stop a moving object, a force must act in the opposite direction to the direction of motion. For example, Look at this diagram. At first, the book is at rest. A push causes the book to slide across the desk. The force of the push (big  $F$ ) keeps the book moving. As the book slides across the desk, a force of friction ( $f$ ) acts in the opposite direction. The friction slows down the motion of the book. Finally, the book is once again at rest.



Friction always works in the direction opposite to the direction in which the object is moving, or trying to move. Friction always slows a moving object down. The amount of friction depends on the materials from which the two surfaces are made. The rougher the surface, the more friction is produced. Friction also produces heat. If you rub your hands together quickly, you will feel them get warmer.

## TYPES OF FRICTION

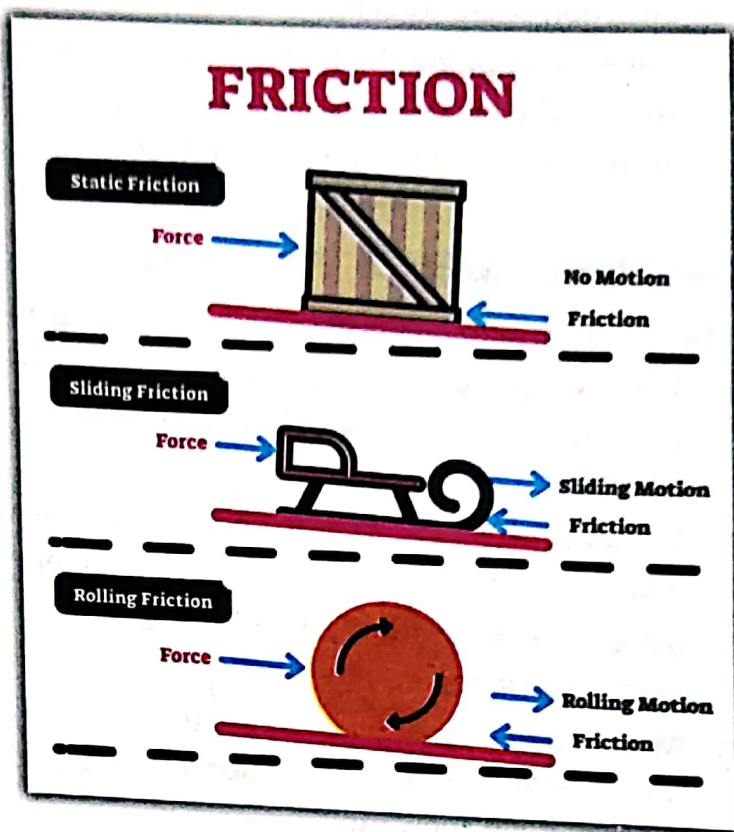
Friction is of two types :

(i) **Static Friction** : The force of friction which acts between two surfaces before the motion actually begins is called static friction. Static friction is also called limit friction because it represents the biggest possible friction between given surfaces under given conditions.

(ii) **Dynamic or kinetic friction** : The force of friction which comes into play when a body moves over the surface of another body is called dynamic/kinetic friction.

(a) **Sliding Friction** : When an object slides or tends to slide over another object, it is called sliding friction. In this type, friction depends on the types of object and its surface. For example, sharpened ice skate blades reduce friction between the blade and the ice.

(b) **Rolling Friction** : Rolling friction can be seen in the movement of wheel. In other words a wheel rolling across a surface is called rolling friction. In this type of friction also, nature of surface plays an important role. For example on a rough surface, the friction will be more and on a smooth surface, the resistance will be less.



## APPLICATION OF FRICTION IN SPORTS

Friction is usually called a necessary evil. Practically every single sport relies on friction in some way. Friction in sport and physical exercise is sometimes an advantage and sometimes a disadvantage.

## ADVANTAGES OF FRICTION

- Helps in movement** : It is difficult to walk on a slippery road due to low friction. When a person moves on ice, it becomes difficult to walk due to the low friction of the ice with the shoe. The friction between the sole of a shoe and the surface of the ground prevents us from slipping. Athletes (racers and jumpers) use spikes and football players use studs in their shoes to have proper friction while they run fast. Without friction it would not have been possible for us to walk.
- Helps in holding objects** : Friction enables us to hold the objects and equipments. Without friction the equipments would just fall out of the hand. Handles of hockey sticks and tennis racquets are covered with special tapes to increase friction.

3. **Helps to catch objects** : Friction between hand and ball allows us to catch and throw the ball.
4. **Helps in changing direction** : Friction between feet and ground helps an athlete to change direction while running.
5. **Helps in stopping the moving objects** : When you apply the brakes of a car, friction helps to stop it. The brake or disc pad pushes against the inside of the brake drum or against the rotor inside the moving wheel. The surface of the drum or rotor, slide against the brake disc or pad, which is a force of friction that slows the vehicle down.

## **DISADVANTAGES OF FRICTION**

Friction is disadvantageous in some sports and games. For example :

1. **Wastes energy** : In cycling if there is more friction between road and tyres, there will be more wastage of energy of the cyclist. The tyres must be properly inflated to reduce force of friction.
2. **Wears things out** : Due to friction, there is wear and tear of object. Lubrication is used to allow the parts to move easier, moreover, prevents wear and tear.
3. **Slows speed** : Friction slows down the speed. Rolling shoes and smooth surface are used to minimize friction in roller skating.
4. **Makes movement difficult** : Friction can make the job more difficult when one has to move the other object. Excess friction can make it difficult to slide a box across the floor, walk through deep snow etc.
5. **Causes Injuries** : Friction can cause injuries if a player slides across the ground.
6. **Limits the ball flight** : Friction between ball and air limits how far the ball can be thrown.
7. **Heats parts** : Constant rubbing of two surfaces together creates heat energy and is threat of overheating due to friction.

Thus it can be said that friction has its advantages and disadvantages in various sports.

## **METHODS OF REDUCING FRICTION**

- (i) **Polishing the surface** : Friction can be reduced by polishing and rubbing the surface to reduce their unevenness and making the surface smooth.
- (ii) **Lubrication** : Lubricants such as oil, grease etc are used to minimize the force of friction.
- (iii) **Streamlining** : Streamlining applies to the friction generated by the wind and liquids. By adopting a more streamlined shape, the flow of air or liquid will be smoother and easier against the surface of a particular object.
- (iv) **Ball bearing or roller bearing** : The use of ball bearings and rollers greatly reduces friction between surfaces, as it changes the nature of the relative motion between the surfaces from sliding to rolling.
- (v) **Special Designing** : Now days, specially designed helmets are used in some sports to reduce friction and save important time. These helmets reduce friction by allowing air to flow over the head and down the back.



## **METHODS OF INCREASING FRICTION**

- (i) By making both the surfaces rough. In this way irregularities of both surfaces will be interlocked. e.g. spikes on soles of shoes.
- (ii) By making both the surfaces highly smooth. In this way molecular attraction between the two surfaces will increase. e.g. ten pin bowling.
- (iii) **Using Magnesium Powder** : In some sports like weight lifting, gymnastics, outdoor/ indoor rock climbing, badminton, tennis, basketball, golf, bowling, baseball and Pole dancing, athletes always smear white powder (magnesium powder) into their hands and instruments. When playing the athletes sweat in the hands and wet hands reduce the frictional force, making it difficult for athletes to hold instruments well, thus affecting the effect of the action, easily to make a mistake and injured. In this condition, magnesium carbonate powder can absorb the palms sweat, at the same time it also can increase the friction between the palms and instruments. In this way, athletes can hold instrument perfectly.