UNIT-8: BIOMECHANICS AND SPORTS

Content

- Meaning and Importance of Biomechanics in Sports
- Types of Movements (Flexion, Extension, Abduction and Adduction)
- Newton's Laws of Motion and Its application in Sports
- Friction and Sports

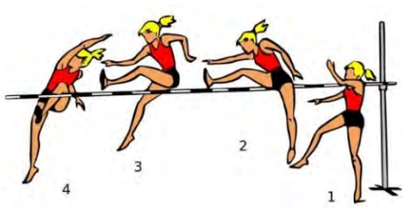
Learning Outcomes

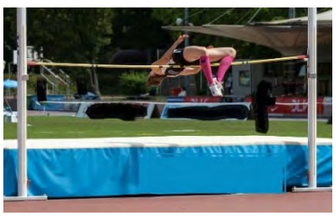
At the end of this unit students will be able to:

- recognize the concept of sports biomechanics
- know the importance of biomechanics in sports
- classify the various types of movements (such as flexion, extension, abduction and adduction) as well as know the forces involved in it
- define Newton's laws of Motion and identify their applicability in sports
- define friction and its usage in sports

Discussion

Look at the pictures of the various techniques of high jump carefully. and then read the paragraph given below.






Now, discuss in your group

- What are the techniques used in high jump?
- Why do different players adopt a specific technique?
- What do you know about the Fosbury flop? Why is it so called?
- What is the best high jump technique?
- Which biomechanical principle is applied in high jump?

Study of biomechanics provides you with some insights to answer these and other questions you may have about human movement.

8.1.1 Meaning of Biomechanics

It was realized after 1950 that the mechanical principles involving on the human body is entirely different from other things. So, during the early 1970s the international community adopted the terms Biomechanics to describe the application of mechanical principles in the study of living organisms.

Biomechanics is the combination of two words- **bio** and **mechanics**. *Bio* means, s***omething 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.

Within "mechanics" there are two sub-fields of study. One is ***statics*** which is the study of systems that are in a state of constant motion either at rest (with no motion) or moving with a constant velocity; and the second one is ***dynamics***, which is the study of systems in motion in which acceleration is present, which may involve ***kinematics*** and ***kinetics***.

Kinematics is the study of the motion of bodies with respect to time, displacement, velocity, and speed of movement either in a straight line or in a rotary direction. Whereas, ***Kinetics*** is the study of the forces associated with motion, including forces causing motion and forces resulting from motion.

8.1.2 Meaning of Sports Biomechanics

Sports biomechanics is a quantitative based study and analysis of professional athletes/sportspersons and sports activities in general. In simple terms, it may be described as the physics of sports. In this subfield of biomechanics, the laws of mechanics are applied to sporting events through mathematical modelling, computer simulation and measurement in order to gain a greater understanding of athletic or sporting performance.

Mechanics is a branch of physics that is concerned with the description of motion/movement and how forces create motion/movement. Biomechanics in sport incorporates detailed analysis of sport movements in order to minimise the risk of injury and improve sports performance. Sport as well as exercise biomechanics encompasses the area of science concerned with the analysis of the mechanics of human movement. It refers to the description, detailed analysis and assessment of human movement during sport activities.

In other words, sport biomechanics is the science of explaining how and why the human body moves in the way that it does. In sport and exercise that definition is often extended to also consider the interaction between the performer and her/his equipment and environment.

Do you know?

- A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modelling. Mathematical models are used in the natural sciences (such as physics, biology, earth science, chemistry) and engineering disciplines (such as computer science, electrical engineering), as well as in the social sciences (such as economics, psychology, sociology, political science).
- Computer simulation is the reproduction of the behaviour of a system using a computer to simulate the outcomes of a mathematical model associated with said system. Since they allow to check the reliability of chosen mathematical models, computer simulations have become a useful tool for the mathematical modelling of many natural systems in physics (computational physics), astrophysics, climatology, chemistry, biology and manufacturing, as well as human systems in economics, psychology, social science, health care and engineering. Simulation of a system is represented as the running of the system's model. It can be used to explore and gain new insights into new technology and to estimate the performance of systems too complex for analytical solutions.

8.1.3 Definitions of Sports Biomechanics

"The area of study between wherein knowledge and methods of mechanics are applied to the structure and function of the living human system." [1]

"The area of study where the knowledge and methods of mechanics are applied to the structure and function of the living human system."[2]

"Biomechanics is the science concerned with the internal and external forces acting on a human body and the effects produced by these forces".[3]

8.1.4 Importance of Biomechanics in Sports

Sports biomechanics is limited to the study those individuals who are involved in exercise or sports or any physical activity. Sports biomechanics can be defined as the study of forces and their effect on individuals while he/she is exercising or taking part in any sporting activity. The following are some of the areas where biomechanics is applied, to either support the performance of athletes or solve issues in sport or exercise.

- Performance Enhancement,
- Technique Improvement,
- Equipment Improvement,

- Training Improvement, and
- Injury prevention and rehabilitation.

Performance Enhancement: The ultimate goal of sports biomechanics is improvement of sports performance or improvement in the benefits of exercising. Understanding biomechanics and applying the mechanical principles helps improve an individual's technique and enhance performance by utilising the equipment he/she uses more effectively and by modifying the specific training method. By studying how the human body moves, we can remove stress and pressure on the bones, joints, muscles and ligaments. This results in improved athletic performance.

Helps in Improvement of Technique: A sportsperson's performance can be improved by improving her/his technique. The application of biomechanical principles can be applied to improve technique in two ways. First, the coaches may use their knowledge of biomechanics to rectify the errors made by the sportsperson in order to improve the execution of a skill. Second, the sportsperson may discover a new and more effective technique for executing a sports skill.

Do you Know

Researchers have recently also developed a new swimming suit which helped swimmers at the Sydney Olympics in 2000 better several world records because it has a favourable influence on the draft force and buoyancy of water that is acting against swimmers. This swimming suit had such an influence on sport performance in swimming, in fact, that its use was later banned.

Improvement of Equipment: How else can biomechanics contribute to performance improvement? What about improved designs for the equipment used in various sports? Shoes and apparel (sports cloth) constitute the equipment used in almost every sport. The equipment worn may have an effect on the performance, either directly or through injury prevention. Besides shoes and apparel, many sports require the use of some sort of tools.

Think of sports in which an implement is used in your institution. How have changes in sports implements changed performances in these sports? What about bicycling, swimming, tennis, golf, hockey, high jump, javelin throw, soccer, basketball, etc. Lighter and better-designed implements have not only contributed to improved performances by elite athletes in these sports, they have contributed to improved performances by recreational participants as well.

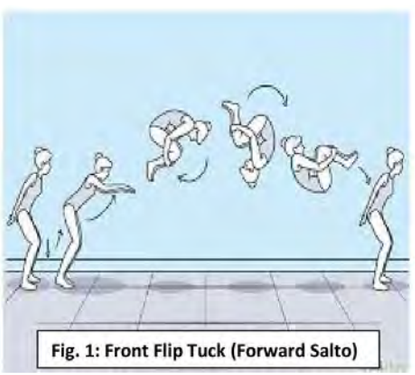


Fig. 1: Front Flip Tuck (Forward Salto)

Improvement in Training: Biomechanics helps improve a sportsperson's performance by offering customised modifications in training to suit an individual's capacity and skills. This can occur in several ways. An analysis of the deficiencies of an athlete's technique can assist the coach in identifying the type of training the athlete requires to improve performance. The athlete's performance, for example, may be limited by the strength or endurance of certain muscle groups, by speed of movement, or by one specific aspect of his/her technique. For example, if a gymnast has difficulty in turning a somersault, the coach could recommend she/he (a) jumps higher, (b) flings arms with more energy before taking off, or (c) curls up more tightly in order to execute the somersault correctly. All these recommendations are based on the principles of biomechanics. Sport events that saw substantial changes in technique in the past include javelin, high jump, and cross-country skiing.

Injury Prevention and Rehabilitation: Injuries are fairly common on the sports field. However, a good knowledge of biomechanics helps in preventing injury in various ways. For example, analysis of the runner's style of running, her/his arm swing, foot strike, even trunk leaning will determine the cause of injury. In fact, just as biomechanics is useful in identifying what forces may have caused an injury, it also helps determine how to prevent the injury from reoccurring. It also helps in the process of rehabilitation of injuries, and helping determine the exercises that may help in the process of rehabilitation of injury. Biomechanics is used to provide the basis for changes in techniques, equipment and training to prevent injuries.

Facilitates in Understanding of Human Body: Biomechanics helps in understanding the complete human body. Knowledge of biomechanics provides the teachers and learners with a better understanding of the human body and various internal and external forces that affect movement. Teachers and Coaches come to know about the various systems such as nervous system, muscular system, skeletal system etc., and their mutual interactions. This knowledge in turn enables them to be better teachers/instructors of many physical activities and skills encompassed within physical education.

I. Tick the correct options.

1. The term 'biomechanics' to describe the application of mechanical principles in the study of living organism was adopted in

   (a) **early 1970s**

   (b) late 1970s

   (c) 1970

   (d) early 1980s

2. The field where the study of forces is in focus is known as

   (a) dynamics

(b) kinematics

(c) statics

(d) **kinetics**

3. Sports biomechanics cab be described as-

(a) mechanics of sports

(b) kinesiology

(c) **physics of sports**

(d) sports dynamics

II. Answer the following questions briefly.

1. Define biomechanics.
2. What do you understand by the concept of sports biomechanics? Write in your own words.

III. Answer the following questions in 150-200 words.

1. List the importance of sports biomechanics.
2. Differentiate between biomechanics and sports biomechanics.

Extension Activity

Discuss with your group

- What is biomechanics and sports biomechanics?
- How can study of sports biomechanics helps a coach to train their trainee in a better scientific manner?

Design a poster to show the importance of sports biomechanics for an athlete.

8.2.1 Movement

Body movement is something that gets polished as we grow in age. In our childhood, we tend to start with basic movements such as rolling, crawling and eventually walking. But have you ever actually decoded, how this happens? What are all body parts involved? In this section, you will learn the exact meaning of movement and its various versions experienced in human beings.

Movement is one of the things that differentiates a living thing from a non-living thing. Movement refers to a change in the position of an object. In the human body, it takes place when the living organism moves a body part or a combination of parts to bring without a change in the position. We use the term locomotion to describe the movement which results in the change of position of the whole organism. It is important to understand the

difference between the two – movement and locomotion – in relation to living things. Movement is the displacement of a body or its parts from their original position to a new position. Locomotion is when the movement of a part of the body leads to change in the position and location of the organism. Both of these are brought about by the joint efforts of the skeletal and muscular systems. Movement is seen in both vertebrates and invertebrates.

There are a variety of movements which happen in the human body, eg., the movement of eyelids, heart muscles, jaw and teeth. In addition, movement could also refer to movement of arms and legs, as well as head and neck. Interestingly, movement of some organs occur because of the collaboration of muscles and bones. In these cases, it happens along a point at which two or more bones form a joint.

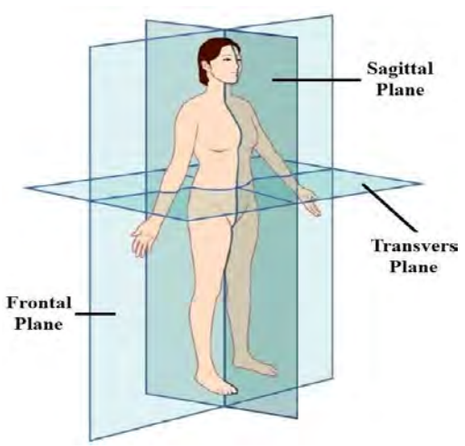
Human movements are described in three dimensions based on a series of planes and axis.

Plane

A plane is an imaginary surface through movement takes place. There are three planes of motion that pass through the human body.

- Sagittal plane
- Frontal plane
- Transverse (horizontal) plane

Sagittal Plane: The sagittal plane is an imaginary vertical surface which divides the body into right and left parts or sections. Flexion and extension types of movement occur in this plane, eg., kicking a football, chest pass in netball/basketball, walking, jumping, squatting.



Frontal Plane: The frontal plane is also an imaginary vertical surface which divides the body into front (anterior) and back (posterior) parts or sections. Frontal plane is also known as Coronal plane. Abduction and adduction movements occur in this plane, eg., jumping jack exercises, raising and lowering arms and legs sideways, cartwheel.

Transverse Plane: The transverse plane is an imaginary horizontal surface which divides the body into upper (superior) and lower (inferior) parts or sections. Rotation types of movement occur in this plane, eg., hip rotation in a golf swing, twisting in a discus throw, pivoting in netball/basketball, spinning in skating.

Axis

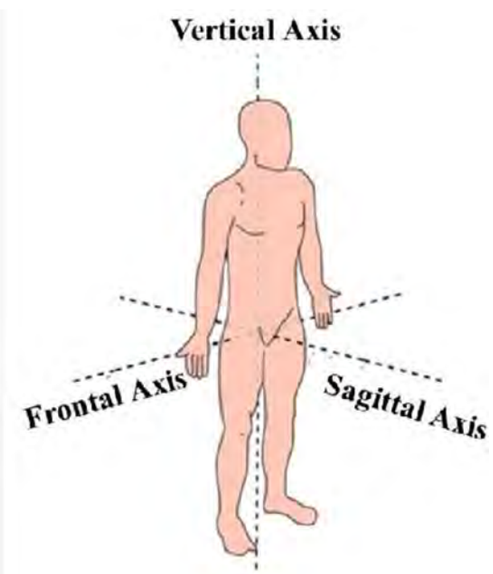
An axis is an imaginary straight line around which an object/parts of human body rotates. Movement at a joint takes place in a plane about an axis. There are three axes of rotation.

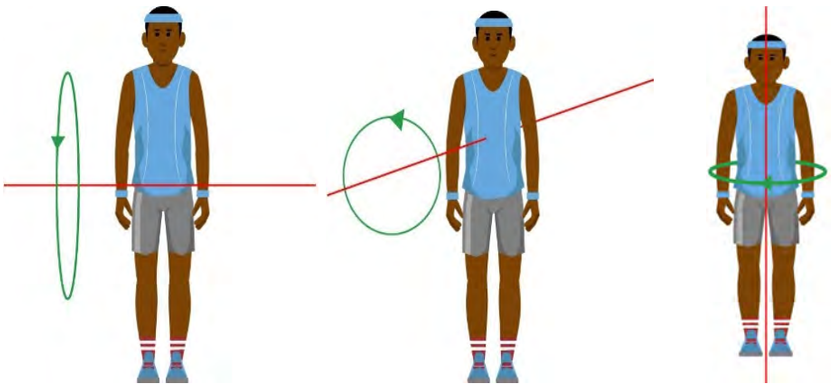
- Sagittal axis
- Frontal axis
- Vertical axis

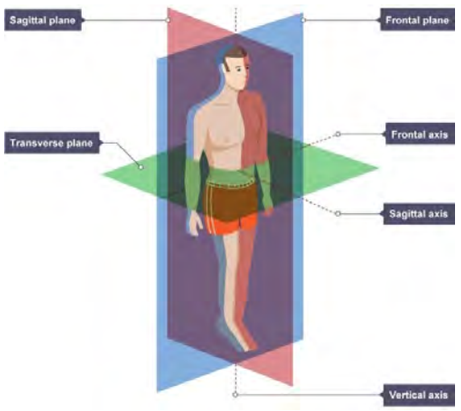
Sagittal Axis: The sagittal axis also known as anteroposterior axis or dorsoventral axis. It is an imaginary line which passes horizontally from back (posterior) to front (anterior) through the centre of the body. It is formed by the intersection of the sagittal and transverse planes. eg., when a person performs a cartwheel they are rotating about the sagittal axis.

Frontal Axis: It is also known as Horizontal axis or Left-right axis. The frontal axis is an imaginary line which passes horizontally from left to right through the centre of the body. It is formed by the intersection of the frontal and transverse planes. eg., when a person performs a somersault they rotate around this axis.

Vertical Axis: The vertical axis is also knowns as Longitudinal axis or Craniocaudal axis. This axis is an imaginary line which passes vertically from bottom (inferior) to top (superior) through the centre of the body. It is formed by the intersection of the sagittal and frontal planes. eg., when a skater performs a spin they are rotating around the vertical axis.



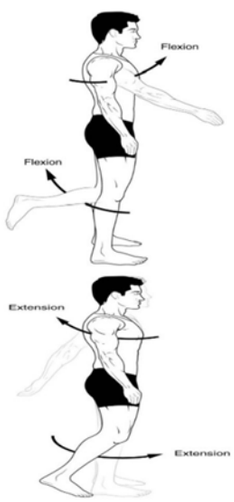




8.2.2 Types of Movement

Flexion and Extension

Flexion and extension are the movements which occur in the sagittal plane. They refer to increasing and decreasing the angle between two body parts.



8.2.3 Flexion

Flexion refers to a movement that decreases the angle between two body parts. Flexion at the elbow is decreasing the angle between the ulna and the humerus. When the knee flexes, the ankle moves closer to the buttock, and the angle between the femur and tibia decreases.

8.2.4 Extension

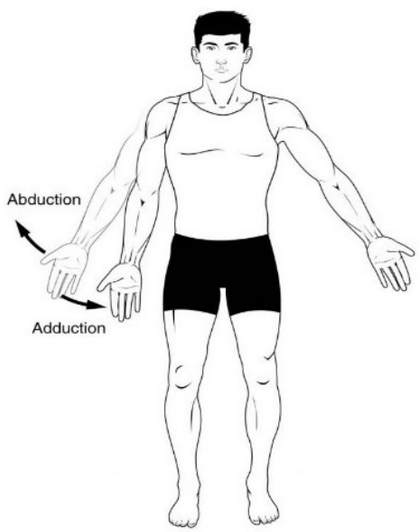
Extension refers to a movement that increases the angle between two body parts. Extension at the elbow increases the angle between the ulna and the humerus. Extension of the knee straightens the lower limb.

Abduction and Adduction

8.2.5 Abduction

Abduction and adduction are two terms that are used to describe movements towards or away from the midline of the body.

Abduction is a movement away from the midline - just as abducting someone is to take them away. For example, abduction of the shoulder raises the arms out to the sides of the body.



8.2.6 Adduction

Adduction is a movement towards the midline. Adduction of the hip squeezes the legs together.

Do you know?

All body movements occur in different planes and around different axes. A **plane** is an imaginary flat surface running through the body. An **axis** is an imaginary line at right angles to the plane, about which the body rotates or spins.

Extension Activity

Perform front-roll, back-roll, and cartwheel. Write on which plane and axis these movements took place.

Name of the Activity	Plane	Axis
Front-roll		
Back-roll		
Cartwheel		

I. Tick the correct options.

1. The term flexion refers to
   (a) **bending**
   (b) turning
   (c) twisting
   (d) straightening
2. Extension is
   (a) bending
   (b) turning
   (c) twisting
   (d) **straightening**
3. Moving away from the reference axis is known as
   (a) flexion
   (b) extension
   (c) **abduction**
   (d) adduction
4. Bringing closer to the reference axis is called
   (a) flexion
   (b) extension

(c) abduction

(d) **adduction**

5. The plane which divides the body into a left and a right is called

(a) coronal plane

(b) **sagittal plane**

(c) vertical plane

(d) transvers plane

II. Answer the following questions briefly.

1. What is plane of movement?
2. Which plane and axis is involved while we kick a football.
3. Differentiate between flexion and extension.

III. Answer the following questions in 150-200 words.

1. Differentiate between abduction and adduction.
2. How does knowledge of movement and its type contribute for graceful movement?

8.3.1 Newton's Laws of Motion

Sir Isaac Newton (1642-1727) was one of the greatest scientists and mathematicians that ever lived.

Newton came up with three general rules about the movement of objects, which are now known as Newton's Three Laws of Motion.

8.3.2 Newton's First Law of Motion: Law of Inertia

The Newton's First Law of motion is known as Law of Inertia. ***Inertia*** is a Latin word used for idleness or laziness. The Law of Inertia can be interpreted as everything in the universe is lazy, thus requiring a force to get it on the move (which then occurs in a straight line). Once moving, more force is needed to slow it, stop it, or to speed it up or to change direction.

So, you can say that the Law of Inertia states a body likes to preserve in its state of being at rest or of moving forward in a straight line except insofar as it is compelled to change its state by applied force. In simple words you can say '**an object will stay at rest or continue at a constant velocity unless acted upon by an external unbalanced force**'. For example, the golf ball remains at rest until it is struck by a golf club.

This is often paraphrased as "zero net force implies zero acceleration", but this is an over-simplification. The key point here is that if there is no net force acting on an object then the

object will maintain a constant velocity. If that velocity is zero, the object remains at rest. If an external force is applied, the velocity will change because of the force.

In brief, the Law of Inertia essentially makes two important points: (a) An object that is not moving will not move until a net force acts upon it; and (b) An object that is in motion will not change its velocity (acceleration) until a net force acts upon it. In football, for example, at the time of kick-off, the ball shall roll forward unless kicked by the player, or, in golf the ball is not moved unless hit. Similarly, the moving football shall not change its velocity unless a player or another object acts upon it.

Inertia is the body's resistance to change in movement. It is proportional to mass, thus the mass of an object is the measure of its inertia. Therefore, mass is the quantity of resistance to change. It should not be confused with weight. The weight of a person (or an object) is the measure of force with which the earth pulls on the body's mass. This downward gravitational force is the body's weight directed towards the earth's centre. Understandably so, a body's mass and weight are directly proportional. The more mass a body has, the greater the earth's attraction on it, the more it will weigh. Weight is a force; whereas, mass is not. It has no direction. Mass is the resistance to change (i.e., inertia).

Principles related to the Law of Inertia

Combining Translator and Rotary Motion: The combined motions, if performed correctly with proper timing and sequence, will produce maximum final velocity of 'an object' in the desired direction of release (eg., discuss toss, bike riding, car, wheelchair etc.).

- **Continuity of Motion:** The accomplishment of the first motion represents the overcoming of a certain amount of inertia and, therefore, any hesitation prior to the next motion will result in loss of some or all of the advantage gained by the previous motion (eg., backward roll, pole vaulting). Interruption of motion costs energy.
- **Effects of Momentum:** More momentum can be produced with a longer implement in that the end will move faster than a shorter implement (eg., don't choke up on a tennis racket or baseball bat).
- **Transfer of Momentum:** Momentum develop in a body segment may be transferred to the total body, but only while the body is in contact with the supporting surface (eg., earth, diving board).

8.3.3 Newton's Second Law of Motion: Law of Acceleration or Law of Resultant Force

The second law states that, the rate of change of momentum of a body is proportional to the resultant force acting on the body and is in the same direction. This explains how the

velocity of an object changes when it is acted upon by an external force. The law defines a force to be equal to change in momentum (mass times velocity) per change in time.

Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated), the greater the amount of force needed (to accelerate the object). In simple words you can say the acceleration of an object is directly proportional to the force exerted upon it, takes place in the direction of applied force, and is inversely proportional to the mass of the body.

When a body is acted upon by a force, its resulting acceleration is proportional to the force and inversely proportional to the mass. Hence, with a constant mass, the greater the force, the greater the acceleration. And, with a constant force applied, the greater the mass, the less the acceleration. Another way of saying the same thing is: "The velocity of a moving object will remain constant unless a force acts on it."

What does this Second Law mean?

Everyone knows that heavier objects require more force to move the same distance as lighter objects.

However, the Second Law gives us an exact relationship between force, mass, and acceleration.

Do you know?

A Newton (N) is the international unit of measure for force. One newton is equal to 1 kilogram meter per second squared.

$$1\ N = 1\ kg\ \frac{m}{s^2}$$

It can be expressed as a mathematical equation:

F = MA

or

FORCE = MASS times ACCELERATION

Important Principles Related with the Law of Acceleration

Acceleration is propositional to the force causing it: A sprinter can increase acceleration by increasing the force that he/she applies backward and downward against the surface on which he/she is running and, if he/she should double the force, then acceleration would double and, similarly, if he/she should keep the force constant and reduce mass, he/she would increase acceleration.

Maximum acceleration and efficiency of motion: To achieve maximum acceleration, all available forces should be applied sequentially with proper timing and as directly as possible in the intended line of motion.

Effects of body's radius on angular velocity: The rate of rotation is increased as the radius of rotation is decreased (For example, tuck head and bend knees; a shorter person will have higher rate of rotation).

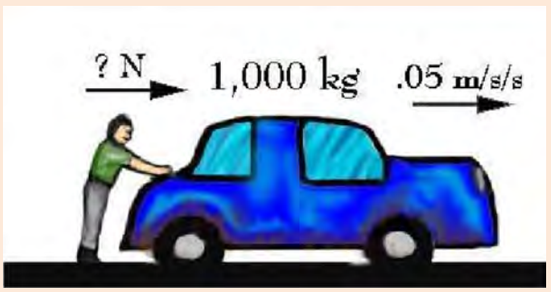
Conservation of momentum in swinging movements: To build or to conserve momentum in any swinging movement, the radius of rotation should be shortened on the upswing and lengthened on the downswing.

Movements while unsupported: When the body is unsupported, movements may occur to aid in controlling balance, but the flight path (trajectory angle) will be unaffected by the movements.

Twisting movements: These are based on the transfer of momentum from part to whole, when in contact with a surface (have to initiate the twist in some way at take-off).

Extension Activity

Anmol's car, which weighs 1,000 kg, is out of fuel. Anmol is trying to push the car to a fuel station, and he makes the car go 0.05 m/s/s. Using Newton's Second Law, compute how much force Anmol is applying to the car.



8.3.4 Newton's Third Law of Motion: Law of Reaction or Law of Reciprocal Action Force

Commonly paraphrased as; "For every force (action) there is an equal, but opposite, force (action)", the Third law of motion states: All forces occur in pairs, and these two forces are equal in magnitude and opposite in direction.

A more direct and detailed description of the law may be that the mutual actions of two bodies upon each other are always equal, and directed to contrary parts. Whatever draws or presses another object is as much drawn or pressed by that other. If you press a stone with your finger, the finger is also pressed by the stone. If a horse draws a stone tied to a rope, the horse will be equally drawn back towards the stone: for the distended rope, by the same endeavour to relax or unbend itself, will draw the horse as much towards the stone, as it does the stone towards the horse, and will obstruct the progress of the one as much as it

advances that of the other. If a body impinges upon another body, and by its force changes the motion of the other, that body also (because of the equality of the mutual presser) will undergo an equal change, in its own motion, towards the contrary part. The changes made by these actions are equal, not in the velocities but in the motions of the bodies; that is to say, if the bodies are not hindered by any other impediments. For, as the motions are equally changed, the changes of the velocities made toward contrary parts are reciprocally proportional to the bodies.

What is meant here is that all forces are interactions - that there is no such thing as a unidirectional force. If body A exerts a force on body B, simultaneously, body B exerts the same force on body A.

That means for every action there is an equal and opposite reaction. Whenever one body exerts a force on another body, the second body always exerts a force on the first body which is equal in magnitude, opposite in direction and has the same line of action.

Principles Related to the Law of Counter Force

Surface variation and the amount of counterforce: The counterforce is equal to the applied force when a stable surface is used. The less stable the surface, the less will be the counterforce. Examples include: (a) decreased friction on ice (fast skating); (b) increased friction running in the sand; and (c) quality of a trampoline bed (ie., new vs. old, as in sagging). **Direction of the counterforce:** The direction of the counterforce is directly opposite that of the applied force. The counterforce is most effective when it is perpendicular to the supporting surface. If not perpendicular, the force is separated into two components, vertical and horizontal. Hence, it is important to consider the trajectory angle.

Counterforce in striking activities: The amount of force a striking implement imparts to an object depends upon the combined momentum of the implement and the object at the moment of impact (ie., how is the force dissipated). Also, it depends on the mass of the object and the implement. Examples include baseball bat hitting a baseball or a tennis racket hitting a tennis ball.

Temporarily stored counterforce: If a surface or implement used in a performance has elasticity, then an applied force produces bend or compression that represents stored force, and the stored force increases the propulsive force over what it would be if elasticity were not present. Examples include pole vaulting (eg., fiberglass poles bend more and store more energy than aluminium poles) and diving boards (the aluminium board vs. the wooden board). **Surface contact while applying forces to external objects:** In throwing, pushing, pulling, and striking activities, one or both feet should be kept in firm contact with the supporting surface until the force providing motion is complete, otherwise the maximum force is decreased.

8.3.5 Application of Newton's Law of Motion in Sports

Newton's Laws of Motion form the basis for principles used in sport movements. Methods of training that depart from these laws would not make sense mechanically. Tips for efficient sport performances are built around these laws and principles.

First, it helps to know that there are two basic types of motion. These come into play in combination when applying mechanical principles to sport skills:

1. **Linear motion** occurs when an object or person travels in a straight line, as when sledding across a level surface.
2. **Angular motion** occurs when an object or person turns about a centre point, axis, or fulcrum and does not travel from place to place. It is common in diving and gymnastic skills when athletes rotate, twist, or spin.

I. Tick the correct options

1. According to Newton's Second Law of Motion, the greater the movement of an object, the
   (a) longer distance will it travel
   (b) stronger will it resist the external forces
   (c) speedier it will cover the given distance
   (d) **more stable will it remain in its motion.**
2. Newton's First Law of Motion is known as the
   (a) Law of Reaction
   (b) **Law of Inertia**
   (c) Law of Effect
   (d) Law of Momentum
3. Newton's Second Law of Motion is also known as
   (a) Law of Reaction
   (b) Law of Inertia
   (c) **Resultant Force**
   (d) Law of Effect
4. Acceleration due to an external force acting on a moving object is technically defined as change in that object's
   (a) location
   (b) direction

(c) **velocity**

(d) movement

II. Answer the following questions briefly.

1. List Newton's Laws of Motion.
2. Elucidate Newton's Law of Inertia.
3. What is linear motion?

III. Answer the following questions in 150-200 words.

1. With the help of suitable examples, discuss the application of Newton's Laws of Motion in sports.
2. How can Newton's second law and third law of motion be applied in sports?

8.4.1 Friction

Friction may be defined as

1. Force acting over the area of contact between two surfaces in the direction opposite that of motion or motion tendency. [4]

2 Force that resists the sliding or rolling of one solid object over another. [5]

Friction is a force that acts parallel to the two surfaces. or in other words, it is a force that resists the movement. Friction works in opposite direction of the moving object resulting in slowing down that moving object. Friction is dependent upon properties of the two surfaces. Rough surface produces more friction and smooth surface produces less friction. Friction also produces heat. For example, if you rub your hands against each other you can feel he heat that is generated. Friction helps to prevent falling while walking and running. If you wear shoes that are new or those that have a good grip you will experience more stability, then shoes that are old and have a poor grip. Similarly, if the surface is wet or slippery, you will find it difficult to stabilize your body.

8.4.2 Friction in Sports

In sports, friction in human movement varies widely depending on different sports because each sport has its own movements and surface of the playing field. For example, in Athletics (running), the surface is a track and the movement is linear or curvy linear. Here, the sports person has to wear shoes with spikes. However, in other events in Athletics like discuss throw and shot put, the surface is hard and movement is rotatory so the shoes are relatively flat. In football, where surface is grassy and the players need greater stability to control the ball and make quick movements, they wear studs or football boots to increase friction. In hockey, badminton, tennis grip taps are used by the player to increase friction. In shot put,

javelin throw, gymnastics magnesium powder is used to increase friction. Thus to adjust friction, the two surfaces should be compatible with each other, to provide desired movement in sports.

8.4.3 Types of Friction

In the field of sports, we will study following types of friction.

1. **Static friction**: Static friction is friction that exists before an object starts to slide. For example, When you hit a cricket ball with a bat, or a tennis ball with racket, or in rock climbing where hand and feet are static.
2. **Kinetic or Sliding friction**: Kinetic friction is friction that is created when the object starts to slide. For example, when an ice skater is skating, or friction produced while rubbing hands.
3. **Rolling friction**: Rolling friction is friction when an object rolls on the surface. For example, a ball bearing, any ball rolling on the ground.
4. **Fluid Friction** (Air and Water resistance): Fluid friction is friction when the movement of an object or a person is hindered or meets resistance from water or air. For example, swimming, diving, sky diving, discuss and javelin floating in air, high jump etc

Do you know?

Recently one more friction type has been recognised which is known as Limiting Friction. Limiting friction is the force that comes into play when one body is just on the verge of moving over the surface of another body.

8.4.4 Co-Efficient of Friction

Friction is determined by the coefficient of friction. It is a ratio of force of friction between bodies or force required to start movement and the force pressing the two bodies together. It is symbolized by μ. Range of COF is ranging near to 0 from 1 but sometimes it can be greater than 1 due to a stronger frictional force. When force is applied to an object, the resistive force of friction acts in the opposite direction, parallel to the surfaces. The standard friction equation for determining the resistive force of friction when trying to slide two solid objects together is written as $Fr = \mu N$, where Fr is the resistive force of friction and N is the perpendicular force pushing the two objects together (both in units of force, pounds or newtons), and μ is the coefficient of friction for the two surfaces. The coefficient of friction varies for each situation, and is related to the two specific surfaces that are in contact with each other.

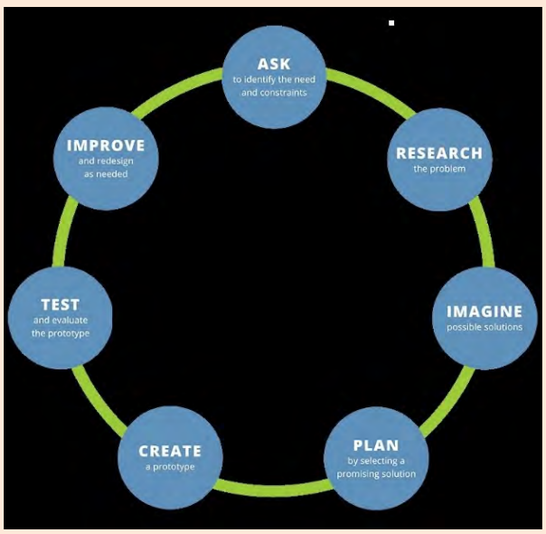
Extension Activity

Draw images of five sports where you find usage of Friction most prominent.

Art Integration

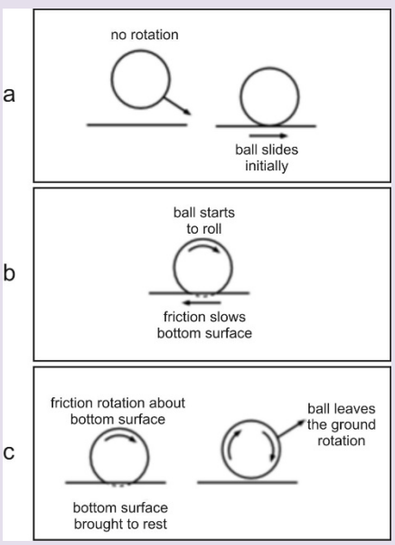
Keeping in mind the biomechanics of sports, design sports apparel – dress, footwear etc. – for your favourite sport. You must justify the changes in design by listing the benefits of your apparel.

You could follow the steps given below.



Case Study

Study the picture given below.



Based on your study above, and your own knowledge, answer the following questions.

Q1. Which of the following Laws of Motion to initiate the rotation of the ball is depicted in illustration (a)?

(a) Law of Acceleration

(b) Law of Inertia

(c) Law of action and reaction

Q2. In illustration (b), which force is acting upon the ball to slow it down?

(a) Gravity

(b) Buoyancy

(c) Friction

Q3. Which force will determine the quality of bounce?

(a) Law of Acceleration

(b) Law of Inertia

(c) Law of action and reaction

Q4. In what ways will the Laws of Motion help you if you are a

Football player, Batsman, Bowler and Badminton Player

I. Tick the correct option.

1. The Friction force acts in a/an _____direction to the direction of motion of an object.

(a) **opposite**

(b) same

(c) downwards

(d) diagonal

2. Among the following sports, in which friction plays the least important role?

(a) Car Race

(b) Football

(c) Hockey

(d) **Ice Skating**

3. Friction is a -

(a) Magnetic Force

(b) Non-contact Force

(c) **Contact Force**

(d) Couple Force

4. The measurement of the amount of friction a surface will generate is called the___of friction.

   (a) Calibration

   (b) **Coefficient**

   (c) Smoothness

   (d) Description

II. Answer the following questions briefly.

1. Define Friction.
2. What is Air Resistance?
3. What is Limiting Friction?

III. Answer the following questions in 150-200 words.

1. Discuss various types of friction.
2. Is friction advantageous or disadvantageous in games and sports?
3. Suggest the methods of reducing friction.

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[1] Dhananjay Shaw (2000), Mechanical Basis of Biomechanics, Sports Publication, Delhi, p.10.

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[3] James. G. Hay.(1985). The Biomechanics of Sports Techniques, 3rd ed. Prentice/Hall International, Inc. New Jersey. p.2.

[4] Susan.J.Hall (2004), Basic Biomechanics, 4th ed. McGraw-Hill, p.389.

[5] Dhananjay Shaw (1998), Biomechnaics and Kinsiology of Human Motion, 4th ed, Khel Sahitya Kendra, Delhi, p.120.

Suggested Readings :

- Dhananjay Shaw (2000), Mechanical Basis of Biomechanics, Sports Publication, Delhi,
- Lutlegen, & Nancy, H. (1997). Kinesiology: Scientific Basis of Human Motion. Mc Graw Hill.
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- Thompson, & Floyd. (2017). *Manual of Structural Kinesiology.* Mc Graw Hil.