10 Kinesiology, Biomechanics and Sports

Chapter at a Glance

INTRODUCTION

Human body is made-up of bones and muscles which help them to perform external movement. Bones act as lever in performing work, whereas muscles provide necessary energy and force for movement. All movements of games and sports are based on physics. In other words, movements of games and sports are based on laws of motion, levers, gravity, *etc.* Hence, without knowledge of physics, no positive result can be achieved in the field of sports.

Biomechanics plays an important role in games and sports. This subject is the study of biological movement of human beings and its relation with the principles of physics. In other words, it is the scientific study of human body movements by applying the basic principles and laws of physics.

Kinesiology is the branch of physiology that studies mechanics and anatomy. In relation to human movement. This term means "the study of movement". This is a wide term which includes various sub disciplines such as biomechanics, sports medicine, fitness etc.

It involves various principles of physics like laws of motion, principles of lever and its types, principle of projectile, friction, equilibrium and many more. These principles help us use proper techniques. Moreover, they prevent us from injury. Their knowledge improves the efficiency of a player to a great extent. Thus, we must understand their application in sports.

10.1 PROJECTILE AND FACTORS AFFECTING PROJECTILE TRAJECTORY

Projectile

A **projectile** is an object that is projected into space by the exertion of a force. Although any object in motion through space (for example a thrown baseball) may be referred to as a projectile. In other words, an object thrown into the space either horizontally or at an acute angle under the action of gravity is called projectile.

Forces Act on Projectile

There are two forces which act on a projectile. They are gravitational force and air resistance.

(1) **Gravitational Force:** Gravity acts to influence the vertical motion of the projectile, thus, causing a vertical acceleration. The horizontal motion of the projectile is the result of the tendency of an object in motion to remain in motion at a constant velocity. (Newton's 1st law of motion)

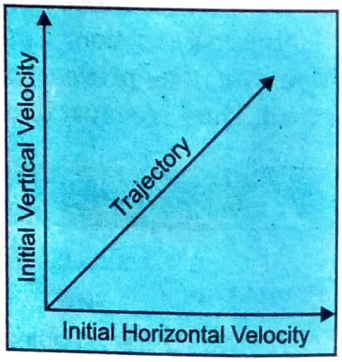
(2) **Air Resistance:** Projectile motion is the motion of the bodies that have been projected into air. Air resistance is the force applied by air on the object in the opposite direction.

Air resistance of an object varies greatly and it depends on the object's particular shape, size and the atmospheric conditions in which the object is released or projected.

Factors Affecting Projectile Trajectory

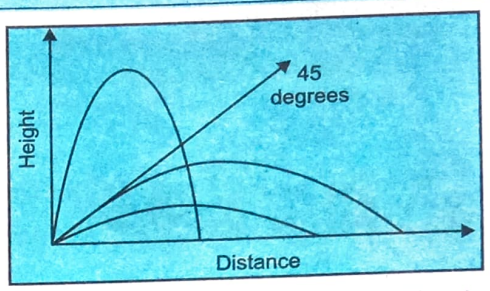
Regardless of the type of object that is being released, or by what means it is being projected, they are all governed by six basic principles:

1. **Gravity:** Gravity acts on a body or object to give it mass. Therefore, the greater the weight of an object, the greater the influence of the gravity upon it. Gravity will affect a projectile as it will decrease the height the projectile can obtain. The force of gravity acts on the object to stop its upward movement and pull it back to earth, limiting the vertical component of the projectile.
2. **Air resistance:** As a projectile moves through the air, it is slowed down by air resistance. Air resistance will decrease the horizontal component of a projectile. The effect of air resistance is very small, but needs to be considered if you want to increase the horizontal component of a projectile. There are several factors that relate to the amount of air resistance acting on a projectile.
   (*a*) **Surface to volume ratio:** The larger the surface to volume ratio, the more air resistance will affect the object. For example, a badminton shuttle will have much more air resistance than a golf ball, because of the holes in it.
   (*b*) **The surface of the object:** If the surface is rough, the air resistance will be greater.
   (*c*) **Speed:** As speed increases, so does air resistance. This is because of friction, for example a space shuttle.
   (*d*) **Mass:** The smaller the mass of an object, the more air resistance will affect it. For example, a feather, compared to a stone. Because air resistance affects the horizontal component of a projectile's trajectory, the effect of it can be minimised by lowering the angle of release.
3. **Speed of release:** Speed or velocity is directly related to distance. The greater the speed of release, the greater the distance covered in flight. It is divided into two components:
   (*a*) **Initial Vertical Velocity:** Having a higher initial vertical velocity will increase the height of the trajectory, resulting in a longer flight path. This would be an advantage in sports which primarily require height, such as tumbles in gymnastics, high jump and ski jumping (tricks).
   (*b*) **Initial Horizontal Velocity:** Having a higher initial horizontal velocity will increase the length of the flight time and therefore the distance covered. This would be an advantage in sports which primarily require good distance, such as long jump, ski jumping (distance), and vaults in gymnastics.



4. **Angle of release:** The angle of release changes the relationship between the horizontal and vertical components of a projectile. The ideal angle of release is 45 degrees, assuming that there is no air resistance and the take-off and landing points are at the same height.

If the angle is greater or lesser than 45 degrees, the distance covered in flight is less. This is because the 45 degrees is half way between vertical and horizontal and will ensure the greatest amount of each component. If the angle of release is too high for a given activity, the distance gained will be poor. If the angle of release is too low for a given activity, the projectile will be in the air for less time, gaining less distance.

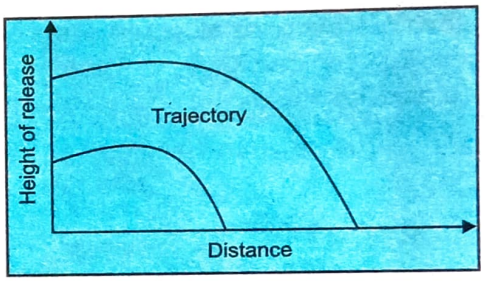


In sporting situations the angle of release is often lower, around 35 degrees to 45 degrees. This is because of the air resistance of the body and because the take-off point is usually higher than the landing point, *e.g.* long jump.

In sporting situations, the objects thrown in the air shows different angle of release due to difference in weights. Moreover, the throwing action also leads to an angle of release.

5. **Height of release:** The higher the level of release, the greater will be the distance covered in flight. This is because the higher the projectile is released; the longer it will be in the air. The horizontal component will be acting on the projectile for longer.

Example: A golfer hitting a ball off the top of a hill would hit it further than a golfer at the bottom of the hill. The ball will stay in the air longer so will have a greater chance to gain distance. This assumes that the same golf club, technique and force are being used.



In javelin, to gain more distance, athletes will hold the javelin up higher to create a greater height of release.

There is a relationship between the height of release and the angle of release.

As the height of release increases, the angle of release decreases.

As the height of release decreases, the angle of release increases.

Example, when shooting, longer basketball players will have a lower angle of release than shorter basketball players to shoot the ball at the same hoop height.

6. **Spin:** The amount and direction of spin acting on a projectile will directly affect the distance a projectile will travel. The reason for this is the air pressure acting on the ball.

Example: In a tennis shot, topspin gives poorer distance compared to backspin.

Range is decreased with topspin.

Range is increased with backspin.

A topspin shot creates a region of high pressure on top of the ball, and a region of low pressure below. Air moves from a region of high to low pressure and as a consequence the ball will dip suddenly, decreasing the vertical component of the trajectory and in turn, the distance travelled.

In a backspin shot, a region of high pressure is created under the ball, and low pressure above the ball. Air moves from high to low pressure. The air pressure acting on the ball will cause it to stay up longer, increasing the vertical component of the trajectory, therefore, increasing the distance travelled.

Importance of Projectile in Sports

Projectile motion is by definition an object moving through space under the influence of forces. Thus, any ball, puck, javellin, shot put or other objects and the players him/herself in long jump, high jump and other similar games, hit, kicked, thrown or otherwise sent on its way by some burst of force and then left to move through space under external forces, like gravity is a projectile in motion.

10.2 NEWTON'S LAWS OF MOTION AND ITS IMPORTANCE IN SPORTS

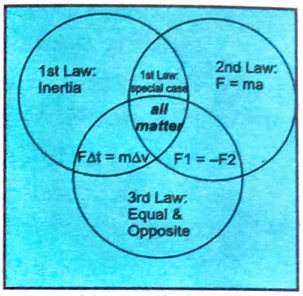
Newtonian Laws

In 1687, Sir Issac Newton investigated the impact of forces on the objects and he formulated three laws to describe them. These laws are called 'Newton's Laws of Motion' and are explained as:

1. Newton's First Law

Law of Inertia

First Law: *Everybody continues in its state of rest or motion in a straight line unless compelled to change that state by external forces exerted upon it.*



Newton's Laws

Newton's 1st Law states that an object continues in a state of rest or of uniform motion in a straight line unless acted upon by an external force. Inertia is Latin word means 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. 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.

2. Newton's Second Law

Law of Acceleration

Second Law: *The rate of change of momentum of a body is proportional to the force causing it and the change takes place in the direction in which the force acts.*

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."

3. Newton's Third Law

Law of Action and Reaction

Third Law: *To every action there is an equal and opposite reaction* OR *for every force that is exerted by one body on another there is an equal and opposite force exerted by the second body on the first.*

The third principle of motion can be explained as follows: If one body exerts a force on another body, the second body will exert an equal and opposite force on the first body. Hence, it is sometimes referred to as the principle of action and reaction, which can be stated: "For every force, there is an equal and opposite reaction force." Essentially, Newton's Third Law is a statement that forces always exist in pairs. For example, when we take a step forward, we press our foot against the floor. Because of the friction between the foot and the floor, we exert a backward force on the floor. The reaction force is the equal and opposite force exerted by the floor on our foot. It is this force, which acts in the forward direction that moves us in the forward direction.

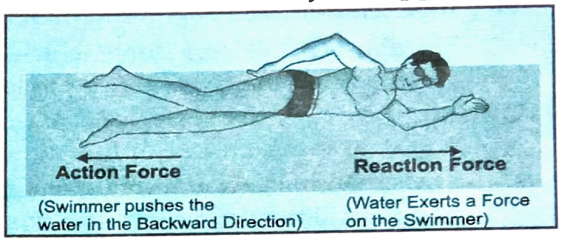
Application of Newton's Law in Sports

1. **First Law of Motion:** There are a great number of examples of this law in the field of sports and games, such as starting in rowing, starting on roman rings, starting in sprinting, starting in

throwing the hammer and raising an opponent in wrestling, *etc.* Basically, if an object is in motion, it remains in motion unless something or some external force stops it. The external force may be gravitational force, the surface of the playing field, a defensive player or the braking action of the sportsperson's body to stop.

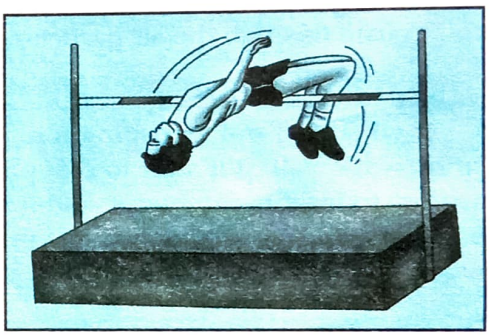
2. **Second law of Motion:** This law is also applied in various sports, such as in hammer throw, the thrower, who is stronger (who has more force), will throw the 12 lbs hammer farther than a thrower who has less force or strength. A hammer thrower will find that the more force is required to throw 16 lbs hammer than a 12 lbs hammer. If a base ball player hits a ball with the double force, the rate at which the ball will accelerate will be doubled. Football players can slow down, stop or reverse the direction of other players depending upon how much force they can apply and in which direction.

3. **Third Law of Motion:** The application of this law in various sports is given below:



(*a*) *Swimming*: A swimmer pushes the water backwards (action). The water pushes the swimmer forward (reaction) with the same force.

(*b*) *Shooting*: In shooting, when a gun or pistol is fired the bullet moves forward (action). The gun or pistol jerks backward (reaction).

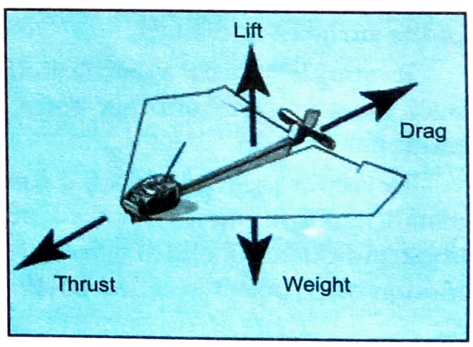


(*c*) *Dribbling in basketball*: When a basketball player dribbles, he exerts force on the ball and the ball strikes on he floor with a force (action). Then the ball comes up with an equal force from the floor (reaction).

(*d*) *High Jump*: A high jumper 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 any other unstable surface.

10.3 AERODYNAMICS PRINCIPLES

The word 'Aerodynamics' comes from two Greek words: **aerios**, concerning the air, and **dynamics**, which means force. Aerodynamics is a term of physics that describes the ability of an object to ovecome air resistance. Anything that flies such as airplanes, helicopters, and birds, utilize the principles of aerodynamics to move through the air.



Basic Forces

Aerodynamics can be applied to cycling, the bicycle composition and design, the clothing worn by the cyclist, and even the positioning of the rider on the bicycle. In addition, aerodynamics plays a big role in all ball sports related. The air flow around a ball thrown through the air differs greatly depending on whether it has a smooth surface or a rough surface. From ball games like baseball, soccer, football and tennis to athletics, skiing, swimming and many other sports, the proper application of some basic principles of aerodynamic can make a difference between winners and losers. Throwing a ball along a curved trajectory or reducing the drag for a runner, all can be explained and improved through the science of flight.

The four basic forces of aerodynamics and how they affect sports players

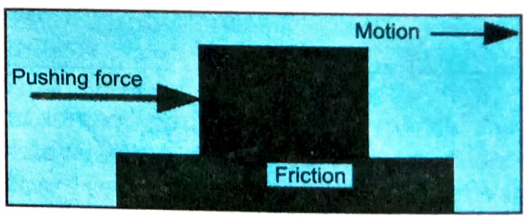
1. **Weight:** The force of weight plays a major role in Aerodynamic Movement. "Weight is the force generated by the gravitational attraction of the Earth" (NASA). The force of weight plays a major role i speed. The froce of weight is one of the main reasons smaller cars create less wind resistance compared to larger vehicles.
2. **Lift:** "Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air." (NASA) Lift can change how long you can hold your arm up when shooting a basket or serving a ball. It can also effect how hard you hit a ball because if you cannot hold your arm ready for a period of time longer than a few seconds, your arm could wear out and fall, causing you to miss the ball. You also could hit a ball, but not with nearly as much force.
3. **Thrust:** "Thrust is the force which moves an aircraft through the air." (NASA) Thrust overcomes the forces of weight and drag to keep something in the air, so if you jump for a shot or a spike, knowing how to use the force of thrust to your advantage can make a huge difference in how you come up to the basket, or how much force you put behind a ball being shot/spiked.
4. **Drag:** "Drag is the aerodynamic force that opposes an aircraft's motion through the air." (NASA) Drag can slow you down when you're running down the court, especially if your uniform is baggy because the uniform pushes against the air around you. This force pushes you backwards as you run through the air particles.

How does Aerodynamics affect a ball?

If you don't put any spin on it, the airflow around the ball will be symmetric. However, if you put spin on the ball, it'll start to curve. The spin on the ball imparts vorticity on the air, which causes the airflow to lose its symmetry, and for the air to curve to one direction or the other as it goes around the ball. Since the air is being pushed in one direction by the vorticity generated by the spinning ball, the air will push the ball in the opposite direction. This results in life, and in a curveball.

10.4 FRICTION AND SPORTS

Friction is an external force and can be defined as the resistance to the motion of two moving objects or surfaces that touch. Friction is a result of interaction between the molecules of the surfaces in contact.



In simple words, when a body moves or tends to move over the surface of another body, the forces that opposes the motion is friction.

To stop a moving object, a force must act in the opposite direction to the direction of motion. For instance, if you push your book across your desk, the book will move. The force of the push moves the book. As the book slides across the desk, it slows down and stops moving. The force that opposes the motion of an object is called **friction**.

Types of Friction

There are generally two types of frictions:

1. **Static friction:** It acts between two or more solid objects that are not moving relative to each other. For example, static friction can prevent an object from sliding down a sloped surface it is considered to arise as a result of roughness.
2. **Kinetic friction:** It acts when two objects are moving relative to each other and rub together (like a sled on the ground) or the object is actually moving or sliding.

Friction in Sports and Human Locomotion

Friction in sports and physical exercise is sometimes as advantage and sometime a disadvantage. Friction is usually called a necessary evil. Practically every single sport relies on friction in some way. Moreover they are covered with tapes to increase friction.

Advantages of Friction

1. Running and walking is only possible due to friction between shoes and ground. For example, athletes use spikes and football players use studs.
2. Friction enables us to hold the objects and equipments. For example, holding of badminton rackets, tennis rackets, *etc.*
3. Magnesium powder is used on palms in gymnastics and javelin throw.
4. In ball games, catching and throwing ball is possible due to friction between hand and ball.
5. Nowadays, specially designed helmets are used to reduce friction by allowing air to flow over the head and down the back.

Disadvantages of Friction

1. In cycling, tyres of cycles must be properly inflated to reduce friction as if there is more friction, there will be more wastage of energy of the cyclist.
2. Wear and tear of object is a result of friction. For this lubrication is applied to reduce friction and parts are allowed to move easily and prevents wear and tear.
3. Friction slows down the speed of the athlete. For this rolling shoes and smooth surface are used in roller skating to reduce the friction.
4. Friction is also responsible for player injuries if they slides across the ground.
5. The distance covered by a thrown object is depends on friction between object and air. More the friction, decrease the distance covered by object.

Reduction of Friction

Sometimes in sports we also need to reduce friction. The ways to reduce friction are:

1. **Polishing:** We use powder in carrom to slide the sticker easily.
2. **Lubrication:** We need to lubricate skates to reduce friction, so that it can roll easily.
3. **Streamlining:** In designing of automobiles, also helps in making correct posture for swimming, *etc.*
4. **Ball/roller bearing:** use in wheel of cycle, axle of motor car, *etc.* to reduce friction.
5. Correct combination of surfaces.

Increase in Friction

1. By making the surface rough friction can be increased.
   Examples of increasing friction-the tyres of a motor car and bicycles are made rough to increase the friction which helps in racing activities.
2. When a surface/cricket ground or any other ground become slippery after rain or water splashing it is made rough by spreading sand to increase the friction.
3. In athletes shoes soles have spikes to increase friction, so that they can run fast.

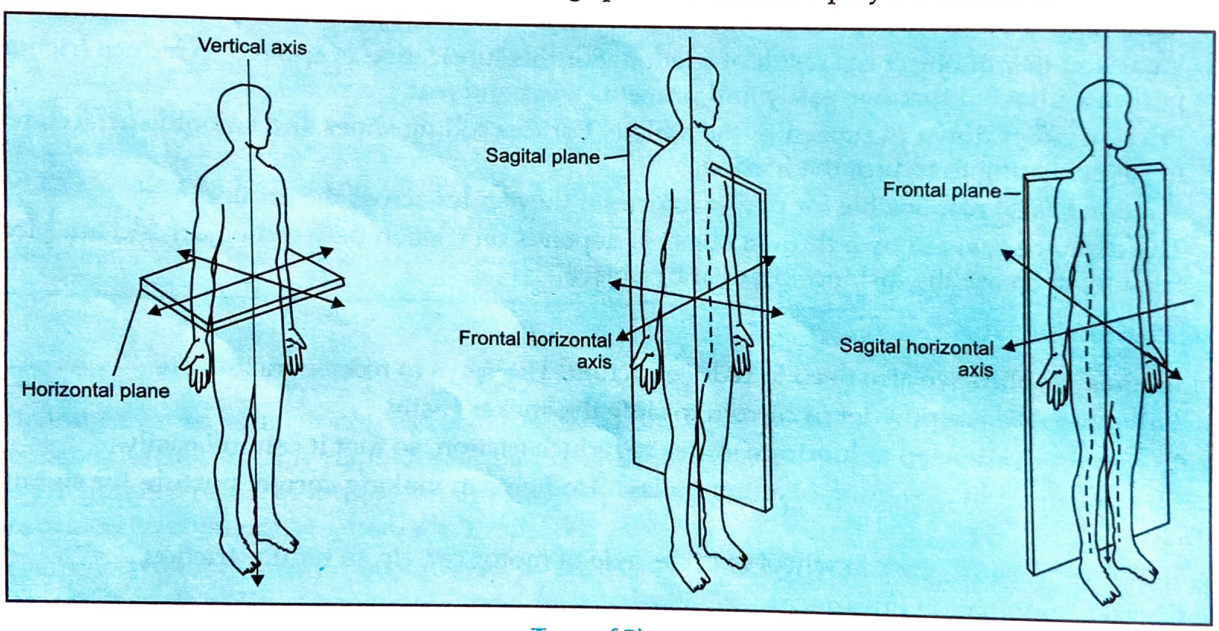
10.5 INTRODUCTION TO AXIS AND PLANES

Human movements are stated in three dimensions on a series of planes and axes.

Meaning of Planes

An imaginary, flat surface passing through the body or organ is called plane. In other words, plane is the surface on which the movement occurs or takes plane. There are three planes of motion that passes through the human body.

1. **Sagittal or Medial plane:** The sagittal or medial plane is a vertical plane passing from the rear to the front, dividing the body into left and right halves. It is also known as anteroposterior plane. It can also be said that plane lies vertically and divides the body into right and left parts. Most of the sports and exercise movements that are two dimensional, such as running, long jumping and somersault take place in this plane.
2. **Frontal or Coronal plane:** The frontal plane is also vertical and passes from left to right dividing the body into posterior to anterior halves. It is also known as coronal plane. In simple words, frontal plane cuts the body into front and back. Movements along the frontal plane can include cartwheel and star jumps.
3. **Transverse or Horizontal Plane:** The transverse plane divides the body into top and bottom halves. It is also known as horizontal plane. This plane lies horizonally that is why it is also called horizontal plane. In simple words, it divides the body into upper and lower sections. Movements along this plane can include an ice-skating spin or rotation to play a tennis shot.



Types of Planes

Meaning of Axis

An axis is a straight line around which an object rotates. In fact, movements at the joints of human musculoskeletal system are mainly rotational and take place about a line perpendicular to the plane in which they occur. This line is known as axis of rotation. In other words, axis is an imaginary line (point of rotation) that passes through a joint or body to describe movement.

Types of Axes of Rotation

There are three types of axes of rotation:

1. **Sagittal Axis:** The segittal axis passes horizontally from posterior to anterior; it is formed by the intersection of the sagittal and transverse or horizontal plane. In fact, sagittal axis passes from front to back.

2. **Frontal Axis:** The frontal axis passes horizontally from left to right; it is formed by the intersection of the frontal and horizontal or transverse planes. It can be stated that the frontal axis passes side to side.
3. **Vertical Axis:** The vertical axis passes vertically from interior to superior. In other words, it passes straight through the top of the head down between feet; it is formed by the intersection of sagittal or frontal planes. It is also known as longitudinal axis. It is the longest axis.

10.6 TYPES OF MOVEMENTS

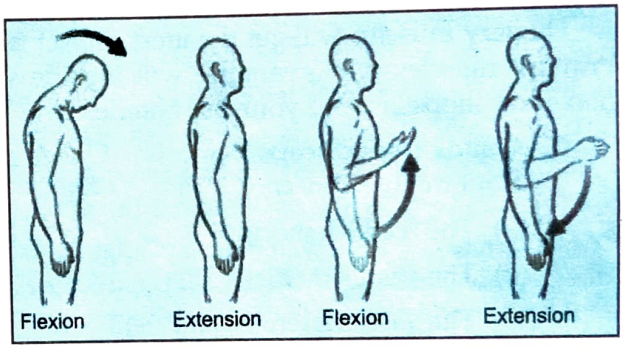
Motion, the process of movement includes movement of organs, joints, limbs, and specific sections of the body.

In general, motion is classified according to the anatomical plane it occurs in. Flexion and extension are examples of angular motions, in which two axes of a joint are brought closer together or moved further apart. Abduction and adduction are examples of midsagittal motion, in which a structure moves away from or towards the centre of the body.

Flexion and Extension

Flexion and extension describe movements that affect the angle between the two parts of the body. These terms come from the Latin words with the same meaning.

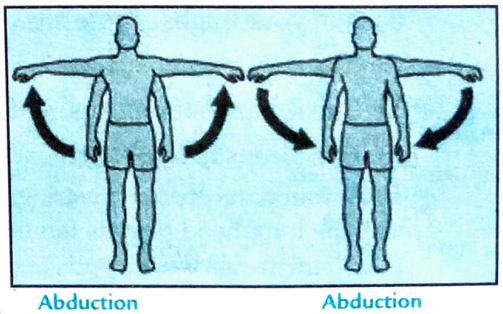
Flexion describes a bending movement that decreases the angle between a segment and its proximal segment. For example, bending the elbow, or clenching a hand into a fist, are examples of flexion. When sitting down, the knees are flexed. When a joint can move forward and backward, such as the neck and trunk, flexion refers to movement in the anterior direction. Flexion of the shoulder or hip refers to movement of the arm or leg forward.



Extension is the opposite of flexion, describing a straightening movement that increases the angle between body parts. When a joint can move forward and backward, such as the neck and trunk, extension refers to movement in the posterior direction. For example, when standing up, the knees are extended. Extension of the hip or shoulder moves the arm or leg backward. When the chin is against the chest, the head is flexed, and the trunk is flexed when a person leans forward.

Abduction and Adduction

Abduction and adduction refer to motions that move a structure away from or towards the centre of the body. The centre of the body is defined as the midsagittal plane. These terms come from the Latin words with the same meaning.



Abduction refers to a motion that pulls a structure or part away from the midline of the body. In the case of fingers and toes, it refers to spreading the digits apart, away from the centreline of the hand or foot. Abduction of the wrist is also called radial deviation. For example, raising the arms up, such as when tightrope walking, is an example of abduction at the shoulder. When the legs are splayed at the hip, such as when doing a star jump or doing a split, the legs are abducted at the hip.

Adduction refers to a motion that pulls a structure or part toward the midline of the body, or towards the midline of a limb. In the case of fingers and toes, it refers to bringing the digits together, towards the centreline of the hand or foot. Adduction of the wrist is also called ulnar deviation. Dropping the arms to the sides, and bringing the knees together, is examples of adduction.

Ulnar deviation is the hand moving towards the pinky/fifth digit. Radial deviation is the hand moving towards the thumb/first digit.

10.7 MAJOR MUSCLE INVOLVED IN RUNNING, JUMPING AND THROWING

The more we know about our body, the better we can protect it by treating it with care and avoiding injury.

Running

Running on a regular basis has many benefits, including weight loss, stress relief and maintaining a strong and healthy body.

As it is one of the more physically exerting activities, it can also cause damage to our body such as a pulled hamstring or dislocation of our knee caps. With a little knowledge, we can help prevent these injuries with the right equipment and by properly stretching our muscles before the run.

Primary Muscles Used While Running

Primary muscles will get the most impact from movement and therefore should receive more care. Primary muscles while running will include your quads (quadriceps femoris), hamstrings, gluteus maximus, iliopsoas, and your calf muscles.

1. **Quads (Quadriceps Femoris):** Quads are muscle groups of four basic muscles located on our front thighs. *They are*
   (*i*) The rectus femoris
   (*ii*) The vastus medialis
   (*iii*) The vastus lateralis, and
   (*iv*) The vastus intermedius.

   Our quads are responsible for moving two of the joints used in running, our knee-joint and our hip-joint. They work together to straighten our knees and bend our hips.

   If we are interested in strengthening our quad muscles, we should consider doing squats and lunges. Increasing strength in our muscles apart from running can decrease our risk of injury and increase our speed.
2. **Hamstrings and Gluteus Maximus:** Our hamstrings are made up of four muscle parts on the back of your thighs. These are known as:
   (*i*) The semitendinosus
   (*ii*) The semimembranosus, and
   (*iii*) The biceps femoris (two parts: long head and short head)

   These four parts of our hamstrings allows us to flex our knees. The semitendinosus, semimembranosus and the long head bicepts femoris work together to extend the hips. As you might have noticed, your hamstrings work opposite your quads in how your knees and hips move, creating a systematic medley that works well for your body.

   The gluteus macimus, is the largest of the gluteal muscles. You will recognise it easily as it is the muscle that contributes most to creating the shape of the buttocks, better known as butt or rear-end. This muscle will help you keep proper erect posture by extending your hips.

3. **Hip Flexors (Iliopsoas):** Our hip flexors (or iliopsoas), like our quads, is *comprised of a muscle group of two muscles*:

   (*i*) The iliacus and

   (*ii*) The psoas major.

   To our right, the shortest muscle, the iliacus, begins on our pelvic crest (the iliac fossa) and stretches over to our thigh bone (femur). The larger of the muscles, the psoas major, stretches from our T-12 spinal vertebrae to our L-5 spinal vertebrae and there attaches to the femur.

   These two muslces work together to help our hips flex. The iliopsoas are often the culprit behind seven hip pain. If you experience hip pain while running, you should stop your routine immediately, and go see your doctor or a chiropractic specialist. Do not resume running until you are sure that your hip pain is cured and you are determined to be safe.

4. **Calf Muscles:** Our calf muscles are located on the back of our leg, below our knee. Though many anatomists see the calf muscles to be a single muscle (triceps surae), most say that it is a muscle group, like our quads and hip flexors. *This group consists of two main muscles, the*

   (*i*) The gastrocnemius and

   (*ii*) The soleus.

   Our calf muscles will alow us to flex our knee and planter flex our ankle. Like our quads, our calf muscles can be strengthened by doing squats. Other good strength-building exercises would include calf muscle raises and skipping.

Jumping

Only a small percentage of people has the natural ability to jump high. That is why it is important to train properly to improve your hops if you are not among that group.

Part of this battle is knowing just what muscles are most important to lift your body off the ground. The stronger you make them, the more power you will have to jump high.

1. **Quadriceps:** The quadriceps rest on the front of the thighs and they have four components: the vastus medialis, vastus lateralis, rectus femoris and vastus intermedius. During a jump, you perform hip flexion and knee extension, which both activate the quadriceps. His flexion takes place when you move your thigh towards 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.
2. **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 towards 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.
3. **Hip Flexors:** The hip flexors fun 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. 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.
4. **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 anteior, 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.

Throwing

Following are the muscles which are used while throwing things like ball, football, *etc:*

1. **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.
2. **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.
3. **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-ups, seated cable rows, and bent-over barbell rows.
4. **Abdominals:** While many people exercise their abdominal muslces in the hope 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 benefits from the strength of your legs. Among the best exercises for your abs are hanging leg raises and swiss ball crunch.
5. **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 towards your intended targets 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 for your abdominal muscles.

IMPORTANT QUESTIONS

Very Short Answer-type Questions

1. What is kinesiology?
2. What do you mean by biomechanics?
3. What do you mean by projectile?
4. An object thrown into the space either horizontally or at an acute angle under the action of gravity is called a projectile. Name the two forces which act on a projectile. **(2017)**
5. Explain what is projectile trajectory? **(2016)**
6. To cover the maximum distance at what angle an object should be released. **(Delhi, 2016)**
7. What is law of inertia?
8. What is Newton's second law of motion?
9. What is law of action and reaction?
10. What is aerodynamics?
11. Name the forces affect aerodynamics?
12. What is friction?
13. Name the two types of forces?
14. What is axis?

15. What are planes?
16. Name the muscles involved in running?
17. Name the muscles involved in jumping?
18. Name the muscles involved in throwing?

Short Answer-type Questions

1. Explain the forces that act on projectile?
2. Explain in brief the factors affecting the projectile trajectory?
3. Write about the importance of projectile in sports?
4. Explain why are the angle of release for shot-put, javelin and discus throws different? (C.B.S.E. Sample paper, 2015)
5. What are the Newton's law of motion? in sports
6. How could the third laws of motion is applicable in sports?
7. How do the principles of aerodynamics affect a ball?
8. "Friction is the necessary evil" Justify this statement with reference to sports. (C.B.S.E. Sample paper, 2015)
9. Write about the axis of movement?
10. Explain the planes of movements?
11. Write the difference between
    (a) Flexion and extension
    (b) Abduction and adduction

Long Answer-type Questions

1. What is projectile? What is trajectory? Explain the factors affecting projectile trajectory?
2. What are the laws of motion and how are they important in games and sports?
3. What is aerodynamics? Explain the forces act in aerodynamic principle and how they affect the game?
4. Discuss the advantages and disadvantages of friction in the field of games and sports. What strategies does a sportsperson adopt to minimise the friction? Give suitable examples from sports? (2016)
5. What are the various types of friction? How is friction advantageous and disadvantageous in the field of games and sports? Explain with suitable examples. (2017)
6. Explain the muscles involved in running?
7. Explain the muscles involved in jumping?
8. Explain the muscles involved in throwing?

what are the importance of Biomechanics in sports.