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Lecture Title

Concept of Movement and Equilibrium

Introduction

Hello and welcome to yet another module on physical education. Today we are talking about the concept of movement in physical education training. The concepts of equilibrium and center of gravity applied to movement.

As body parts move independently of one another, the body's mass redistributes thus changing the location of the body's center of gravity. Body parts also move to change the body's base of support from one moment to the next to cope with imminent loss of balance. The entire center of gravity of the body shifts in the same direction of movement of the body's segments. As long as the center of gravity remains over the base of support, the body will remain in a state of equilibrium. The more the center of gravity is situated over the base, the greater the stability. A wider base of support and/or a lower center of gravity enhances stability. To be effective, the base of support must widen in the direction of the force produced or opposed by the body. Shifting weight in the direction of the force in conjunction with widening the base of support further enhances stability. Constant interaction of forces that move the body in the elected direction results in dynamic balance. The smooth transition of the center of gravity changing from one base of support to the next produces speed.

2. Concept of Force Applied to Movement

Force is any influence that changes the state of motion of an object. We must consider the objective of movement.

Magnitude of Force – force must overcome the inertia of the object and any other resisting forces for movement to occur.

For linear movement, force applied close to the center of gravity requires a smaller magnitude of force to move the object than does force applied farther from the center of gravity.

For rotational movement, force applied farther from the center of gravity requires a small magnitude of force to rotate the object than does force applied closer to the center of gravity.

For objects with a fixed point, force applied anywhere other than through the point of fixation results in object rotation.

Energy – the capacity to do work. (The more energy a body has the greater the force with which it can move something [or change its shape] and/or the farther it can move it).

Movement (mechanical energy) has two types:

1. Potential energy (energy possessed by virtue of position, absolute location in space or change in shape).

A. Gravitational potential energy - potential energy of an object that is in a position where gravity can act on it.

B. Elastic (strain) potential energy - energy potential of an object to do work while recoiling (or reforming) after stretching, compressing, or twisting.

2. Kinetic energy (energy possessed by virtue of motion that increases with speed).

Force Absorption - maintaining equilibrium while receiving a moving object's kinetic energy without sustaining injury or without losing balance while rebounding.

The force of impact is dependent on an object's weight and speed. The more abruptly kinetic energy is lost, the more likely injury or rebound occurs. Thus, absorbing force requires gradually decelerating a moving mass by utilization of small forces over a longer period of time. Stability is greater when the force is received closer to the center of gravity.

Striking resistive surfaces - the force of impact per unit area decreases when the moving object's area of surface making contact increases and the surface area that the object strikes increases.

Striking non-resistive surfaces - the force of impact decreases if the moving object's area of surface making contact decreases because it is more likely to penetrate. The more time and distance that motion stops for a moving object to strike any surface, the more gradually the surface absorbs the force of impact, and the reaction forces acting upon the moving object decrease. Equilibrium returns easily when the moving body (striking a resistive surface) aligns the center of gravity more vertically over the base of support. Angular force against a body lessens when the distance between a contacting object and the body decreases and the contact occurs closer to the center of gravity. By widening the base of support in the direction of the moving object stability is increased.

3. Concept of Leverage applied to Movement

First-class lever - the axis is between the points of application of the force and the resistance.
Second-class lever - the force arm is longer than the resistance arm (operator applies resistance between the axis and the point of application of force).
Third-class lever - the force works at a point between the axis and the resistance (resistance arm is always longer than the force arm).
With a few exceptions, the body consists primarily of third-class levers, with bones functioning as the levers and contracting innervated muscles acting as the fulcrums or by gravity acting on various body masses. As a result, the human body favors speed and range of motion over force. Because most human body levers are long, their distal ends can move rapidly. Thus, the body is capable of swift, wide movements at the expense of abundant muscle force. The human body easily performs tasks involving rapid movement with light objects. Very heavy tasks require a device for the body to secure an advantage of force. Sports instruments increase body levers, thereby increasing the speed of an object's imparting force. However, the use of sports instruments requires more muscle force. The body's leverage rarely includes one part of the body (a simple, singular lever). Movement of the body is an outcome of a system of levers operating together. However, levers do function in sequence when the force produced by the system of levers is dependent on the speed at the extremity. Many levers function simultaneously for a heavy task (e.g. pushing).

Mechanical Principles of Motion Applied to Physical Education Activities

1. Inertia - tendency of a body or object to remain in its present state of motion; an object will stay in a prescribed straight path and will move at its given speed unless some force acts to change it.
2. Projecting objects for vertical distance - the forces of gravity and air resistance prevent vertically projected objects from continuing at their initial velocities. The downward, resistive force of gravity slows a projectile directed upward until it halts (at the peak of vertical path). At this point, the downward force of gravity becomes an incentive force that increases the speed of the object until it confronts another force (the earth or other external

object) that slows the object until it stops. When the object stops ascending and begins to descend, gravity alters the object's direction of motion. Air resistance (of still air) always opposes the object's motion. Therefore, an ascending object's air resistance is downward and a descending object's air resistance is upward.

An increase in velocity increases air-drag force that decreases the magnitude of the drag as the object moves upward, slowing in velocity. The magnitude of the drag increases as the object moves faster and faster downward. Moreover, the direction and magnitude of the object's acceleration, due to the force of gravity, are constant while direction and magnitude of changes, due to air resistance, are dependent on the object's speed and direction. An object travels the highest when projected with the greatest velocity, and the object's weight affects neither gravity's upward deceleration nor its downward acceleration.

The object's weight, however, is a factor in calculating the net force acting on the object's vertical movement through the air.

• Projecting the body for vertical distance - for these activities (e.g. vertical leaping), the height of reach of the hand from the ground is the significant factor. The following three factors determine the body's reach height:

1) the center of gravity's vertical velocity,

2) the center of gravity's height from the ground at takeoff, and

3) the vertical distance of the fingertips relative to the center of gravity at the peak of the jump.

• Projecting for vertical distance with a horizontal component - for these activities (e.g. high jumping), a running approach to the point of takeoff produces some horizontal velocity even with a 100% vertical takeoff.

• Projecting for horizontal distance - a body will continue to travel horizontally until an external force, usually the ground, halts it. Gravity stops vertical movement while ground friction eventually stops horizontal velocity, preventing any additional horizontal distance. "Air time" increases when the initial upward vertical velocity component is greater. There is a tradeoff between maximum "air time" (determined by vertical velocity) and maximum horizontal distance (determined by horizontal velocity).

• Horizontal projections where takeoff and landing heights are equal - maximum horizontal distance occurs when the projection angle is 45 degrees.

• Horizontal projections where takeoff and landing heights are uneven – the height of an object's center of gravity depends on a performer's height and his/her location in relation to the ground upon release or impact of the object. The greater the object's travel time forward,

the farther the object's distance before landing. Hence, a taller performer has an automatic advantage over a shorter performer who throws with the same projection velocity. In addition, the greater the difference between takeoff and landing heights, the smaller the optimum angle of release - given equal projection velocities.
Projecting objects for accuracy:
• Vertical plane targets - accuracy is easiest when using a trajectory that is perpendicular to the target as it coincides with the target face. As projection distance increases, a more curved parabolic path is required.
• Horizontal plane targets - the more vertically the projectile arrives at the target (as close to 90 degrees as possible), the greater the likelihood of successfully hitting the target and preventing the object from rolling or sliding away from the target area.
Projecting the body for accuracy - for moving or positioning the body (or its segments) to achieve an ideal/model performance by body maneuvers, the performer projects his body's center of gravity to an imaginary target point in space.
Projecting objects for accuracy when speed may enhance the performance - the performer must increase the angle of projection for slower projection speeds (must consider participant's height).

4. Acceleration and Momentum

• Acceleration - the movement response (acceleration) of a system depends not only on the net external force applied, but also depends on the resistance to movement change (inertia). If an object's acceleration is proportional to the applied force, greater force produces greater acceleration. An object's acceleration is inversely proportional to its mass (the greater the mass, the less the acceleration).
• Angular acceleration (rate that an object's angular speed or direction changes) - angular acceleration is great when there is a large change in angular velocity in a short amount of time. A rigid body (or segment) encounters angular acceleration or deceleration only when a net external torque is applied. When torque stops, the body reaches and maintains a new velocity until another torque occurs. Acceleration is always in the direction of the acting torque, and the greater the torque, the greater the angular acceleration.
• Linear acceleration (time rate of change in velocity) - an object's magnitude of acceleration is significant if there is a large change of velocity in a small amount of time. When the same velocity changes over a longer period of time, acceleration is small. Acceleration occurs only

when force is applied. When the force stops, the object/body reaches a new speed and the object/body continues at the new speed until a force changes that speed or direction. In addition, the direction of acceleration is the same direction as the applied net force. A large force produces a large acceleration. A small force produces a modest acceleration.

• Zero/Constant Acceleration (constant velocity) - there is no change in a system's velocity when the object/body moves at a given velocity and encounters equal, opposing forces. Hence, velocity is constant since no force causes acceleration or deceleration.

• Acceleration caused by gravity - a falling object/body continues to accelerate at the rate of 9.8 m/sec. (32 ft/sec.) throughout its fall.

• Radial acceleration (direction change caused by centripetal force) - centripetal force is aimed along an illusory line (the circular path) at any instant. Therefore, it is the force responsible for change of direction. The bigger the mass, the greater the centripetal force required. A tighter turn magnifies direction change (radial acceleration), so friction must increase to offset the increased acceleration. Maximum friction (centrifugal force) reduces speed. A combination of the variables mass, radius of curvature, speed of travel, and centripetal force cause radial acceleration. Action/Reaction - every action has an equal and opposite reaction.

• Linear motion - the larger the mass, the more it resists motion change initiated by an outside force. Body segments exert forces against surfaces they contact. These forces and the reaction of the surfaces result in body movement. For example, a runner propels himself forward by exerting a force on the ground (as long as the surface has sufficient traction and friction). The force of the contact of the runner's foot with the ground and the equal and opposite reaction of the ground produces movement. A canoe paddler or swimmer exerts a backward force by pushing the water backwards, causing a specific velocity that is dependent on the stroke's force - as well as the equal and opposite force made by the water pushing forward against the canoe paddle or arm moving. Every torque (angular motion) exerted by one body/object on another has another torque equal in magnitude and opposite direction exerted by the second body on the first.

Changing angular momentum requires a force that is equal and opposite to the change in momentum. Performing actions in a standing position requires the counter pressure of the ground against the feet for accurate movement of one or other parts of the body. Research shows that space, direction, and speed are interrelated with movement concepts. Students who understand these concepts will move with confidence and avoid collisions. A student or player incorporates movement concepts such as space, direction, speed and vision to understand and perform a sport. For instance, a player will determine the appropriate personal space while playing soccer or basketball. For a player, the concepts are all interconnected. The player has to understand how to maintain or change pathways with speed. This means the player has the ability to change motion and perform well in space or the area that the players occupy on the field.

5. Movement Techniques & Conclusion

Techniques for promoting students' application of fundamental movement concepts through exploration of shapes, levels, and pathways. Movement is the currency of life. Even when at rest, there is movement within our bodies, if only the rise and fall of our chest as we breathe. We move to survive, to learn and to discover. Young students have an insatiable desire for movement. Older students desire for movement may decrease, particularly if it requires physical effort. Using movement concepts through exploration of shapes, levels and pathways, however, involve activities that usually all age students enjoy. Pathways can be straight, curved or zigzag. Teachers need to explain to the student's that pathways are like designing or shapes that are painted on the floor (feet, legs…) or in the air (hands, head, elbows, arms…) with their body parts.
Examples of techniques for using pathways and shapes are:

• instruct students to paint a straight pathway in the air with their hands.
• instruct students to paint a zig zag in the air with their elbows
• instruct students to paint a figure eight on the floor with only their right foot

Additionally example techniques in using just shapes alone are:

• instruct students to make their bodies look like a ball
• instruct students to make their bodies look like a triangle
• instruct students to make their bodies look like a square.

Now let us summarize the whole lecture, now the conclusion of the lecture is to be given. So we have learnt a lot about the movement and the physics behind the movement. I hope that the information was of some use to all of you. Thank you so much for watching.