Jimma University

College of Natural science

Sport science Department

Course Title:	**Kinesiology**
Course Code:	**SPSC2083**
Credit Hours:	**3**
Academic Year:	**2019/20**
Semester:	**2**
Instructor:	**Hirko Taye (Asstt. Professor)**

Course Description

The basic of athletic performance and physical education is human movement .The science that investigates and analyses human movement is kinesiology. Since sport professionals and physical educators deal with movement, kinesiology is an indispensable course that equips students with fundamental concepts of kinesiology and its application to enhancing athletic performance, application of principles and lows that govern human movement and anatomical and physical fundaments of human motion.

Course Objectives:

1. Describe the fundamental concepts of kinesiology and its role in the field of sports or and other aspects of life;
2. Recognize the nature and types of human movement;
3. Recognize the mechanical factors and laws that govern human movement;
4. Identify the fundamental principles and laws of human motion to enhance movement performance;
5. Apply the analysis of human movements in the daily activity and common sports.

Course Content

5.5 Second law of thermodynamics

Chapter Six: Fluid Mechanics

6.1 Forces in a Fluid Environment

6.2 Buoyance and Floatation

6.3 Dynamic Fluid Force

6.4 Drag Force/ Surface drug

6.5 Lift Force

Chapter Seven: Biological and Structural Bases

7.1 Musculoskeletal system

7.2 Mechanics of muscle-skeletal system

7.3 Anatomical descriptions and its limitation

7.4 Words /Terms/ commonly used in nominal analysis/Movement

Chapter Eight: Biomechanical Analysis of Sports Techniques

8.1 Biological aspects human movement

8.2 Types of Biomechanical Analysis

8.3 Qualitative Biomechanical Analysis

8.4 Quantitative Biomechanical Analysis

Methodological Strategies

- Individual and group work
    - Discussion
    - Picture analysis
    - Practice
    - Presentation
    - Lecture
    - Laboratory

- Project work

Mode of Assessment

- Class Activity
- Individual and group assignment
- Presentation
- Quiz
- Test
- Examination

Reference

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2. Bezabih Woldie (PHD) Kinsiology for HPE students 1996
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5. Adrian, M.J. and Cooper, J.M.(2005). Biomechanics of Sports (2nd ed). Missouri; McGraw-Hill.
6. Joseph Rugai. Methods of Biomechanical Analyses in Sports. International Journal of Secondary Education. Special Issue: Teaching Methods and Learning Styles in Education. Vol. 3, No. 6-1, 2015, pp. 88-91. doi: 10.11648/j.ijsedu.s.2015030601.14
7. Peter M. McGinnis (2013). Biomechanics of Sport and Exercise ,Third Edition, State University of New York, College at Cortland

Chapter One: Introduction to kinesiology

1.1What is kinesiology

- KENIEN-means kinetics=motion
- LOGOS - means to discover ,explain ,study
- KINESIOLOGY is the combination of Anatomy, Physiology & Biomechanics.
- Anatomy deals with the structure & name of body parts by dissecting.
- Physiology deals with the function of body parts.
- Bio-mechanics deals with the motion of all life Starting from the cell.

Kinesiology is also divided /branched / in

to psychological kinesiology ,physiological kinesiology & mechanical kinesiology.

- **Psychological K** refers to movement of

nerve impulse.

- **Physiological K** refers to the movement of

body parts.

- **Mechanical K** refers to a person in

motion.

Kinesiology is defined as the study of gross human body parts motion (gross refers to the movement of the whole body from one point (place) to another. And body refers to the combination of all segment body).

- ✓ Kinesiology encompasses holistic health disciplines which use the gentle art of muscle monitoring to access information about a person’s well being

- ✓ The history of kinesiology is started & integrated with the history of anatomy, physiology, biomechanics & medicine.
- ✓ The central point in this course understands that man is in motion & there is great challenge that is the diverse motion of human body parts.
- ✓ Kinesiology used for physical educators, coaches, medical doctors, physiotherapists etc.

1.2 **Function of kinesiology**

- It considers the symptoms that we may have and then uses the wisdom of our body to find information about what is going on for us.
- It can help to reduce stress in our bodily systems and restore the body to its *naturally balanced state*.
- To promoting health and reducing disease.
- To determine what techniques will help to bring
- To move safely , effectively and efficiently is the purposes of kinesiology

1.3 Relation of kinesiology to biomechanics

- Kinesiology is the study of human movement, performance and function by applying, the sciences of biomechanics, anatomy, physiology psychology, and neuroscience .All to often biomechanical analysis focuses on the kinetic energy or the working numbers in execution of technique.
  - More emphasis should be placed on muscles and joints as they are involved in the action and the role they play in execution of the techniques is critical. Generally there is considerable overlap B/n the discipline of kinesiology & biomechanics

Study of the mechanics and anatomy of human movement and there role in promoting health and reducing disease.

Kinesiology has direct applications to fitness and health, including developing exercise programs for people with and without disabilities, preserving the independence of older people, preventing disease do to trauma and neglect, and rehabilitating people after disease or injury.

Kinesiology is applied in areas of health and fitness for all level of athletes, by physical education teachers, the rehabilitation professions, such as physical and occupational therapy as well as applications in the sport and exercise industry.

The word biomechanics can be divided into two parts: the prefix bio- and the root word mechanics. The prefix bio- indicates that biomechanics has something to do with living or biological systems.

The root word mechanics indicates that biomechanics has something to do with the analysis of forces and their effects. So it appears that biomechanics is the study of forces and their effects on living systems.

- Biomechanics is the study of forces and their effects on living systems.

Chapter Two: Forms of motion

Motion can be defined as a change in the positions of a body with respect to time and another body. A reference point is a requirement for any description of motion as there is no real fixed point within the universe.

2.1 Mechanical Principle: Motion

2.1.1 Newton's First Law of motion ,Law of inertia

This is Newton's first law of motion in Latin as originally presented in Principia. It is commonly referred to as the law of inertia. Translated directly, this law states, "Every body continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it" This law explains what happens to an object if no external forces act on it or if the net external force (the resultant of all the external forces acting on it) is zero.

More simply stated, Newton's first law says that if no net external force acts on an object, that object will not move (it will remain in its state of rest) if it wasn't moving to begin with, or it will continue moving at constant speed in a straight line (it will remain in its state of uniform motion in a straight line) if it was already moving.

- If no net external force acts on an object, that object will not move if it wasn't moving to begin with, or it will continue moving at constant speed in a straight line if it was already moving.

2.1.2 Newton's Second Law ,Law of Acceleration

This is Newton's second law of motion in Latin as originally presented in Principia. It is commonly referred to as the law of acceleration. Translated directly, this law states, "The change of motion of an object is proportional to the force impressed; and is made in the direction of the straight line in which the force is impressed" This law explains what happens if a net external force acts on an object. More simply stated, Newton's second law says that if a net external force is exerted on an object, the object will accelerate in the direction of the net external force, and its acceleration will be directly proportional to the net external force and inversely proportional to its mass.

Newton's second law expresses a cause-and-effect relationship. Forces cause acceleration. Acceleration is the effect of forces. If a net external force acts on an object, the object accelerates. If an object accelerates, a net external force must be acting to cause the acceleration.

Newton's first law of motion is really just a special case of Newton's second law of motion—when the net force acting on an object is zero, its acceleration is also zero.

- Any time an object starts, stops, speeds up, slows down, or changes direction, it is accelerating and a net external force is acting to cause this acceleration.

2.1.3 Newton's Third Law ,Law of Action and Reaction

This is Newton's third law of motion in Latin as presented in Principia. It is commonly referred to as the law of action-reaction. Translated directly, this law states, "To every action there is always opposed an equal reaction: or the mutual actions of two bodies upon each other are always equal and directed to contrary parts" Newton used the words action and reaction to mean force. The term reaction force refers to the force that one object exerts on another. This law explains the origin of the external forces required to change motion . More simply stated, Newton's third law says that if an object (A) exerts a force on another object (B), the other object (B) exerts the same force on the first object (A) but in the opposite direction. So forces exist in mirrored pairs. The effects of these forces are not canceled by each other because they act on different objects. Another important point is that it is the forces that are equal but opposite, not the effects of the forces.

- If an object exerts a force on another object, the other object exerts the same force on the first object but in the opposite direction.

2.2 Mechanical Principle: Stability

The lower the center of gravity to the base of support, the greater the stability.

The nearer the center of gravity to the center of the base of support, the more stables the body.

Stability can be increased by widening the base of support.

2.3 Mechanical Principle: Leverage

Lever - mechanical device used to produce a turning motion around a fixed point called an axis.

Lever components

Fulcrum - center or axis of rotation

Force arm - distance from the fulcrum to the point of application of the force

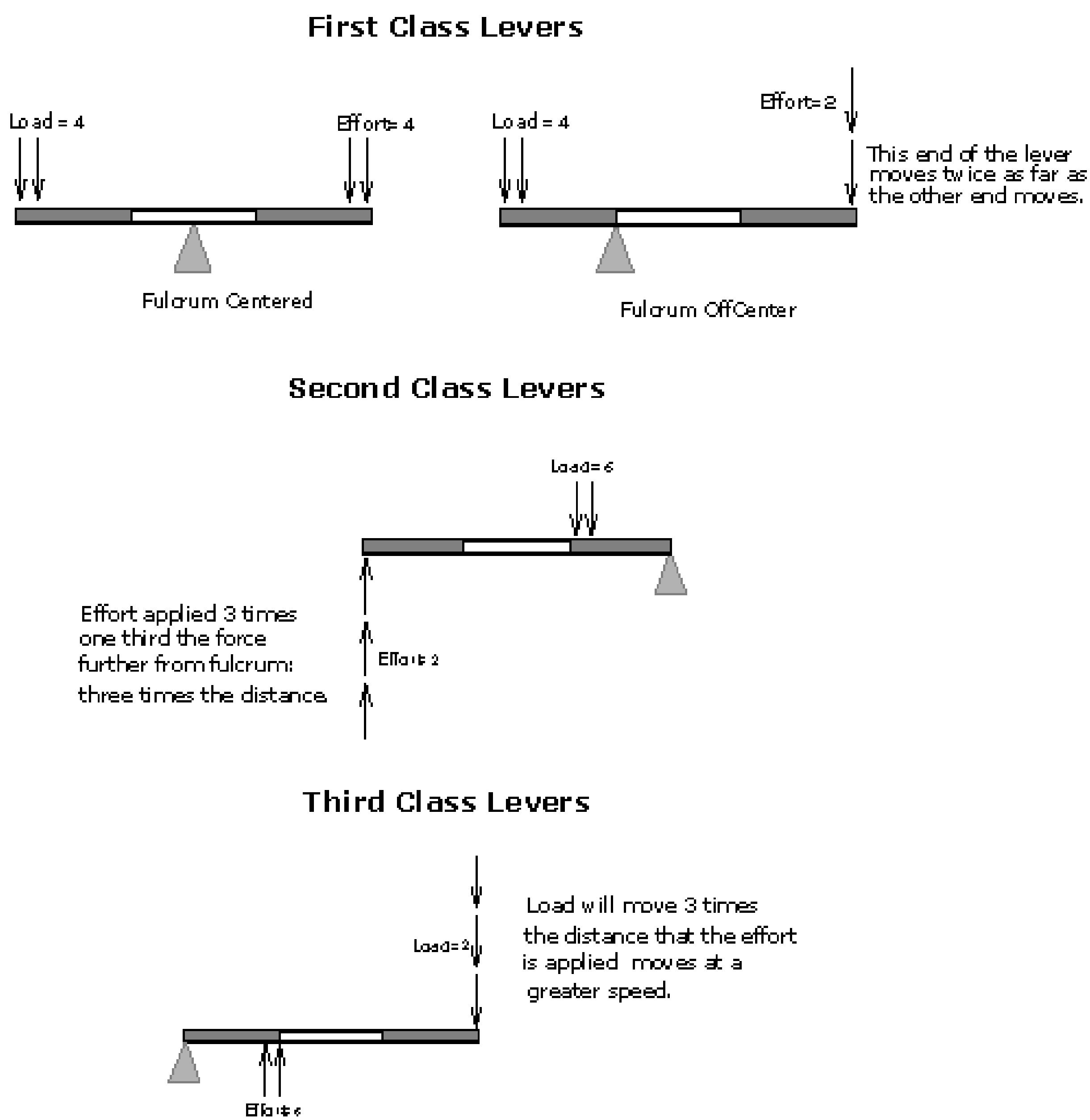
Resistance arm - distance from the fulcrum to the weight on which the force is acting

Levers

First class - fulcrum between the weight and the force ex. Crossbar, seesaw, scissors, elbow extension

Second class - weight is between the fulcrum and the force ex. push up exercise, wheelbarrow, planter flexion, Third class - force is between the fulcrum and the weight ex elbow flexion

Classes of Levers



2.4 Mechanical Principle: Force

The effect that one body has on another.

Production of Force

Produced by the actions of muscles. The stronger the muscles, the more force the body can produce.

Application of Force

The force of an object is most effective when it is applied in the direction that the object is to travel.

Absorption of Force

The impact of a force should be gradually reduced ("give with the force") and spread over a large surface.

2.5 Type of motion and mechanical quantities

motion as the action or process of a change in position. Movement is a change in position. Moving involves a change in position from one point to another. Two things are necessary for motion to occur: space and time—space to move in and time during which to move. To make the study of movement easier, we classify movements as linear, angular, or both (general).

Linear motion is also referred to as translation. It occurs when all points on a body or object move the same distance, in the same direction, and at the same time. This can happen in two ways: rectilinear translation or curvilinear translation.

The path way of the motion experienced by moving bodies can be described as the followings

2.5.1 Straight line (rectilinear motion)

Rectilinear translation occurs when all points on a body or object move in a straight line so that the direction of motion does not change, the orientation of the object does not change, and all points on the object move the same distance.

2.5.2 Curved line (curvilinear motion)

Curvilinear translation occurs when all points on a body or object move so that the orientation of the object does not change and all points on the object move the same distance. The difference between rectilinear and curvilinear translation is that the paths followed by the points on an object in curvilinear translation are curved, so the direction of motion of the object is constantly changing, even though the orientation of the object does

not change.

2.5.3 Rotation (Movement of a body bout an axis (angular motion)

Angular motion is also referred to as rotary motion or rotation. It occurs when all points on a body or object move in circles (or parts of circles) about the same fixed central line or axis. Angular motion can occur about an axis within the body or outside of the body. A child on a

swing is an example of angular motion about an axis of rotation external to the body. An ice-skater in a spin is an example of angular motion about an axis of rotation within the body. To determine whether or not a motion is angular, imagine any two points on the object in question. As the object moves, are the paths that each of these points follow circular? Do these two circular paths have the same center or axis? If you imagine a line connecting the two imaginary points, does this line continuously change orientation as the object moves? Does the line continuously change the direction in which it points? If these conditions are true, the object is rotating.

Examples of angular motion in sports and human movement are more numerous than examples of linear motion. What about a giant swing on the horizontal bar? Are parts of this motion rotary? What about individual movements of our limbs? Almost all of our limb movements (if they are isolated) are examples of angular motion. Hold your right arm at your side. Keeping your upper arm still, flex and extend your forearm at the elbow joint. This is an example of angular motion. Your forearm rotated about a fixed axis (your elbow joint). During the flexing and extending, your wrist moved in a circular path about your elbow joint. Every point on your forearm and wrist moved in a circular path about your elbow joint. Consider each limb and the movements it can make when movement about only one joint is involved.

Are these movements rotary—that is, do all the points on the limb move in circular paths about the joint? Let's consider motion about more than one joint. Is the limb's motion still angular? Extend your knee and hip at the same time.

Was the movement of your foot angular?

Did your foot move in a circular path?

Was the motion of your foot linear?

- Translation- when all part of the body moves in the same direction (rectilinear &curvilinear motion)

  Example 1, an ice hokey player gliding straight across the ice with the same posture will result in all segments of his body moving the same distance over the same time period (translation)

Example 2,A discus traveling in the air following a curved path is linear motion since its motion is translational too.

Example 3, A gymnast who rotates around the high bar with a straight body position undergoes rotation about an external fixed axis where all the body segments travel through the same angle, in the same direction, in the same time, but covering different curvilinear distances the segments further away from the axis (e.g. feet) travelling further than the segments closer to the axis (e.g. shoulders).

There are also occasions where angular motion is observed with respect to an imaginer axis, which in many events could be located outside the physical boundaries of the human body. However the most common form of motion in sport and exercise is a combination of angular and linear motion.

2.5 General Motion

Combining the angular motions of our limbs can produce linear motions of one or more body parts. When both the knee and hip joints extend, you can produce a linear motion of your foot. Similarly, extension at the elbow and horizontal adduction at the shoulder can produce a linear motion of the hand. General motion is a combination of linear and angular motions.

- Classifying motion as linear, angular, or general motion makes the mechanical analysis of movements easier.

2.6 Analyzing movement in physical activities and sport

One of the main uses of biomechanics in sport and exercise science is in the analysis of patterns of human movement in either physical activity or sport. General movement patterns have common elements in terms of segment movements, axes of rotations and planes of movement and are easily recognized by most people and described as walking, running, jumping, throwing, catching, striking and kicking. When a general movement pattern is adapted for use in a particular physical activity or sport it is a skill.

e.g. high jump would be a particular skill within the general group we would all recognize as a jumps

Chapter Three: Kinetics

Kinetics, which is concerned a casual analysis of motion with consideration of interacting forces that causes motion.

Kinetics analysis in sport and exercise also employ images, but supplement this with force plates and other force transducers, that allow the forces exerted against the ground or on sports equipment to be measured.

Understanding force is essential to understanding movement not just in sporting context but also in everyday activities.

While kinematic is about describing movement and kinetics is about explaining cause and effect in movement, understanding force is a key component of kinetics. Force is a vector quantity and so it has magnitude and direction associated with it.

In general kinematics and kinetics analysis is a mechanical factors affecting human body at rest or in motion.

3.1 Linear and Angular kinetics

Linear kinetics Identifying the causes of motion and mechanical information for determining what potential changes could be used to improve human movement. Linear kinetics provides precise ways to Document the causes of the linear motion of all objects. The specific laws and mechanical variables a bio mechanist will choose to use in analyzing the causes of linear motion often depend on the nature of the movement. When instantaneous effects are of interest, Newton's Laws of Motion are most relevant. When studying movements over intervals of time is of interest, the Impulse-Momentum Relationship is usually used. The third approach to studying the causes of motion focuses on the distance covered in the movement and uses the Work-

Energy Relationship. Human movement. Most importantly, we will see how these laws can be applied to human motion in the biomechanical principles of Force-Motion, Force-Time, and Coordination Continuum Principles.

Chapter Four: Kinematics

Biomechanics has a long history of kinematic measurements of human motion and Accurate kinematic measurements are sometimes used for the calculation of more complex, kinetic variables.

Kinematics is the accurate description of motion and is essential to understanding the biomechanics of human motion. Kinematics can range from anatomical descriptions of joint rotations to precise mathematical measurements of musculoskeletal motions. Kinematics is subdivided according to the kinds of measurements used, either linear or angular. Whatever the form of measurement, biomechanical studies of the kinematics of skilled performers provide valuable information on desirable movement technique.

The principles of biomechanics that apply kinematics to improving human movement are Optimal Projection and the Coordination Continuum.

Normal human movement encompasses linear and angular displacement.

Walking: you move linearly but your joints go through angular motion.

Throwing ball: arm moves angularly to project ball linearly

4.1 Linear and Angular Kinematics

- Linear (meters): every part of the object experiences equivalent displacement
  If you (object) are walking in a straight line, every part of you will get from A to B (equivalent displacement)
- Angular: all parts of the object do not experience the same displacement
  Units: Degree, Revolution, Radian:
  Ratio of circumference of a circle to its radius
  1 revolution = 360deg
  1 rev = 2pi radians = 6.28 radians

Chapter Five: Temperature, heat and thermodynamics

Thermodynamics, science of the relationship between heat, work, temperature, and energy. In broad terms, thermodynamics deals with the transfer of energy from one place to another and from one form to another. The key concept is that heat is a form of energy corresponding to a definite amount of mechanical work.

The application of thermodynamic principles begins by defining a system that is in some sense distinct from its surroundings. For example, the system could be a sample of gas inside a cylinder with a movable piston, an entire steam engine, a marathon runner, the planet Earth, a neutron star, a black hole, or even the entire universe. In general, systems are free to exchange heat, work, and other forms of energy with their surroundings.

A system's condition at any given time is called its thermodynamic state. For a gas in a cylinder with a movable piston, the state of the system is identified by the temperature, pressure, and volume of the gas. These properties are characteristic parameters that have definite values at each state and are independent of the way in which the system arrived at that state. In other words, any change in value of a property depends only on the initial and final states of the system, not on the path followed by the system from one state to another. Such properties are called state functions. In contrast, the work done as the piston moves and the gas expands and the heat the gas absorbs from its surroundings depends on the detailed way in which the expansion occurs.

The behavior of a complex thermodynamic system, such as Earth's atmosphere, can be understood by first applying the principles of states and properties to its component parts—in this case, water, water vapors, and the various gases making up the atmosphere. By isolating samples of material whose states and properties can be controlled and manipulated, properties and their interrelations can be studied as the system changes from state to state.

5.1 **Concepts of heat and temperature**

Heat: energy that is transferred from one body to another as the result of a difference in temperature. If two bodies at different temperatures are brought together, energy is transferred—i.e., heat flows—from the hotter body to the colder. The effect of this transfers of energy usually, but not always, is an increase in the temperature of the colder body and a decrease in the temperature of the hotter body. A substance may absorb heat without an increase in temperature by changing from one physical state (or phase) to another, as from a solid to a liquid (melting), from a solid to a vapour (sublimation), from a liquid to a vapour (boiling), or from one solid form to another (usually called a crystalline transition). The important distinction between heat and temperature (heat being a form of energy and temperature a measure of the amount of that energy present in a body)

Temperature:, measure of hotness or coldness expressed in terms of any of several arbitrary scales and indicating the direction in which heat energy will spontaneously flow—i.e., from a hotter body (one at a higher temperature) to a colder body (one at a lower temperature). Temperature is not the equivalent of the energy of a thermodynamic system; e.g., a burning match is at a much higher temperature than an iceberg, but the total heat energy contained in an iceberg is much greater than the energy contained in a match. Temperature, similar to pressure or density, is called an intensive property—one that is independent of the quantity of matter being considered—as distinguished from extensive properties, such as mass or volume.

5.2 Concept of Homeostasis

The term 'homeostasis' is derived from two Greek words; Homeo which means 'unchanging' and Stasis which means 'standing'

It is an organism's internal environment which 'stays the same'

In fact, the internal conditions are not absolutely constant, but allowed to vary within very narrow limits.

Three of the major homeostatic mechanisms that are particularly relevant to sport and exercise are :

- Thermoregulation
- Osmoregulation and
- regulation of blood glucose levels

Human require a stable internal environment to function effectively

The maintenance of this internal environment within tolerable limits is called homeostasis.

humans survive in their natural external environment based on the physiology of their internal environment, homeostasis is a dynamic process, with continual monitoring of the body's biomechanical and physical status.

The nervous and endocrine body organ system provide control and regulation of the body's internal biochemical and physical environments. All living organisms have a boundary that separates their internal environment from external environment, in single cell organisms it is the cell membrane that acts as this boundary. In complex multicellular organisms an external boundary is found by the integumentary system.

This system protect external organ from drying out and forms a boundary lyres b/n the internal and external environments. This is one of the function of our skin. At a cellular level a semi-permeable membrane surrounds all cell to maintain the internal environment of each cell.

Homeostasis is one of the fundamental characteristics of living things and the normal functioning of the body requires biomechanical and physical parameters to be mentioned around a set point, just like a temperature setting on a central heating thermostat .

When the desired temperature is achieved ,the heating system is switched off and when the temperature drops below the desired setting , the heating system is switched on.

Homeostatic control mechanics act to reduce the change in the internal environment to achieve the body's set point for each biochemical and physical parameter .

These parameters include body temperature ,blood pH , blood glucose level and electrolyte balance.

- **Thermoregulation**

In human the core temperature is maintained at 37 ºC Or 36.1 to 37.8 ºC (97.0 to 100.0 ºF), while the shell temperature can vary b/n less than 20 ºC and 40 ºC ,depending on the external environment. The core temperature and highest temperature in the body is found in the skull , thoracic and abdominal cavities were body organs are located .

At the heat – loss surface area, which is the skin ,the shell temperature is lower and the skin is less vulnerable to temperature changes.

- **Modes of Heat Transfer**

Body heat is transferred by the following mechanism.

Conduction involves direct molecular contact.

Convection involves motion of gas or liquid across heated surface.

Radiation involves infrared rays (heat generated from metabolism) , Primary means of heat loss at rest.

Evaporation involves loss of heat as fluid evaporates , is the main means of heat

loss During exercise.

Evaporation accounts for 80% of heat lost during exercise and can also be gained via these four mechanisms

5.3 Heat exchange and change of phase

Regulators of Heat Exchange

Hypothalamus

Central and peripheral thermoreceptors Effectors

Sweat glands

Smooth muscle around arterioles

Skeletal muscles

Endocrine glands

- **Rate of heat exchange**

Heat produced by an average body at rest is 1.25 to 1.5 kcal per minute.

Heat produced during exercise can exceed 15 kcal per minute.

This heat must be dissipated by the body's thermoregulatory systems.

- **Control of Heat Exchange**

The hypothalamus monitors the body's temperature and speeds up heat loss or heat production as needed.

Peripheral thermo receptors in the skin relay information back to the hypothalamus.

Central thermo receptors in the hypothalamus transmit information about internal body temperature.

Sweat gland activity increases to lower body temperature by evaporative heat loss.

Smooth muscles in the arterioles dilate or constrict to allow the blood to dissipate or retain heat.

Skeletal muscle activity increases temperature by increasing metabolic heat.

Metabolic heat production can also be increased by actions of hormones.

Mean body temperature is a weighted average of skin and core temperatures.

- **Metabolic Responses to Exercise in the Heat**

Body temperature increases.

Oxygen uptake increases.

Glycogen depletion is hastened.

Muscle lactate levels increase.

- **Body Fluid and Exercise in the Heat**

Sweating increases (up to 3-4 L/hr or 10-15 L/d)

High volumes of sweat cause

blood volume to decrease,

loss of minerals and electrolytes, and

release of aldosterone and ADH and water reabsorption in kidneys.

- **Heat Disorders & Treatment**

Heat cramps—Move to cooler location and administer fluids or saline solution.

Heat exhaustion—Move to cooler environment, elevate feet; give saline if conscious or intravenous saline if unconscious.

Heatstroke—Rapidly cool body in cold water or ice bath or with wet towels; seek medical attention.

- **Acclimatization**

Heat acclimatization refers to the physiologic adaptations that improve heat tolerance.

Most effective method of avoiding heat stress

Involves becoming accustomed to heat and exercising in heat

Early pre-season training and graded intensity changes are recommended with progressive exposure over 7-10 day period and 80% of acclimatization can be achieved during first 5-6 days with 2 hour morning and afternoon practice sessions

- **Effect of heat acclimatization**

Ability to get rid of excess heat improves ,Sweating becomes more efficient ,Blood flow to skin is reduced; more blood is available to muscles ,Blood volume increases ,Heart rate increase is lower, Stroke volume increases , Muscle glycogen usage decreases.

- **Mechanism of heat Conserve**

  Shivering involves rapid involuntary cycle of contraction and relaxation of muscles.

  Non shivering thermogenesis is stimulation of metabolism.

  Peripheral vasoconstriction reduces blood flow to skin.

5.4 First law of thermodynamics

The laws of thermodynamics are deceptively simple to state, but they are far-reaching in their consequences. The first law asserts that if heat is recognized as a form of energy, then the total energy of a system plus its surroundings is conserved; in other words, the total energy of the universe remains constant.

The first law is put into action by considering the flow of energy across the boundary separating a system from its surroundings. Consider the classic example of a gas enclosed in a cylinder with a movable piston. The walls of the cylinder act as the boundary separating the gas inside from the world outside, and the movable piston provides a mechanism for the gas to do work by expanding against the force holding the piston (assumed frictionless) in place.

5.5 Second law of thermodynamics

The laws of thermodynamics are important unifying principles of biology. These principles govern the chemical processes (metabolism) in all biological organisms. The First Law of Thermodynamics, also known as the law of conservation of energy, states that energy can neither be created nor destroyed. It may change from one form to another, but the energy in a closed system remains constant.

The Second Law of Thermodynamics states that when energy is transferred, there will be less energy available at the end of the transfer process than at the beginning. Due to entropy, which is the measure of disorder in a closed system, all of the available energy will not be useful to the organism. Entropy increases as energy is transferred.

The first law of thermodynamics asserts that energy must be conserved in any process involving the exchange of heat and work between a system and its surroundings. A machine that violated the first law would be called a perpetual motion machine of the first kind because it would manufacture its own energy out of nothing and thereby run forever. Such a machine would be impossible even in theory. However, this impossibility would not prevent the construction of a machine that could extract essentially limitless amounts of heat from its surroundings (earth, air, and sea) and convert it entirely into work.

Chapter Six: Fluid Mechanics

Fluid mechanics is the area of sport and exercise that biomechanics that helps as understand the force exerted on objects or body's by interactions with the fluid they are travelling.

Both air(aerodynamics) and water (hydrodynamics) are fluid mediums that exert forces on bodies moving through them, Both gases and liquids are fluids with similar mechanical properties. Unlike solids, liquids and gases can flow and change shape quickly and easily without separating, so they are classified as fluids. The fluids we are most concerned about in sport biomechanics are air and water. Air is the medium we move through in all land-based sports and human activities, and water is the medium we move through in all aquatic sports and activities. In swimming and other aquatic activities, fluid forces are large, and their importance to success in these activities is obvious. In many land-based activities, fluid forces (air resistance) may be so small that they can be ignored. But in other land-based activities, fluid forces may be large enough to affect the movements of bodies or implements or so large that they determine the outcome of a movement skill. Consider the importance of air resistance in the following activities: sprint running, baseball pitching, cycling, sailboarding, discus throwing, sailing, speed skating, downhill ski racing, hang gliding, and skydiving. In the last two of these activities, one’s life depends on air resistance! Because fluid forces are fundamental for success in aquatic sports and activities, as well as certain land-based activities, a basic understanding of fluid forces is desirable.

6.1 Forces in a Fluid Environment

Two types of forces are exerted on an object by a fluid environment: a buoyant force due to the object’s immersion in the fluid and a dynamic force due to its relative motion in the fluid. The dynamic force is usually resolved into two components: drag and lift forces. The buoyant force, on the other hand, always acts vertically. A buoyant force acts upward on an object immersed in a fluid.

6.2 Buoyant force and Floatation

Because of the magnitude of the buoyant force is directly related to the volume of the submerged object, the point at which the buoyant force acts is the object's center of volume, which is also known as the center of buoyancy. The ability of a body to float in a fluid medium depends on the relationship between the body's buoyancy and its weight. In order for a body to float, the buoyant force it generates must equal or exceed its weight. Some people float and other sink, This difference in floatability is a function of body density.

The orientation of the human body as it floats in water is determined by the relative position of the total body center of gravity relative to the total body center of volume.

The exact locations of the CG and CV vary with anthropometric dimensions and body composition. Typically the CG is inferior to the CV due to the relatively large volume and relatively small weight of the lungs, Because weight acts at the center of gravity and buoyancy acts at the center of volume, a torque is created that rotates the body until it is positioned so that these two acting forces are vertically aligned and the torque ceases to exist.

Specific Gravity and Density Whether or not something floats is determined by the volume of the object immersed and the weight of the object compared to the weight of the same volume of water. Specific gravity is the ratio of the weight of an object to the weight of an equal volume of water. Something with a specific gravity of 1.0 or less will float. Another measure that can be used to determine if a material will float is density.

Archimedes' Principle

Physical law stating that the buoyant force acting on a body is equal to the weight of the fluid displaced by the body.

6.3 Dynamic Fluid Force

Buoyant force is the vertical force exerted on an object immersed in a fluid. It is present whether the object is at rest or is moving relative to the fluid. When an object moves within a fluid (or when a fluid moves past an object immersed in it), dynamic fluid forces are exerted on the object by the fluid. The dynamic fluid force is proportional to the density of the fluid, the surface area of the object immersed in the fluid, and the square of the relative velocity of the object to the fluid.

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- **Flow properties**

Laminar flow - flow characterized by smooth, parallel layers of fluid.

Turbulent flow - flow characterized by mixing of adjacent fluid layers.

- **Fluid properties**

Others factors that influence the magnitude of the forces a fluid generates are the fluid’s density, specific weight, and viscosity.

The denser and heavier the fluid medium surrounding a body, the greater the magnitude of the forces the fluid exerts on the body.

The property of fluid viscosity involves the internal resistance of a fluid to flow.

The greater the extent to which a fluid resists flow under an applied force, the more viscous the fluid is.

A thick molasses, for example, is more viscous that a liquid honey, which is more viscous than water.

Increased fluid viscosity results in increased forces exerted on bodies exposed to the fluid.

Atmospheric pressure and temperature influence a fluid's density, specific weight, and viscosity.

6.4 Drag Force/ Surface drug

Drag Force which are forced that are parallel and opposite to the motion of the object or body as it moves through a fluid .

A resistance force that slows the motion of a body moving through a fluid.

The effect of drag is more consequential when a body is moving with high velocity, which occurs in sports such as cycling, speed skating, downhill and etc.

Increase or decrease in the fluid density also results in proportional change in the drag force.

Type of Drag:-The type of drag experienced by the body depends upon the nature of fluid and the shape of the body:

- Skin friction drag:-

  Skin friction is derived from the sliding contacts between successive layers of fluid close to the surface of a moving body.

  It is also called surface drag and viscous drag.

  Several factors affect the magnitude of skin friction drag:

  It increases proportionally with increases in the relative velocity of the fluid flow, the surface area of the body over which the flow occurs, the roughness of the body surface, and the viscosity of the fluid.

  Wearing smooth, snug clothing helps to minimize skin friction.

- Pressure drag:-

  The part of the total drag that is due to pressure on the body is called as Pressure Drag. It is also called as Form Drag since it mainly depends on the shape or form of the body

- Form drag:-

  Resistance created by a pressure differential between the lead and rear sides of a body moving through a fluid.

  Also called profile drag and pressure drag.

  Several factors affect the magnitude of form drag including:

  the relative velocity of the body with respect to the fluid, the magnitude of the pressure gradient between the front and rear ends of the body , and the size of the surface area that is aligned perpendicular to the flow.

  Streamlining helps to minimize form drag.

- Wave drag:-

  Resistance created by the generation of waves at the interface between two different fluids, such as air and water.

  Although bodies that are completely submerged in a fluid are not affected by wave drag, this form of drag can be a major contributor to the overall drag acting on a human swimmer, particularly when the swim is done in open water.

  When a swimmer moves a body segment along, near, or across the air and water interface, a wave is created in the more dense fluid (the water).

  The reaction force the water exerts on the swimmer constitutes wave drag.

  At fast swimming speeds, wave drag is generally the largest component of the total drag acting on the swimmer.

- Induced drag:-

When a body has a finite length (Ex., Wing of an airplane), the pattern of flow is affected due to the conditions of flow at the ends. The flow cannot be treated as two-dimensional, but has to be treated as three-dimensional flow. Due to this, body is subjected to additional drag. This drag, due to the three dimensional nature of flow and finite length of the body is called as Induced Drag.

6.5 Lift Force

Lift force is the dynamic fluid force component that acts perpendicular to the relative motion of the object with respect to the fluid. Rather than opposing the relative motion of the object through the fluid, the effect of lift force is to change the direction of the relative motion of the object through the fluid. The word lift implies that the lift force is directed upward, but this is not necessarily the case. A lift force can be directed upward, downward, or in any direction. The possible directions of the lift force are determined by the direction of flow of the fluid. The lift force must be perpendicular to this flow.

Qualitatively, lift force can be considered in the following manner. Lift is caused by the lateral deflection of fluid molecules as they pass the object. The object exerts a force on the molecules that causes this lateral deflection (an acceleration, because the molecules change direction). According to Newton's third law, an equal but opposite lateral force is exerted by the molecules on the object. Lift force is thus proportional to the lateral acceleration of the fluid molecules and the mass of the molecules that are deflected.

Lift force is the dynamic fluid force component that acts perpendicular to the relative motion of the object with respect to the fluid.

Bernoulli's Principle

An expression of the inverse relationship between relative velocity and relative pressure in a fluid flow. Faster-moving fluids exert less pressure laterally than do slower-moving fluids.

Chapter Seven: Biological and Structural Bases

7.1 Musculoskeletal system

The combination of bones, joint, muscles and related connective tissues are known as the musculoskeletal system.

Biomechanics is deals with the locomotion system which is the musculoskeletal system (bones, joints and muscles).

Joints, Where the bones come together (and with the power of the muscles) give a variety of range of motion (R.O.M). Joints, (joints, classification) consist of 360 joints.

A joint or articulation is any place where two bones meet or join. Joints have a variety of functions. Their primary function is to join bones together while controlling the motion allowed between them. Joints can provide rigid or highly mobile connections between bones, depending

on their individual functions. In addition to joining bones together, another joint function is to transfer forces between bones. These two competing functions, force transferal and motion control, lead to interesting structural designs of joints.

Joint Classifications

Joints have been categorized in a variety of ways, but most classification schemes are based on joint structure or function (mobility). Structurally, joints can be classified into three general groups. These groups may be further subdivided into subgroups or types of joints. The structural classifications of joints are fibrous (sutures and syndesmoses), cartilaginous (synchrondoses), and synovial. Bones connected by fibrous connective tissue form a fibrous joint. These joints are typically (although not necessarily) rigid. The sutures of the skull are examples of fibrous joints. Bones connected by cartilaginous tissue form a cartilaginous joint. This type of joint may be rigid or may allow slight movement. The pubic symphysis between the left and right pubic bones of the pelvis is an example of a cartilaginous joint. The joint between the diaphysis and epiphysis in an immature skeleton is another example of a cartilaginous joint. Bones connected by ligaments and separated by a joint cavity form synovial joints. Synovial joints are highly mobile. Their distinguishing characteristic is a joint cavity that encloses the space between the joints. Most of the joints of the appendicular skeleton are synovial joints. Functionally, joints can be classified by how much movement they allow. The functional classifications for joints are synarthrodial (immovable), amphiarthrodial (slightly movable), and diarthrodial (freely movable). Some functional classification systems group immovable and slightly movable joints together as synarthroses. Fibrous and cartilaginous joints are classified as synarthrodial and amphiarthrodial, respectively, in the structural classification scheme, whereas synovial joints

are classified as diarthrodial joints.

The synovial joints

are of most interest to us because these are the joints where movement occurs. Examples of joints classified by function and by structure

Synovial (or diarthrodial) joints are sub classified into six different types according to the movements allowed and the structure of the joint: gliding, hinge, pivot, ellipsoidal, saddle, and ball and socket.

Gliding joints are also called irregular, plane, or arthrodial joints. The articulations are flat and small, and planar sliding movements are allowed at these joints. The intercarpal (wrist), intertarsal (ankle), and acromioclavicular (shoulder girdle) joints are examples of gliding joints.

Hinge joints are uniaxial and allow only one degree of freedom of movement (only one number, say the angle between the two bones of this joint, would be needed to fully describe the orientation of the bones with respect to each other).

Hinge joints are also called ginglymus joints. The pair of articulating surfaces in a hinge joint

approximate a round cylinder (oriented perpendicular to the long axis of the bone) that fits into a matching shallow trough. The movements allowed at a hinge joint are flexion and the return movement of extension (or plantar flexion and dorsiflexion at the ankle). The humeroulnar (elbow), tibiofemoral (knee), talotibial and talofibular (ankle), and interphalangeal (finger and toe) joints are all examples of hinge joints.

Pivot joints are also uniaxial, allowing only one degree of freedom of movement. These joints may also be called trochoid or screw joints. The articulating surfaces of a pivot joint may approximate a pin inserting into a hole or a cylinder (aligned with the long axis of the bone) that fits into a shallow trough. Rotation about a longitudinal axis is allowed at a pivot joint. The proximal radioulnar joint (between the bones of the forearm) and the atlantoaxial joint (between the first and second cervical vertebrae) are examples of pivot joints. The rotary movements of the proximal radioulnar joint are called supination and pronation. The rotary movements of the atlantoaxial joint are called rotation to the right or left.

Ellipsoidal joints are biaxial and allow two degrees of freedom of movement. These joints may also be called condyloid or ovoid joints. The articulating surfaces of an ellipsoidal joint approximate the shape of an ellipse (or egg) that fits into a matching oval depression. These joints have also been described as oval ball-and-socket joints. The movements allowed at an ellipsoidal joint are flexion and extension; abduction and adduction; and circumduction, a combination of these movements. The radiocarpal (wrist), metacarpophalangeal (fingers), metatarsophalangeal (toes), and occipitoatlantal (head and neck) joints are all examples of ellipsoidal joints.

Saddle joints are also biaxial and allow two degrees of freedom of movement. These joints are also called sellar joints. The articulating surfaces of a saddle joint look like a pair of saddles turned 90° to each other. Cup the fingers of each hand, then put your hands together, rotating one of them 90°. This approximates a saddle joint. The U-joints in the driveshaft of a car are like saddle joints. A saddle joint also allows flexion and extension, abduction and adduction, and circumduction. The first carpometacarpal joint (at the base of the thumb) is an example of a saddle joint.

Ball-and-socket joints are triaxial and allow three degrees of freedom of movement. These joints are also called enarthrodial, spheroidal, or cotyloidal. The articulating surfaces of these joints look like a ball and a socket. Ball-and-socket joints are the most freely movable of the synovial joints. They allow flexion and extension, abduction and adduction, and internal and external rotation. The glenohumeral (shoulder) and hip joints are examples of ball-and-socket joints. The sternoclavicular joint (between the shoulder girdle and the axial skeleton) is classified as a ball-and-socket or gliding joint.

- **Muscles:**

The body's motive power (muscular system) consist of 640 muscles.

Muscles classification

Skeletal or voluntary - found in limbs, Abdominal wall , Face

Heart or cardiac - confined to the heart

Smooth, visceral, or involuntary –Stomach, bladder, Blood vessels, uterus

7.2 Contraction Mechanics of muscles

The action responsible for the contraction of a muscle occurs within the sarcomere. In response to a stimulus from the motor neuron that innervates a muscle, the muscle becomes active, and the cross bridges of the thick myosin filament attach, pull, release, and reattach to specific sites on the thin actin filament. The cross bridges of the myosin filament tug on the adjacent actin filament and pull themselves past it, similar to the way you might pull on (or climb up) a rope hand over hand. The myosin filaments thus slide past the actin filaments, and the muscle shortens (in a concentric contraction). An eccentric contraction is like lowering a bucket on a rope by letting it drop a short distance, then regripping it, then letting it drop, and so on. The cross bridges of the myosin filament attach and tug, but another force pulls them off that attachment site; and as the actin filament slides away, the myosin cross bridges quickly reattach to another site. The force developed during a contraction is the sum of the pulling forces that each myosin cross bridge exerts on the actin filament. The more cross bridges attached to

actin filaments, the larger the contraction force. A single stimulus from the motor neuron (the nerve cell that innervates the fiber) results in a twitch response of the fiber. The cross bridges attach briefly and then release, with muscle tension rising . The duration of tension in the

muscle is short. A repeated series of stimuli received from the motor neuron results in a repeated series of twitch responses of the muscle fiber if the time between each successive stimulus is long enough. With increased frequency of stimulus (and less time between stimuli), there will still be tension in the fiber when the next stimulus occurs. The subsequent tension in the fiber will be greater. If the frequency of stimuli is rapid enough, a tetanic response of the fiber results will occurs . The cross bridges attach, release, and reattach, with increasing tension developed until a maximum value is reached. The maximum tension achieved in a tetanic response is much greater than that achieved in a twitch response. Continued stimuli keep the tension in the muscle high until fatigue occurs.

A single stimulus from the motor neuron results in a twitch response of the fiber.

Muscle Contraction Force

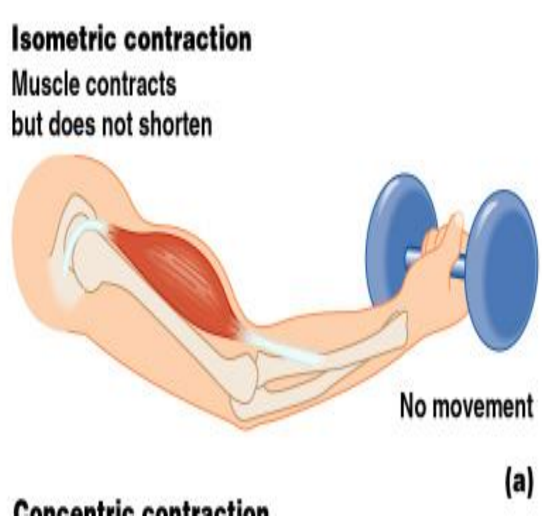
Mechanics of muscle-skeletal system

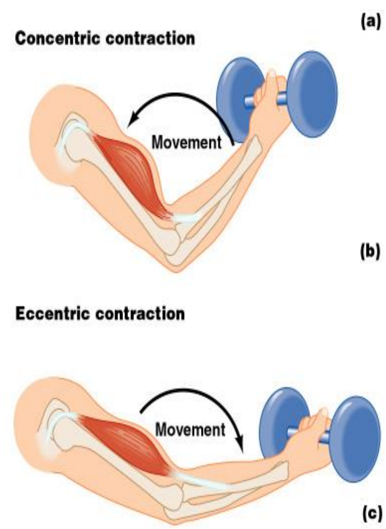
Isotonic (meaning same tension)

Isometric (meaning same distance or not moving)

Isokinetic (meaning same speed)

Isometric, Concentric and Eccentric Muscle Actions





Isotonic contraction can be divided into two types:

Concentric: the muscle shortens as it contracts.

Eccentric: the muscle lengthens but is still under tension

Isometric - During isometric contraction, the muscle remains the same length. While performing a handstand, many of the bodies muscles are contracting.

Isokinetic contraction occurs when the speed of the contraction remains constant throughout the movt.

An example of this can be seen in cycling. The legs are moving at a relatively constant speed, although forces applied by the leg alter during a peddling cycle.

Breast stroke in swimming, where the water provides a constant, even resistance to the movement of adduction.

- The maximum tensile force a muscle is capable of producing is dependent on the velocity of shortening of the muscle as well as its length.
- A muscle contracting eccentrically or isometrically is capable of producing more force than a muscle contracting concentrically

Muscle Fiber Types

Skeletal muscle is made up of bundles of individual muscle fibers called myocytes. Each myocyte contains many myofibrils, which are strands of proteins (actin and myosin) that can grab on to each other and pull. This shortens the muscle and causes muscle contraction.

It is generally accepted that muscle fiber types can be broken down into two main types: slow twitch (type I) muscle fibers and fast twitch (type II) muscle fibers. Fast twitch fibers can be further categorized into type IIa and type IIb fibers.

These distinctions seem to influence how muscles respond to training and physical activity, and each fiber type is unique in its ability to contract in a certain way. Human muscles contain a genetically determined mixture of both slow and fast fiber types.On average, people have about

50 percent slow twitch and 50 percent fast twitch fibers in most of the muscles used for movement.

Slow Twitch Muscle Fibers (Type I)

The slow twitch muscle fibers are more efficient at using oxygen to generate more adenosine triphosphate (ATP) fuel for continuous, extended muscle contractions over a long time. They fire more slowly than fast twitch fibers and can go for a long time before they fatigue. Therefore, slow twitch fibers are great at helping athletes run marathons and bicycle for hours.

Fast Twitch Muscle Fibers (Type II)

Because fast twitch fibers use anaerobic metabolism to create fuel, they are better at generating short bursts of strength or speed than slow muscles. However, they fatigue more quickly. Fast twitch fibers generally produce the same amount of force per contraction as slow muscles, but they get their name because they are able to fire more rapidly. Having more fast twitch fibers can be an asset to a sprinter since she needs to quickly generate a lot of force.

Fast Twitch Muscle Fibers (Type IIa)

These fast twitch muscle fibers are also known as intermediate fast-twitch fibers. They can use both aerobic and anaerobic metabolism almost equally to create energy. In this way, they are a combination of type I and type II muscle fibers.

Anaerobic Metabolism vs. Aerobic Metabolism in Exercise

Fast Twitch Muscle Fibers (Type IIb)

These fast twitch fibers use anaerobic metabolism to create energy and are the "classic" fast twitch muscle fibers that excel at producing quick, powerful bursts of speed.

This muscle fiber has the highest rate of contraction (rapid firing) of all the muscle fiber types, but it also has a faster rate of fatigue and can't last as long before it needs rest.

BONE:- BONE is composed of living & nonliving parts. 67% calcium salts- nonliving part.

33% organic/collagen-living part (absorb shock) At age 25 the final size & shape is assumed.

The framework of the body is the skeleton (bones). Bones of the skeletal system consist of 206 bones.

DIFFERENT SHAPES OF THE BONE & THEIR FEATURE

Long- e.g femur (thigh)

Flat- e.g scapula-ribs-sternum

Short- e.g tarsal- metatarsal-carpal

Irregular-e.g Knee cap- vertebrae- patella

FUNCTION

Locomotion- Movement

Protection- from injury (brain, heart, lung, & liver

produce blood cell-

shape & support of the body

Insertion & origin

PARTS OF BONE ;

.AXIAL BONE

.APPENDULAR/ LIMBS

7.3 **Anatomical descriptions and its limitation**

Plane And Axis of movement

Three basic reference planes are used in anatomy:

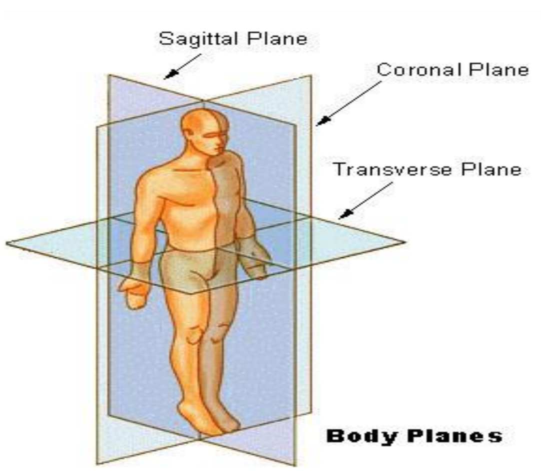
A sagittal plane is perpendicular to the ground and divides the body into left and right. The midsagittal or median plane is in the midline i.e. it would pass through the midline structures (e.g. navel or spine), and all other sagittal planes (also referred to as parasagittal planes) are parallel to it.

Median can also refer to the midsagittal plane of other structures, such as a digit.

A coronal or frontal plane, is perpendicular to the ground and divides the body into dorsal (posterior or back) and ventral (anterior or front) portions.

A transverse plane, also known as an axial plane or cross-section, divides the body into cranial (head) and caudal (tail) portions. It is parallel to the ground, which (in humans) separates the superior from the inferior, or put another way, the head from the feet.

Anatomical planes in a human



Axes :- An axis is a straight line around which an object rotates. Movement at the joint take place in a plane about an axis. There are three axis of rotation.

Sagital axis - passes horizontally from posterior to anterior and is formed by the intersection of the sagital and transverse planes.

Frontal axis - passes horizontally from left to right and is formed by the intersection of the frontal and transverse planes.

Vertical axis - passes vertically from inferior to superior and is formed by the intersection of the sagital and frontal planes.

7.4 **Words /Terms/ commonly used in nominal analysis/Movement**

ABDUCTION-the mov't of the body part away from the central axes (axial skeleton).

ADDUCTION-the mov't of the body segment towards the central axes.

ANTERIOR- near to the front part (chest, pubic).

POSTERIOR- near to the back part.

Coronal (frontal) plane- this plane divides the body in to anterior & posterior halves (abduction & adduction)

DISTAL-away from the main mass (the forearm is distal to the arm)

DORSAL- the same as back (posterior)

EVERSON- walking on the inside boarder of the foot.

EXTENSION-moving away from the segment.

FLEXION- moving towards the segment.

INVERSION-walking on the outside boarder of the foot.

ELEVATION-moving upward (e.g when we breath in)

DEPERSSION-moving downward (when we breath out)

LATERAL-to the side.

MEDIAL-towards inside.

OPPOSITION-the movement of the thumb towards each finger.

POSTERIOR-dorsal (back).

Pronation - the movement of the hand (palm) towards the floor surface (down).

Proximal-closer to the center.

SAGITAL PLANE- is an imaginary plane w/c divides the body to the right & left halves.

Supination- the act of begging (the movement of hands upward.

Superior- towards the head.

Transverse plane -this plane divides the body in to upper & lower parts halves.

Visceral-internal

Circumduction – rotation + flexion + extension+ adduction+ abduction.

Chapter Eight: Biomechanical Analysis of Sports Techniques

8.1 Biological aspects human movement

Mechanics

Statics:- Study of factors relating to nonmoving systems or those characterized by steady motion.

-Is the study of stationary objects (body in state of equilibrium) caused by balanced forces.

Example, of statics analysis in sport standing different balance in gymnastics and acrobatics in certain resistance exercise were no movement is apparent but large forces my be exerted

Dynamics :- Is the study of moving objects (body in state of motion) change caused by unbalanced forces. most activities in physical activities involve movement require the application of dynamics to understand that movement. Study of mechanical factors that relate to systems in motion, Kinematics and Kinetics

Analysis involves breaking something into smaller parts and then examining those parts.

A qualitative analysis involves breaking something into smaller parts and then examining those parts without measuring or quantifying their characteristics. A qualitative biomechanical analysis of a movement or sport skill is thus breaking down the movement into its basic elements and then qualitatively examining those elements from a biomechanical perspective, depending on the approach of goal for the analysis, to improve technique? To improve training? To prevent injury? To improve equipment?

8.2 Types of Biomechanical

The adjectives qualitative and quantitative describe how the characteristics of the performance are observed and analyzed by the coach, teacher, or clinician. If the performance or any of its aspects is quantified or measured (described with numbers), the resulting analysis based on these measurements is a quantitative biomechanical analysis. If the performance or any of its aspects is evaluated using only the senses of the observer, the resulting analysis is a qualitative biomechanical analysis. This and subsequent chapters focus on qualitative biomechanical analysis methods.

8.3 Qualitative Biomechanical Analysis

Teachers and coaches often perform qualitative biomechanical analyses, but they rarely perform any quantitative biomechanical analyses. They observe their athletes and students performing and describe the mechanical characteristics of the performance subjectively. Comparative descriptors (faster, slower, higher, lower, shorter, longer, larger, smaller, and so on) may be used to denote these characteristics. The sense of sight, or visual observation,

is the basis for most qualitative analyses.

How a coach or teacher observes a performance affects the subsequent qualitative biomechanical analysis.

8.4 Quantitative Biomechanical Analysis

Comprehensive quantitative biomechanical analyses are usually limited to performances by elite athletes; however, teachers and coaches may make some performance measurements and thus do limited quantitative biomechanical analyses. A stopwatch and a tape measure may be used to measure and thus quantify many biomechanical parameters. Counting steps and timing how long it takes to take that many steps gives the coach a measure of step rate. Measuring a specific distance and timing how long it takes to move that distance gives a measure of speed.

If assistants record where each footfall lands, step length can be measured. These types of measurement allow the coach or teacher to do limited quantitative biomechanical analyses, but taking such measurements prevents the coach or teacher from observing the whole performance.

A comprehensive quantitative biomechanical analysis requires specialized and expensive equipment for recording and measuring the biomechanical variables of interest.

Bio mechanists or trained technicians, rather than teachers or coaches, usually conduct comprehensive biomechanical analysis .