SECTION

5 HUMAN ANATOMY AND PHYSIOLOGY

PHYSICAL EDUCATION

Scientific Bases of Physical Activity

INTRODUCTION

Welcome to Section 5. You have made incredible progress through Sections 1 to 4, delving deep into health and wellness, exploring human diseases, embracing physical activity, and mastering sports training principles.

Now, as we embark on Section 5, our focus shifts to understanding human anatomy and physiology, particularly in relation to physical activity.

This section is crucial for anyone looking to optimise their fitness and performance by understanding how their body works.

We will start by discussing the fundamental concepts of anatomy and physiology in physical activity. You will gain insights into how the structure of your body (anatomy) and its functions (physiology) work together during exercise. Following this, we will look into the practical applications of these concepts, showing you how to use this knowledge to enhance your training, prevent injuries, and improve your overall performance.

You will discover the remarkable ways your body supports and enhances physical activity and will have opportunity to share your experiences and support each other in understanding the science behind your movements.

Are you ready to uncover the incredible mechanics behind your movements and take your physical activity to the next level? Let us dive in and discover the amazing capabilities of our bodies!

At the end of this section, you will be able to:

Discuss the concepts of anatomy and physiology in physical activity

Apply the concepts of anatomy and physiology in physical activity

Key Ideas

- **Anatomy**: The study of the structure and parts of living organisms, especially the human body.
- **Physiology:** The study of how living organisms and their body parts function.
- **Adaptation:** A change or adjustment in an organism or behavior that helps it survive or thrive in its environment.
- **Rehabilitation:** The process of helping someone recover from illness, injury, or addiction and return to normal life or functioning.

- **Flexibility:** The ability of a muscle or joint to move through its full range of motion easily without stiffness or restriction.
- **Range of motion:** The full movement potential of a joint, usually its ability to move from the fully bent position to the fully straight position.
- **ATP (Adenosine Triphosphate):** A molecule in cells that stores and provides energy for many cellular processes, including muscle contractions. It's often called the "energy currency" of the cell.

ANATOMY AND PHYSIOLOGY IN PHYSICAL ACTIVITY

By understanding the structures (anatomy) and functions (physiology) of our bodies, we can better appreciate how everything works together when we move, exercise, or play sports.

The human body is made up of various parts specialised for specific functions. Studying how these various parts are organised and how they function is essential for participation in physical activities and sports.

a. Concept of anatomy

Anatomy is the study of structures that make up the body and how those structures relate to each other. It is a branch of natural science and biology, which includes human anatomy, animal anatomy, and plant anatomy. It covers everything from large, visible parts like muscles and bones (macroscopic anatomy) to tiny structures like cells (microscopic anatomy).

b. Branches of human anatomy

Branches of human anatomy include:

i. **Macroscopic or gross anatomy:** This anatomy mainly deals with the study of large body parts, those that can be seen with the naked eye e.g. anatomy of the kidney, heart, lungs etc.

Macroscopic or gross anatomy is further classified into:

- *Regional anatomy*: A study of different structures in a particular area.
- *Systemic anatomy*: A study of the body's structures and organisation of the systems.
- *Surface anatomy*: A study of external structures of the human body.

ii. **Microscopic anatomy:** This anatomy mainly deals with the study of very small and minute structures, those that can only be examined through the microscope. An example is the different types of cells.

Microscopic anatomy is further classified into:

- *Cytology:* Which deals with the study of human blood cells.
- *Histology:* Which deals with the study of different tissues in the human body.

c. Structural organisation of the human body

Before looking into the different structures and functions of the human body, it is helpful to consider its basic architecture, that is, how its smallest parts are assembled into larger structures. We can consider the structures of the body in terms of fundamental levels of organisation that increase in complexity, such as subatomic particles, atoms, molecules, organelles, cells, tissues, organs, organ systems and organisms.

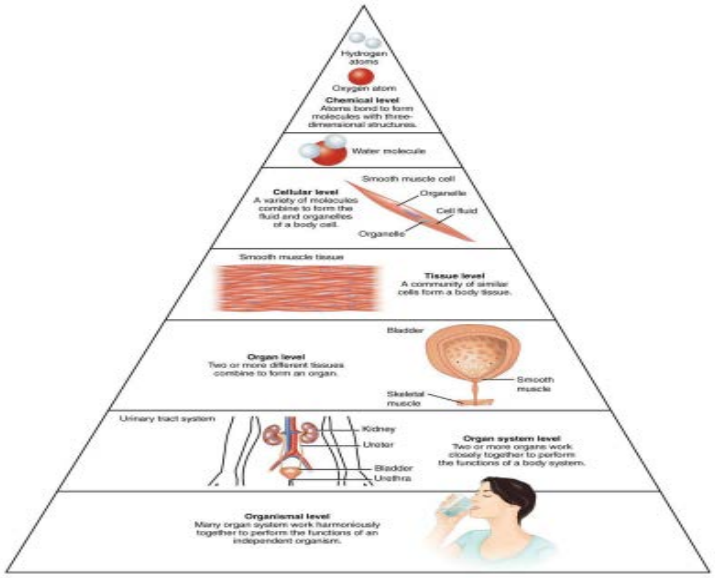

Fig 5.1: The Organisation of the Body Structure

The four main structures of the human body are:

i. **Cells:** Cells are the simplest units of living matter that can maintain life and reproduce themselves. The human body, which is made up of numerous cells, begins as a single, newly fertilised cell.

ii. **Tissues:** Tissues are more complex units than cells. They are an organisation of a great many similar cells with varying amounts and kinds of non-living, intercellular substances between them.

iii. **Organs:** Organs are more complex units than tissues. Organs are an organisation of several different kinds of tissues so arranged that together, they can perform a special function. For example, the stomach is an organisation of muscle, connective, epithelial and nervous tissues.

iv. **Systems:** Systems are the most complex of the component units of the human body. A system is an organisation of varying numbers and kinds of organs so arranged that together, they can perform complex functions for the body.

d. Concept of physiology

Physiology is the study of how the various systems and organs within the human body function and interact to maintain life and health. It looks at how systems like the heart, lungs, and muscles function, especially during physical activity. Physiology is a branch of natural science and biology which is further classified into:

i. **Cell physiology:** The study of the functions of cells.

ii. **System physiology:** The study of the complete functioning of body systems.

iii. **Comparative physiology:** The study of various characteristics of living organisms.

iv. **Pathophysiology:** The study of dysfunctions and other diseases related to the functioning of the human body systems.

v. **Exercise physiology:** This is the study of the effects of physical exercise or physical activity on the body's function. This includes research into bioenergetics, biochemistry, cardiopulmonary function, biomechanics, haematology, skeletal muscle physiology, neuroendocrine function, and nervous system function.

Activity 5.1

With a partner, note down as many differences as you can between macroscopic and microscopic anatomy. Share your answers with your classmates.

Activity 5.2

Group project work - Model building of human organs or systems.

Materials needed: Modeling clay in various colors, Colored paper, Scissors, glue, markers, and Cardboard for base structure.

Procedure:

- Your teacher will assign your group a specific organ or system (e.g., heart, lungs, digestive system)
- Research your assigned organ or system.
- Use clay to model the organ/system ensuring accuracy in shape and size.

- Use colored paper for additional details (e.g., blood vessels, nerves, veins etc).
- Present your modeled work in class.
- Use feedback from your classmates, focusing on accuracy and creativity to make personal notes.

Activity 5.3

Materials needed: Stopwatches, heart rate monitors, blood pressure cuffs, data recording sheets (Visit your school clinic and sports office).

Procedure:

- Measure and record each a peer's resting heart rate, breathing rate, and blood pressure.
- Ask the peer to perform any physical activity (e.g., jogging, jumping jacks) for a set period (e.g., 5 minutes).
- Immediately after the activity, measure and record the same physiological parameters.
- Compare the baseline and post-exercise measurements, discussing how and why these changes occur.
- Reflect on how your bodies responded to exercise and the importance of monitoring physiological changes during physical activities.

We have now laid the foundation by exploring the basics of anatomy and physiology. We learned that human anatomy and physiology are two important areas of study when it comes to physical activities and sports performance. Now, it is time to put that knowledge into practice. We will now look into how understanding our body's structure and function can enhance our physical activities. From muscle movements to energy systems, we will uncover the secrets of optimising performance and preventing injuries. Get ready for engaging discussions, practical exercises, and hands-on activities that will help you see the direct impact of these concepts on your daily life and sports activities.

APPLICATION OF ANATOMY AND PHYSIOLOGY IN PHYSICAL ACTIVITY

a. The musculoskeletal system and physical activity

Exercise is about movement and the muscular and skeletal (musculoskeletal) systems are primarily responsible for creating movement. When we exercise, our muscles contract and our bones act as levers to produce movement. Therefore, the responses and adaptations of the muscular system to exercise are important parts of exercise physiology.

i. **Actions of the skeletal muscles during physical activities:** There are several types of skeletal muscle actions produced during physical activities. Among these types of skeletal muscle actions include;

- *Isometric (static) muscle action/contraction:* Isometric muscle action refers to the contraction of a muscle without a change in its length or joint angle. This occurs when tension is developed in the muscle without movement, therefore the muscle origin and insertion do not move and there are no changes in muscle length e.g. holding the body at a plank position, pushing against an immovable object like a wall, squeezing a fully inflated ball without causing a depression on it.
- *Isotonic (Dynamic) muscle actions/contraction:* This refers to muscle contractions where there is a change in muscle length and joint angle, resulting in movement. The two types of isotonic muscles are:
  - *Concentric contraction:* The muscle shortens as it contracts and there is movement at the joint. The muscle produces enough force to overcome the external resistance e.g. when lifting an item toward the shoulder, the bicep muscles contract and shorten.
  - *Eccentric:* The muscle lengthens while performing an action. This happens because the external resistance moves in the direction opposite to the standard concentric (shortening) action e.g. In lifting an item with the hand toward the shoulder (as described in the concentric), the triceps muscles lengthen (extend).
- *Isokinetic (Dynamic) muscle actions:* Here, the muscle actions are either concentric, eccentric or both. It is an action that focuses on controlling the speed of movement so that the muscle contracts at a constant velocity throughout the range of motion. These types of actions can help athletes perform exercises that simulate the speed and sport-specific activities e,g. the use of a resistance band designed for isokinetic training would make a person experience consistent resistance regardless of the speed at which they push the band. Also, a leg press machine with isokinetic capabilities would ensure that the legs move at a constant velocity against the resistance provided by the machine.

Fig 5.2: Muscle Contraction

b. Energy systems in physical activity

With respect to exercise, metabolism involves how the body generates energy for muscular work. The energy for exercise, in the form of adenosine triphosphate (ATP), is derived from the breakdown of food from the diet. Originally in the form of protein, fat, and carbohydrate, the energy is made available by different enzymatic pathways that break down food and ultimately lead to ATP formation. The body uses different energy systems depending on the activity's intensity and duration.

c. Anatomical position

Anatomical position or standard anatomical position refers to a specific body shape used when describing an individual's anatomy. The standard anatomical position of the human body consists of the body standing upright and facing forward with the legs parallel to each other. The upper limbs or arms, hang at either side and the palms face forward. Understanding the standard anatomical position and terms is essential for describing body movements and positions accurately.

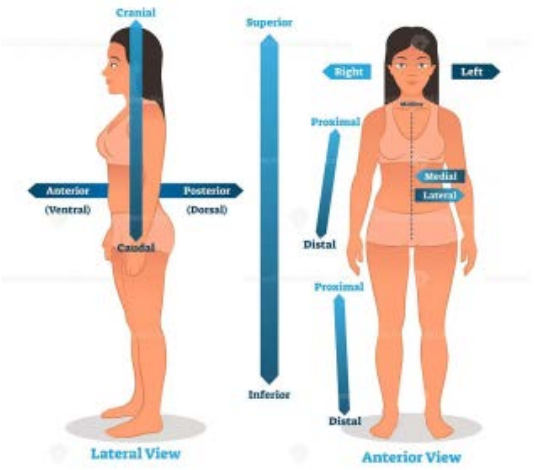

Fig 5.3: Anatomical position

d. Anatomical terminologies for describing body structure

There are three terms used to describe the body structure, namely: Directional Terms, Planes of the Body and Homeostasis.

i. Directional terms

Directional terms describe the position of the body in relation to other structures or parts of the body.

Table 5.1: Anatomical and directional terms

Anatomical term	Direction/location	Example
Superior/cranial	Toward the head end of the body. (Upper)	The hand is part of the superior extremity
Inferior/caudal	Away from the head (Lower)	The foot is part of the inferior extremity
Anterior/ventral	Front	The kneecap is located on the anterior side of the leg
Posterior or dorsal	Back	The shoulder blades are located on the posterior side of the body
Medial	Toward the midline of the body	The middle toe is located at the medial side of the foot
Lateral	Away from the midline of the body	The little toe is located at the lateral side of the foot
Proximal	Toward or nearest the trunk or the point of origin of a part	The proximal end of the femur joins with the pelvic bone
Distal	Away from or farthest from the trunk or the point or origin of a part	The hand is located at the distal end of the forearm

The importance of anatomical position/direction in physical activity and sports:

- It helps us to understand human movement.
- Knowledge of anatomical positions supports procedural training.
- It is useful in general fitness and exercise programmes.
- Understanding anatomical position helps to describe where parts of the body are and the tasks they are performing.
- It helps health workers to understand and explain health problems. This helps them give the right treatment quickly e.g. if an athlete has an inflamed joint, the doctor will be able to describe exactly which joint is affected and what treatment should be given.

ii. Planes of the body

Anatomical body planes describe how the body moves when engaged in an exercise or other activities. Understanding how the body works can help develop a well-balanced strength.

The three anatomical plains are:

- *Coronal Plane (Frontal Plane):* A vertical plane running from side to side. It divides the body or any of its parts into anterior and posterior portions.

- *Sagittal Plane (Lateral Plane):* A vertical plane running from front to back. It divides the body or any of its parts into right and left sides.
- *Axial Plane (Transverse Plane):* A horizontal plane that divides the body or any of its parts into upper and lower parts.

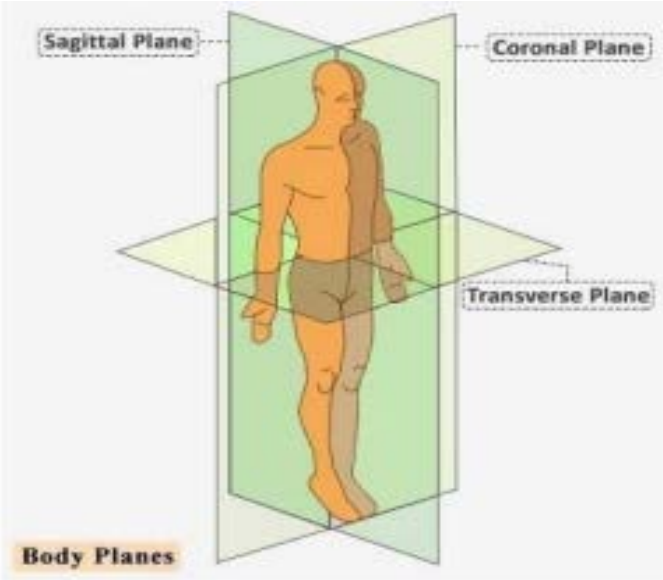

Fig. 5.4: Planes of the human body ....

***Movements that happen in the coronal (frontal) plane*:** Movements that occur in the coronal (frontal) plane are lateral or side-to-side. These include:	– *Abduction*: Moving your limbs laterally, away from the midline of the body (e.g., lifting your leg to the side). – *Adduction*: Moving your limbs medially, toward the midline of the body (e.g., lowering your arm down to the side of your body). – *Elevation*: Raising your scapula (shoulder blade) upward. – *Depression*: Lowering your scapula (shoulder blade) downward. – *Inversion of the ankle*: The sole of the foot turns inward toward the midline of the body (a component of supination. – *Eversion of the ankle*: The sole of the foot turns outward away from the body's midline (a component of pronation).
***Movements that happen in the sagittal (longitudinal) plane*:** The movements of the sagittal (longitudinal) plane include:	– *Flexion*: Bending a limb to decrease the angle at a joint (e.g. lifting a dumb-bell during a bicep curl flexes the elbow). – *Extension*: Movement that increases the angle at a joint (e.g. lifting your leg behind you when standing extends the hip joint). – *Dorsiflexion*: Bending the ankle so the top of the foot and your toes move toward your shin. – *Plantar flexion*: Bending the ankle so the foot pushes down and your toes point away.
Movements that happen in the transverse (axial) plane: Movements that occur in this plane involve rotation or horizontal movement, which include:	– *Rotation*: Rotating the torso or a limb around its vertical axis (e.g., turning your head to the left or right). – *Horizontal abduction*: Moving the arm away from the midline of the body when it's at a 90-degree angle in front of the body. – *Horizontal adduction*: Moving the arm toward the midline of the body when it's at a 90-degree angle to the side of the body.

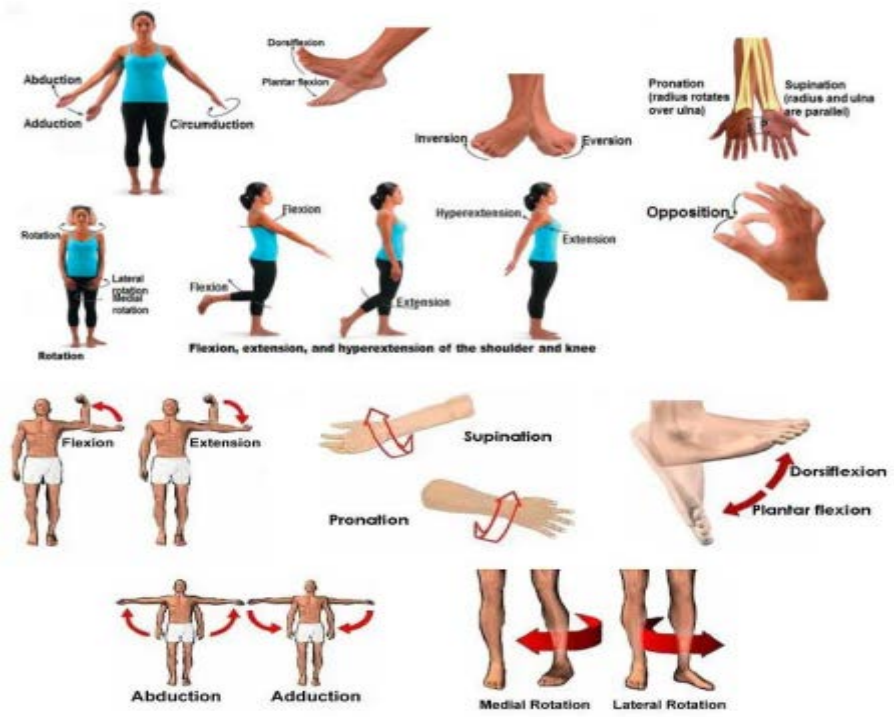

Fig 5.5: Various movements in the body planes

The Importance of anatomical planes in physical activity and sports:

The anatomical planes help athletes to understand the movements associated with the various sports disciplines and tailor training accordingly. Examples include:

a. Sagittal plane dominant sports are running, rowing, weightlifting, etc. Dominant movements in the sagittal plane are flexion, extension, dorsiflexion and plantar flexion.
b. Frontal plane dominant sports are tennis, baseball, cartwheels, star jumps, etc. Movements in these disciplines are dominantly from right to left or side to side. And these are associated with abductions and adductions which are movements in the frontal plane.
c. Transverse plane dominant sports include golf, discus throw, netball, etc. Movements in this plane are rotational in nature such as internal and external rotation, pronation and supination. Movement in the transverse plane is important for the above disciplines because it allows the body to rotate and generate more power.

iii. Homeostasis

Homeostasis is the ability of the body to maintain a stable internal environment for cells by closely regulating various critical variables such as pH or acid-base balance, oxygen tension, blood glucose concentration and body temperature.

- Homeostasis and Exercise: Exercise affects homeostasis in a variety of ways, such as raising the body temperature, increasing the need for more oxygen and changes in blood sugar and fluid balance.
  - How the systems maintain homeostasis during exercise:
    - Breaking down glucose for fuel
    - Increasing heart rate and blood flow
    - Cooling down body temperature
  - How to maintain homeostasis during a workout:
    - Stay hydrated
    - Breathe during exercise
    - Fuel up with pre-workout snack
    - Warm up and cool down

a. Exercise physiology

This is the scientific study of how the body responds and adapts to physical activity and exercise. Through a properly executed exercise programme, the body adapts and becomes more efficient at performing various tasks. These adaptations are acute and chronic and impact cardiovascular, respiratory, musculoskeletal, metabolic, etc functions.

i. Acute adaptations to exercise

This refers to the immediate responses that occur during or shortly after a single and quick physical activity. These responses are temporary and last a matter of minutes.

Some of the adaptations are:

- *Cardiovascular responses:*

The body experiences increased heart rate during a quick intensive exercise. The heart rate rises to meet the increased demand for oxygen and nutrients by the working muscles.

- *Pulmonary system adaptations:* This refers to changes that occur within the respiratory system in response to regular exercise training. The changes are essential for improving breathing and enhancing overall respiratory function during physical activity. It improves respiratory muscle strength, lung capacity, gas exchange and lung diffusion capacity.

b. Chronic adaptations of exercise

Chronic adaptations to exercise refer to the long-term changes that occur in response to regular exercise and training over weeks, months and years.

These changes represent the body's ability to adapt and improve in response to the demands placed on it through exercise.

Chronic adaptations to exercise include:

- *Skeletal muscle adaptations:*
- This refers to changes in skeletal muscle tissues that respond to regular exercise or training. It is essential for improving muscle function, strength, endurance and overall performance. It happens through endurance training and resistance/strength training.
- *Ligament and tendon adaptations:* There is an increase in the cross-sectional area of ligaments and tendons in response to prolonged training as the insertion sites between ligaments, bones and tendons become stronger.
- *Metabolic adaptations of prolonged exercise:* This refers to the changes that occur in the body in response to sustained periods of physical activity. Some metabolic adaptations to prolonged exercise include increased aerobic activity, improved fat oxidation or breakdown and enhanced glycogen storage.
- *Long-term cardiac adaptations:* This refers to changes that occur within the heart in response to regular exercise training over an extended period. They are essential for optimising cardiovascular functions, enhancing exercise capacity and promoting overall health. Some long-term benefits are increased volume of blood pumped at each heartbeat, reduced heartbeats per minute at rest and enhanced ability to pump blood with each heartbeat.

Activity 5.4

1. Take turns to demonstrate isometric, isotonic, and isokinetic contractions using simple exercises like wall sits (isometric), bicep curls (isotonic), and resistance band exercises (isokinetic).
2. Write down how these actions apply to at least three different sports.
3. Research online and provide three (3) primary energy systems that supply energy during physical activity.
4. Select and role-play or act out a scenario where energy systems predominates, such as sprinting, middle-distance running, and marathon running.

Activity 5.5

1. Use diagrams to identify and label different body parts in the anatomical position.
2. Demonstrate movements in different planes (sagittal, frontal, transverse) using activities like squats, lateral lunges, and torso twists.

3. Pay attention to feedback and write down personal notes from it.

Activity 5.6

Portfolio Creation

1. Create a portfolio showcasing the application of anatomy and physiology in a sport of your choice.
2. Include diagrams, explanations of muscle actions, energy systems, and strategies for injury prevention.
3. Present your portfolio for a whole class discussion.

Review Questions

1. Discuss the importance of understanding anatomy and physiology in the context of physical activity and sports.

Importance of understanding anatomy and physiology in physical activity and sports

2. Complete the table on macroscopic and microscopic anatomy, including examples and study methods.

Aspect	Macroscopic Anatomy	Microscopic Anatomy
Focus	Large structures visible to the naked eye	
Examples		
Study Methods		

3. Explain how the circulatory and respiratory systems work together during intense physical activity. Include the roles of relevant anatomical structures and physiological processes.

Circulatory and Respiratory Systems During Intense Physical Activity

4. Discuss how chronic adaptations to exercise can improve athletic performance.

Chronic Adaptations to Exercise and Athletic Performance

5. Analyse the role of the skeletal muscles in a long-distance runner's training programme.

Skeletal Muscles in Long-Distance Running

6. Consider a basketball player recovering from an injury. How can knowledge of anatomy and physiology assist in their rehabilitation process?

Anatomy and Physiology in Injury Rehabilitation for a Basketball Player:

7. Analyse how the anatomical position is used in medical assessments and its importance in sports.

Anatomical Position in Medical Assessments and Sports

8. Develop a personalised fitness plan incorporating knowledge of anatomy and physiology to prevent injuries.

Personalised Fitness Plan for Injury Prevention

9. What are the primary functions of the respiratory system during exercise?

Primary Functions of the Respiratory System During Exercise

10. How do skeletal muscles contribute to movement in the sagittal plane?

Skeletal Muscles and Movement in the Sagittal Plane

Extended Reading

1. The following links highlight the concept of anatomy:

- https://youtu.be/uBGl2BujkPQ?si=fw_VDdRTOhVOvpaM

- https://youtu.be/rx-SjGhBQ_s?si=aYSHUab6P8Qy5lIr

2. The following links highlight the concept of physiology:

- https://youtu.be/nkfunphAKqo?si=Ud5zl9oE6SDOGegI

- https://youtu.be/6qk_LTVXZ2w?si=lfT-EQiVB3Qllhxl

3. The link below introduce the concept of anatomy and physiology:

- https://youtu.be/cXWOIJziIGk?si=iGJK4RfnQhzv7OQj

4. This link will help you to understand the history and branches of anatomy

5. https://www.youtube.com/watch?v=xnUwm4vNMcI
6. The links below will guide you to further understand the basic science of anatomy and exercise, the anatomy of exercise:

7. https://youtu.be/C5yeNVrJN9k?si=unKi49nDOhPfpvKt

8. https://youtu.be/_rLpa3fFj5s?si=NpLWB-iI4afxTCd2

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