Basic Principles of Biomechanics Part 1

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Welcome to the Basics of Biomechanics. This is a simple guide that will teach you the basic principles of biomechanics that we can later apply to the upper limb, the spine, and the lower limb. In this section, we'll be looking at basic concepts in joint anatomy and the types of diarthrodial joints, joint function in the form of kinematic chains, and arthrokinematics.

We'll also be looking at muscle and tendon physiology, muscle physiology and biomechanics, common injuries in muscle, injury grading of muscle, and related sports and rehabilitation. We'll also be looking at ligament physiology, common injuries in ligaments, injury grading of the ligament injuries, and related sports and rehabilitation.

Before we go into the details of joints and anatomy, we need to know the fundamentals of anatomical positioning, the axes of rotation, and the anatomy of a synovial joint. The axes of rotation-- this is characterized by three lines that dissect the body. The x-axis is a line that runs transversely across the body, from left to right. The y-axis is a line that runs vertically through the body from cranial to caudal. And the z-axis is a frontal line that runs from anterior to posterior. The x, y, and z-axes combined in pairs form different planes, as you'll see ahead of this slide. We will work in these planes and see what movements go about these planes.

The sagittal plane-- this divides the body into left and right halves. It is demarcated by the y and z-axes combined. The movements of flexion and extension move through this plane. If we had to visualize flexion at the shoulder joint, we would see anterior movement of the upper extremity through the sagittal plane, where there was a point of rotation about the x-axis at the center of rotation of the shoulder joint.

The coronal plane-- this divides the body into anterior-- or ventral-- and posterior-- or dorsal-- halves. It is demarcated by the y and x-axes combined. Movements of abduction and adduction are seen to move through this plane. If we had to visualize abduction of the shoulder joint, we would see the upper limb being elevated through the coronal plane, laterally away from the body. The point of rotation would be seen at the shoulder joint, rotating about the z-axis.

The transverse plane-- this divides the body into superior and inferior halves. It is demarcated by the x and z-axes combined. Movements of rotation move through this plane. If we had to visualize medial rotation of the upper limb with the elbow bent, we would see translation of the hand medially towards the tummy. This is a rotation at the center point of the joint about the y-axis of the shoulder joint.

The anatomy of a typical diarthrodial joint-- it's also known as a synovial joint. It is characterized by free-moving ends, or epiphyses, encapsulated within a synovial lined joint space. The articular surfaces are free to move relative to each other because of no connective tissue directly connecting the surfaces. The shape of the joint surfaces dictate the motion potential of the joints itself.

Joint function-- the structure of the joints of the human body reflect the functions that the joints are designed to serve. The demand on the limb or segment that needs to move will dictate the type, shape, and size of joint needed. As the joints become larger and have more range of motion, the less stable the joint is. Therefore, we'll see more stabilizing factors in some joints, and less range of motion in others.

This can be seen as an example in the shoulder joint or the glenohumeral joint specifically, where there's an extensive range of motion, but at the sacrifice of stability. The rotator cuff muscles and the rotator interval capsule have to apply different forces in order to stabilize the shoulder as accessory stabilizers for the joint.

These two diagrams are an example of how the joint functions and how the associated tissues replace the stabilization because of the joint shape. As said above, the glenohumeral joint is a large joint with very little stability in order to allow for large ranges of motion. The small stabilizers-- being the rotator cuff muscles and the rotator interval capsule-- maximize stability as best as possible.

Here are a few examples of synovial joints and their specific locations. Your condyloid joint, which is found at the atlanto-occipital joint. The ball and socket joint, found at the glenohumeral joint. And the coxofemoral joint-- the gliding joint which is found at articular processes between vertebrae. The saddle joint, which is found at the carpometacarpal joints. The pivot joint, which is found at the dens of axis between atlas and axis. And the hinge joint, which is also found at the elbow.