ICSC05_Lower Extremity 1.1 Biomechanics Spinal (21:12)

ICSC Lower Extremity Module 5
Section 1.1_ICSC05 Spinal Biomechanics
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Video Lesson: 21:12

Welcome to the basics of biomechanics. This is a simple guide to pick up on Normal and Abnormal biomechanical behavior of the spine. In this short lesson, we will be looking at basic concepts in joint anatomy and the types of diarthrodial joints, joint function in the form of kinematic chains, and alter kinematics. We will 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 will also be looking at ligament physiology, common injuries, and ligaments, injury grading of the ligament injuries, and related sports and rehabilitation.

General Spinal Biomechanics.

The vertebral column resembles a curved rod composed of 33 vertebrae and 23 intervertebral disks. They are divided into the following five regions: the cervical region consisting of 7 vertebrae, the thoracic or dorsal region consisting of 12 vertebrae, the lumbar region consisting of five vertebrae, the sacral region consisting of five fused vertebrae, the coccygeal region consisting of four fused vertebrae. The vertebrae adhere to a common basic structural design but show regional variations in size and configuration that reflect the functional demands of a particular region.

General spinal characteristics can be seen as follows: There is an increase in size from the cervical spine to the lumbar spine region. In fetal life, the spine exhibits one long curve that is convex posteriorly as a c-shaped primary curve. The secondary curves that we see in the lumbar and cervical regions develop secondarily in infancy.

In an adult, there are four distinct anteroposterior curves. There are two in the thoracic and sacral regions which are primary curves, they are convex posteriorly. Two in the cervical and lumbar region which are secondary curves which are convex anteriorly. These developers are a result of their accommodation of forces on the skeleton to the upright posture. A curved vertebral column provides significant advantage to that of a straight rod, and that it is able to resist much higher compressive loads up to four times our own body weight. The image below represents the basic anatomical structure of the vertebrae, the supporting ligamentous structures, and the small anatomical differences between the different regions. Bare these in mind as we move further forward.

General Vertebral Anatomy. The vertebra consists of two major divisions. The anterior virtual body portion or the posterior vertebral or neural arch division. The vertebral body is designed to be the weight bearing structure of the spinal column. It is suitably designed for this task given its block like shape with a generally flat superior and inferior surface. The vertebral body is not a solid block of bone but a shell of cortical bone reinforced by trabeculae which provide resistance to compressive forces. They also disperse the forces through into the intervertebral discs which are found between two adjacent vertebral bodies.

The posterior or vertebral on neural arch is consisted of pedicles, lemony, articular processes, spinous process, and transverse processes. The posterior arch is designed to serve more as a bony protection of the neural arch from compression and torsion more than bearing weight. The intervertebral discs. This is a collection of fibrocartilage rings, which surround an amorphous nucleus pulposus. It has two principal functions: number one, to separate two vertebral bodies, thereby increasing available motion and to two, transmit the load from one virtual body to the next.

The size of the intervertebral disk is related to both the amount motion and the magnitude of the loads that must be transmitted. As said before, it is composed of an annulus fibrosus and a nucleus pulposus. Its main design focuses on both stability yet not sacrificing flexibility. The function of the spine, as a whole. The motions available to the spinal column are seen as flexion and extension in the sagittal plane, lateral flexion through the coronal plane, and rotation about the Y axis. These motions appear to occur independently of each other. However, at the level of the individual motion segment, these motions are often coupled motions.

Spinal Segmental Flexion. At the segment, we see interior tilting and gliding of the superior vertebra on the vertebra below. This causes a widening of the intervertebral foramen and separation of the spinous processes. Tension in the supraspinous and interspinous ligaments resists separation of the spinous processes and thus limits the extent of flexion. Passive tension in the zygapophyseal joints, and ligamentum flavum, posterior longitudinal ligament, posterior annulus fibrosus, and the back extensors also imposes controls on excess of flexion.

Spinal segmental extension. This is seen as posterior tilting and gliding of the superior vertebra over the vertebra below and causes narrowing of the intervertebral foramen. This is also seen as approximation of the spinous processes. The amount of motion available in extension is limited by bony contact of the spinous processes and passive tension zygapophyseal joint capsules anterior fibers of the annulus fibrosus, anterior trunk muscles, and the anterior longitudinal ligament. The only ligament that limits extension is the anterior longitudinal ligament

Spinal Segmental Lateral Flexion. This is seen where the superior vertebral laterally tilts over the vertebra below. There is some degree of rotation and translation over there dries in vertebra below. The annulus fibrosus is compressed on the concavity of the curve and stretched on the convexity of the curve. Passive tension in the annulus fibers intertranverse ligaments, and anterior and posterior trunk muscles on the convexity of the curve limits lateral flexion. The direction of rotation that accompanies lateral flexion differs slightly from region to region because of the orientation of the facets.

Spinal segmental rotation. The superior vertebra rotates axially over the vertebra below. It rotates and translates less than what is seen in lateral flexion. The annulus fibrosus fibers are slightly angulated and alternating direction in each layer. This creates a central compressive force as the disc is twisted. Passive tension in the annulus fibers intertransverse ligaments and anterior and posterior trunk muscles on the convexity of the curve limits rotation. Regional variances of the spine. Facet Joint orientation. Each virtual section has small differences to accommodate force. The vertebrae are depicted as follows and have favorable functions to deal with varying loads and shift of center of gravity through each region. The angulation of the spinal facets vary between segments. In the cervical region, you see the facets facing coronally with a 45° superior to inferior tilt. The thoracic spine region, you see a 40 to 60 degree lateral from coronal plane, and a 30° superior to inferior tilt. In the lumbar spine region is a 45-degree lateral and a sagittal orientation of the facets. The changing orientation of facets is suspected due to the change from mobility in the cervical spine to anchoring in the thoracic spine for the vital organs and weight and load bearing in the lumbar spine.

Posture: The key concepts of posture are as follows: Postural Control, which is the ability to maintain stability of the body and body segments in response to forces applied on the body in any direction. The Base of Support, which is the area bounded posteriorly by the heels and anteriorly by a line joining, the tips of the toes. The Centre of Gravity, this is the line of gravitational force as it transmits down the spine to the base of support. Perturbation, any sudden change in conditions that displaces the body posture away from equilibrium. The basic elements of postural control. These control the body's orientation in space. They maintain the body's center of gravity over the base of support and stabilize the head with respect to the vertical so that eye gaze is appropriately orientated. This requires optimal function of an intact central nervous system, visual system, and musculoskeletal system. Control depends on correct information from proprioceptors in the joint capsule, tendons, ligaments, and the soles of feet. A completely healthy vestibular system and a balanced visual system.

Posture Analysis. For the anterior view, there is quite a list of key landmarks to identify on the anterior view. We always look at the level of the eyes, the level of the ears at the external auditory meatus, the facial features in case of any hemiplegia ptosis or Bell's Palsy, the AC joints to see if they are level and orientated correctly, the manubrium sterni, the antecubital fossae, the ASIS or anterior superior iliac spine, the knee joint line for any deviations of genu valgus or genu varum. The patellae for any patella alta or baja, squinting or divergent patellae. Medial arch of the foot for any arch collapse or pronation of the foot. And angulation of the first rays to see any spreading or foot leg length deformities,

On Posterior View. Key landmarks to identify on the posterior view are as follows: the External Occipital Protuberance, the External Auditory Meatus, the AC joint/spine of scapula on Ectomorphic patient body types, the Inferior Angle of the Scapula to see for any winging or protrusion of the scapulae, any Elbow Joint lines or carrying angles, the Posterior Superior Iliac Spine, notified by dimples above the buttock area, the gluteal folds, the Popliteal Fossa, the Achilles Tendons, for any calcaneus vulgus or virus,

On Lateral View. Key landmarks to identify lateral view are as follows: an Anterior or Posterior Head Carriage, the CT Junction for Dowager's hump or Pottenger's Saucers, the Thoracic Profile or for Hyper or Hypo-Kyphosis, the Chest Profile for Pectus Cavus or Pectus Carinatum, Anterior or Posterior pelvic tilt on the line between the Anterior Superior Iliac Spine, and the Posterior Superior Iliac Spine levels, the Gluteal Profile, the Knees whether they are in semi flexed position for a posterior pelvic tilt, or hyperextended/genu recurvatum position for a severe anterior pelvic tilt, and the Foot Profile for plantar flexion or heel lift.

General Postural Syndromes. Kyphosis, this refers to an abnormal increase in the normal posterior convexity of the thoracic spine. It may be a compensation for an increase in lumbar spine lordosis, or as a result of poor postural habits, or developmental, such as Sherman's disease, or in secondary infections such as TB, or secondary developmental disorders or autoimmune disorders such Ankylosing Spondylitis. A gibbus or humpback deformity can result due to vertebral fractures. These are significantly different with a sharp angulation in the thoracic curvature compared to a general thoracic convexity. A Dowager's hump is a common recognizable condition often found in postmenopausal women, especially if they have osteoporosis. It is a common postural problem that is developed from prolonged anterior head carriage and results in the collapse of the vertebral bodies anteriorly, increasing compression due to the lack of interior support resulting in the hump.

Here are some simple diagrams on General Postural Syndromes, especially around kyphosis. Scoliosis, this is a condition which involves lateral flexion and rotation of the vertebrae in a coupled motion the adolescent form or idiopathic type makes up 80% of all scoliosis cases. These curves are defined as structural curves. They are named according to the direction of the convexity and the location of the curve. It is due to asymmetrical growth and development, which causes wedging of the vertebral bodies. These commonly needs surgical intervention or bracing.

The second type of scoliosis is known as functional or non-structural scoliosis, which can be reversed if the cause of the curve is corrected, and structural changes are not present. The examples for non-structural scoliosis are leg length inequality and or muscle spasm. The following pictures depict the types of scoliosis that can be seen such as a single thoracic curve, a single lumbar curve, a single thoracolumbar curve, and a double lumbar and thoracic curve.

Postural Syndromes to consider in the athlete. Upper Crossed Syndrome. This is signified by tightness of the upper trapezius and Levator scapulae on the dorsal side which crosses with tightness of the pectoral muscles. Weakness of the deep cervical flexes ventrally crosses with weakness of the middle and lower trapezius. This pattern of imbalance creates joint dysfunction at the atlanto-occipital joint or C4-C5 segment, also cervical thoracic joint, glenohumeral joint, and the T4 T5, segment. Specific postural changes are seen in Upper Cross syndrome, including forward head posture, increased cervical lordosis and thoracic kyphosis, elevated and protracted shoulders, and rotation or abduction and winging of the scapula.

Lower Crossed Syndrome. This is signified by tightness of the thoracolumbar extensors on the dorsal side, which crosses with the hip flexor muscles, and weakness of the deep abdominal muscles ventrally, which crosses with the weakness of the gluteal muscles. This pattern of imbalance creates joint dysfunction particularly at The L4 and L5 segments. L5 and S1, the sacroiliac joint, and the hip joint. Specific postural changes are seen in lower crossed syndrome which include anterior pelvic tilt, increased lumbar lordosis, lateral lumbar shift, lateral leg rotation, and knee hyperextension or genu recurvatum. If the lordosis is deep and short, then imbalance is predominantly in the pelvic muscles; every lordosis is shallow and extends into the thoracic area, then imbalance predominates in the trunk muscles.

Thank you for taking the time to refresher your knowledge about the basics of biomechanics. [End]