CORE STRENGTH AND STABILITY IN ATHLETICS

Core strength and stability is an important and often overlooked aspect in athletics. Historically, rehabilitation and reconditioning programs have concentrated on the extremities. However, all power is generated in the core and transferred distally to the extremities. Therefore, neglect of the core in assessment and rehabilitation can impede an athlete's future success. The purpose of this chapter is to explain the importance of core stability and its effect on the athlete.

Core Strength and Stability Defined

The core refers to the lumbo-pelvic-hip complex where the center of gravity is located. [1, 2] The muscles that make up this complex provide a stable base from which the extremities to work. Core strength refers to the strength and endurance of the muscles of the lumbo-pelvic-hip complex, while stability refers to the ability to utilize strength and endurance in a functional manner.[3, 4] Furthermore, function is defined as a multi-planar movement that involves acceleration, deceleration, and stabilization. [5, 6] To be mechanically efficient an athlete must combine strength and stability training in their reconditioning programs. Core strength and stability together is termed functional strength. Functional strength is the ability to produce concentric acceleration force, isometric stabilization force, and eccentric deceleration force in all three planes of movement during activity. [5, 6]

The central nervous system (CNS) plays an integral role in core stability. This system controls proprioception, which is the interpretation of sensory information and the response to position sense. [7] Receptors in the skin, joints, muscles and tendons send information to the CNS, which in turn, sends appropriate information back to the muscles to provide neuromuscular control. [7] In other words, core stability is the ability of the CNS to interpret the position of the body in space and to react accordingly. Appropriate muscle strengh is needed to support the spine and to dynamically stabilize. With injury or lack of training, proprioception can be altered, thus the need for stabilization exercises.

Core Musculature

Muscles that make up the core can be divided into three groups: The abdominal muscles, the hip muscles, and the spinal muscles. The origins, insertions, and actions of these muscles are located in Tables 1-3.

Importance of Core Stability in Athletics

An athlete with a stable core will decrease the likelihood of injury due to increased efficiency of movement.[1, 2, 4, 7-9] When the lumbo-pelvic-hip complex is stable, the peripheral muscles require less forceful contractions to produce the same given amount of power.[2, 4, 9] Adequate pelvic stability allows for efficient transfer of power from the lower extremities to the upper extremities.[7] For example, the act of throwing requires the legs and trunk to initiate movement and to transfer forces up the arm to the baseball.

Low back pain is a common complaint in athletes, as well as non-athletes.[1, 8] Up to 30% of college football players will miss at least one game due to lumbar pain.[8] This pain is caused by repeated mechanical irritation of the tissues that occupy the spine.

[1, 2] Repeated irritation occurs due to instability of the spine and pelvis. Therefore, core stabilization must be incorporated into a low back pain rehabilitation program.[1, 8]

Assessment of Core Stability

Assessment of the athlete must include all segments of the kinetic chain. Emphasis on one joint without attention to the cervical, thoracic, and lumbo-pelvic segments can lead to an incomplete picture of dysfunction. All links in the chain must have appropriate length tension relationships in order for each progressive segment to be utilized efficiently.

Evaluation of the core must include assessment of posture, flexibility, strength, endurance, and stabilization. [6] These components of assessment go hand in hand in determining appropriate function of the athlete. Optimal posture is the correct alignment of each segment. Flexibility is the appropriate length of a muscle that has a direct relationship to posture. A tight psoas muscle will anteriorly rotate the pelvis, which in turn, will increase lumbar lordosis. In addition, a tight muscle can affect the strength of other muscles. The gluteus maximus will have decreased neural drive if the hip flexors are tight. This is termed reciprocal inhibition. [5, 6] To make up for this decreased output other muscles must compensate. Synergistic dominance will take place when synergists take over the role of the primary muscle. [5, 6] An example would be hamstring dominance of hip extension when the neural drive to the gluteus maximus is decreased. This compensation pattern leads to decreased efficiency and possible injury.

Range of motion (ROM) and flexibility needs to be assessed at the lumob-pelvic-hip complex. The athlete must have full ROM at the hip to function appropriately. If the hip opens up too early during the cocking phase of throwing, all distal segments will rotate prematurely and place addition stress to the anterior shoulder. [10, 11] Flexibility assessments at the hip should include the rectus femoris, illiopsoas, tensor fasciae latae, hamstrings, and piriformis.

Strength should be assessed for the hip extensors, back extensors, abdominals, and obliques. This can be accomplished by manual muscle testing as described by Kendall and McCreary. [12] Other authors have advocated additional testing procedures that may be more functional. Bliss [4] recommends four tests for core stability. The prone bridge, lateral bridge, torso flexor endurance, and torso extensor endurance make up the assessment. The athlete must hold each position with a neutral spine. Normative values in seconds are as follows: right lateral bridge 83, left lateral bridge 86, flexion 34, and extension 173. [4] Norms for the prone bridge have yet to be calculated, however, sixty seconds seems to be ideal. Dynamic lower extremity stabilization tests may include single leg stance, overhead squat, single leg squat, and step down. Inadequate lower extremity stabilization may cause a pitcher to rush through the delivery and place increased loads on the shoulder or elbow. [11]

The scapula should be included in the core assessment of the overhead athlete. The scapula should be evaluated statically and dynamically. Manual muscle testing can be undertaken, but can be tedious. A scapular pinch test will decrease assessment time. The athlete should isometrically pinch the shoulder blades together and hold 15 to 20 seconds. Burning in the periscapular area indicates weakness. Kibler [13] also advocates the lateral slide test. A measurement from the inferior angle of the scapula to its associated spinous process is taken with the arm at the side, hands on hips position, and arms abducted and internally rotated at 90 degrees. A positive test is a 1.5 cm or greater difference on one side when compared to the other. [13]

Rehabilitation and Reconditioning

The rehabilitation and reconditioning program should be systematic and progressive.[3-6, 13-16] Training begins with the most challenging environment an athlete can control.[6] Local muscles such as the transverse abdominus and the multifidus, however, must be activated prior to the global muscles of the lumbo-pelvic-hip complex. Progression is from muscle activation to dynamic stabilization[3, 4].

Tactile, auditory, and visual feedback may be necessary at first. [3,4,16] Cues can be eliminated as the athlete masters a specific task. For example, the transverse abdominus (TA) may need several cues to fire correctly. Many athletes have difficulty firing the TA due to previous concentration on the other abdominal muscles for stabilization. When an athlete masters active contraction of the TA, cueing can be eliminated and more dynamic movements can take place. Progression guidelines are as follows: simple to complex, stable to unstable, static to dynamic, and single plane to multi-plane [3-6, 16]

Flexibility is an important aspect of the core stabilization program. Flexibility training in conjunction with stability training yields results. Appropriate length tension relationships must be maintained throughout the kinetic chain in order for efficient movements to take place. All muscles of the lumbo-pelvic-hip complex must be flexible and strong.

Core Stabilization Exercises

Pelvic Tilt Progression This series of exercises has been found to activate the abdominal muscles significantly more than abdominal hallowing exercises in a study using EMG.[17]

1) The athlete is supine with the feet flat on the table. The athlete should be instructed flatten their low back onto the table and then hold for five seconds. A good verbal cue for this exercise is to instruct the athlete to pull their belly button back to their spine while flattening the back. Pulling the belly button back to the spine without tilting the pelvis is an abdominal hollowing (drawing in) exercise only. Breathing should be normal while performing the pelvic tilt. Picture 1
2) When the athlete masters the pelvic tilt they may be progressed to bridging exercises. The athlete performs the pelvic tilt then lifts their hips off the table and holds for five seconds. Picture 2
3) The final progression of the supine pelvic tilt is to have the athlete extend one lower extremity during the bridge. Lower extremities should alternate with each bridge. To make this exercise more difficult, the upper extremities can be alternated with the lower extremities.

Quadruped Progression

1) The athlete is positioned on their hands and knees and instructed to draw in their abdominals. The lower extremity on one side is then extended and held for up to five seconds. Extremities should be altered. A technique that can be used to aid proper performance is to place a dowel across the back, in-line

with the spine. The dowel should not move. When this is mastered, the dowel can be placed perpendicular to the spine and must be held in a level position.

2) The next progression is to extend both the upper and lower extremity on the same side and hold.
3) The final progression of the quadruped exercise involves the athlete extending opposite upper and lower extremities at the same time. A dowel can be used for this exercise as well.

<u>Physioball Exercises</u>

1) Seated Physioball – The athlete is seated on the physioball and raises one lower extremity off the ground. This exercise can be advanced by alternating opposite upper and lower extremities.
2) Bridging – The athlete is supine with the feet on the ball. The abdominals are drawn in and the athlete lifts the hips off the ground. Another way to perform a bridge on the physioball is to have the athlete seated on the ball and then walk their legs out away from the ball. The hips should be level and must not sag. To make the bridge more difficult, one lower extremity can be extended.
3) Crunch – A simple crunch can be performed on the physioball. The athlete starts in a supine position with the back supported on the ball. A crunch is then performed. A medicine ball can be added to provide resistance.

4) Wall Squat – The physioball is placed between the athlete and the wall. The athlete draws in the abdominals and then performs a squat to parallel. Moving the arms or adding a medicine ball can further challenge the core.

5) Hamstring Curl – An additional progression to the bridge exercise is to add a hamstring curl. The athlete is supine with the feet on the physioball and then performs a bridge. At the completion of the bridge, the athlete then performs a hamstring curl while holding the bridge. Picture 3

6) Push Ups – Wall push ups and standard push ups can be progressed by using a physioball. The athlete must draw in their abdominals prior to performing the push up.

7) Walk-outs – The athlete is prone on the physioball with their hands in contact with the ground. The athlete walks forward while keeping their abdominals tight and their spine neutral. This exercise can be progressed from slow to fast. Picture 4

<u>Gluteus Medius Exercises</u>

1) Clamshell – The athlete is positioned on their side with their knees and hips bent. With their feet together the athlete rotates their top knee up and back. The trunk should not rotate. To progress this exercise the athlete extends their knee and performs a SLR in abduction with slight extension.

2) Monster Walk – Resistance band is placed around the athletes ankles. The athlete assumes an athletic stance position and side shuffles a set distance.

Plank Exercises

1) Prone Plank – The athlete props up on their forearms and toes while in the prone position. The spine should be neutral and this position is held for 15 seconds. The athlete can progress to 30 seconds as stabilization improves. Picture 5
2) Side-lying Plank – The athlete props up on their forearm in the side position while drawing in the abdominals. This position is held for 15 seconds and progressed to 30 seconds as stability improves. Picture 6

Medicine Ball Exercises

1) Crunches – Athletes can progress crunching exercises by using a medicine ball. Oblique crunches and trunk twisting maneuvers can be progressed using medicine balls as well.
2) Lunges - With the arms outstretched and holding the medicine ball, the athlete lunges forward and twists to the side of the lunging leg. The clinician should ensure proper form. The knees should be in line with the foot and the knees should not go over the toes. The abdominals should be tight and the spine should be neutral. Picture 7

Scapular Stabilization Exercise

1) Physioball Y – The athlete assumes a prone position on the physioball with the chest off the ball. The shoulder blades are drawn back and down while

the upper extremities are lifted up to form a "Y". Thumbs should be pointing upward. Picture 8

2) Physioball T – The athlete is positioned in similar fashion to the physioball Y. The shoulder blades are pinched together while the upper extremities are horizontally abducted with the shoulder externally rotated. The upper extremities should not go beyond parallel with the ground, as this places additional stress to the anterior shoulder. Picture 9

3) Physioball 90/90 External Rotation – The athlete is positioned prone on the ball as above. Elbows are bent at 90 degrees and then horizontally abducted to 90 degrees. The athlete then externally rotates to 90 degrees, lower and repeat. Picture 10

4) Push up "plus" on the wobble board – The athlete assumes a push up position with hands on the outer edge of the wobble board. The shoulder blades are protracted and the spine is held in neutral. The athlete will hold for 15 seconds and this is progressed to 30 seconds as stability improves. Picture 11

Core Stability and the Overhead Athlete

The role of the scapula must not be overlooked when discussing core stability in the overhead athlete. The scapula attaches to the trunk via a "suction like mechanism" provided by the serratus anterior and subscapularis.[14] Three groups of muscles attach to the scapula.[13] The first group is made up of the trapezius, rhomboids, levator scapulae, and the serratus anterior. The second group is includes the deltoid, biceps, and triceps. The rotator cuff makes up the final group.

The scapula serves three functions[13, 14]. The first function is to maintain dynamic stability. The scapula must move along with the humerus in a coordinated manner to maintain the humeral head within the glenoid. The second function is to serve as a base for muscle attachment. These muscles serve as important force couples to maintain humeral head congruity. The lower trapezius and the serratus anterior are a pivotal force couple for acromial elevation. [13-15] The third function of the scapula is to provide proximal to distal energy transfer. The scapula is the link between the legs and trunk to the arm and hand.

In order for the scapula to function correctly distal segments must be working correctly. [13] Hip and spine extension is necessary for full scapular retraction. [16, 18] Kibler [13] describes scapular retraction as a “full tank of energy” that is necessary for efficient force production during throwing. In addition, muscles that control scapular movement must be strong. The serratus anterior and the lower trapezius must upwardly rotate the scapula to elevate the acromion. [13-15] Failure to do so may lead to impingement. The serratus anterior must also protract the scapula to keep up with a rapidly internally rotating and horizontally adducting humerus during the throwing motion. Inability of the scapula to keep up with the humerus may cause injury to the posterior rotator cuff and lead to instability.[14] The middle and lower trapezius eccentrically contract to control protraction, because too much protraction can close off the subacromial space leading to impingement.[13, 14] When the scapula is functioning correctly the rotator cuff has a stable base from which to work.

Rehabilitation and reconditioning of the overhead athlete should mimic sport specific movements. [6, 14-16] This can be initiated early in the process. An overhead athlete with a rotator cuff injury can begin core strengthening prior to rotator cuff (RTC) work. Scapular stabilization should be initiated as well. Picture 11-12. The rotator cuff is dependent on a stable base and this base must be developed prior to RTC isolated exercise.[15, 16] Closed kinetic chain exercises (CKC) in low range elevation can be initiated early as well to promote co-contraction of the RTC. An athlete can do this in standing with an athletic stance to promote proximal to distal transfer of energy. [16]

Once an athlete has developed appropriate core stability and has developed full pain-free ROM, strength, and endurance peripherally, the athlete may progress back to throwing. The overhead thrower should take part in an interval throwing program. Progression is from short to long toss, and then finally off the mound. Position players can progress hitting from swinging off a tee, to soft toss, to live game situations.

Conclusion

Athletes must display appropriate core strength, stability, and dynamic control of the lumbo-pelvic-hip complex in order to produce efficient movements. A strong core is necessary for force absorption and transfer in a proximal to distal fashion. A thorough evaluation of the core must take place to determine possible weak links along the chain. These “weak links” must be corrected in order for appropriate length-tension and force couple relationships to exist. An athlete with a strong, stable core will be able to transfer energy efficiently, with more power, and with less stress distally. This makes for a productive, successful athlete.

Table 1. Abdominal Muscles of the Core

MUSCLE	ORIGIN	INSERTION	ACTION
Rectus Abdominus	Pubic symphisis and pubic crest	Cartilage 5-7th rib and the xiphoid process	Flexion of lumbar and compression of abdomen during defecation, urination, forced exhalation and childbirth
External Obliques	Inferior portion of the 8th rib	Iliac crest and the linea alba	Flex the lumbar vertebra when fired simultaneously, when fired unilaterally lateral flexion and rotation
Internal Obliques	Iliac crest, inquinal ligament, thoracalumbar fascia	Cartilage of the last 3 or 4 ribs and the linea alba	Flexion of the lumbar and compression of the abdomenwhen fired bilaterally, lateral flexion and rotation when fired unilaterally
Transverse abdominus	Iliac crest, inquinal ligament, lumbar fascia, cartilage of the inferior 6 ribs	Xiphoid process, linea alba, pubis	Compression of the abdomen

Table 2. Hip muscles of the core

MUSCLE	ORIGIN	INSERTION	ACTION
Tensor Fascia Lata	Iliac crest	Lesser trochanter of the femur	Flexes and laterally rotates the thigh and flexes the trunk at the hip joint
Gluteus maximus	Iliac crest, sacrum, coccyx	ITB, linea aspera of femur	Extend the femur and laterally rotate the thigh
Gluteus medius and minimus	Ilium	Greater trochanter of the femur	Medially rotate the thigh and abduction
Piriformis	Anterior sacrum	Greater trochanter of the femur	Lateral rotation of hip
Obturator Externus	Inner surface of the aboturator foramen, pubis, and ischium	Greater trochanter of the femur	Lateral rotation of hip
Obturator Internis	Outer surface of the obturator membrane	Greater trochanter of the femur	Lateral rotation of hip
Superior Gemellus	Ishcial spine	Greater trochanter of the femur	Lateral rotation of hip
Inferior Gemellus	Ischial tuberosity	Greater trochanter of the femur	Hip stabilizer

Table 3. Back muscles of the core

MUSCLE	ORIGIN	INSERTION	ACTION
Quadratus Loborum	Iliac crest, iliolumbar ligaments	Inferior border of 12^{th} rib, transverse process of first 4 lumbar	Extends the lumbar region when fired bilaterally, laterally flexes lumbar region when unilaterally fired, moves the 12^{th} rib inferiorly during forced exhalation
Serratus Anterior	Superior eight or nine ribs	Vertebral border and the inferior angle of the scapula	Abducts and rotates the scapula upward and elevates the ribs when the scapula is stabilized
Trapezius	Nuchal line of the occipital bone and the spines of the seventh cervical and all twelve throracic vertebra	Lateral 1/3 of clavicle and acromion process, medial margin of acromion and superior lip of spine of scapula, tubercle at apex of spine of scapula	Elevate, adduct, depress, and upward rotate the scapula along with help to extend the head
Erector Spinae	Longitudinal axis of the back	Onto the ribs, upper vertebra and head	Principal extensors of the vertebra
Multifidus	Sacrum, ilium, transverse processes of the lumbar, thoracic, and inferior four cervical vertebra	Spinous process of a more superior vertebra	Extend the vertebral column when fired bilaterally, when fired unilaterally lateral flex the vertebral column and rotate the head

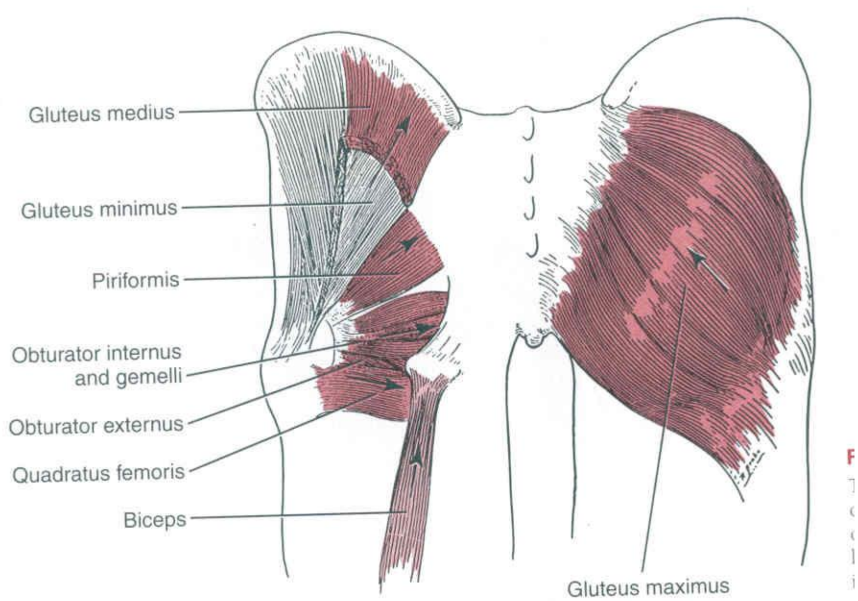

Figure 1 Muscles of the hip

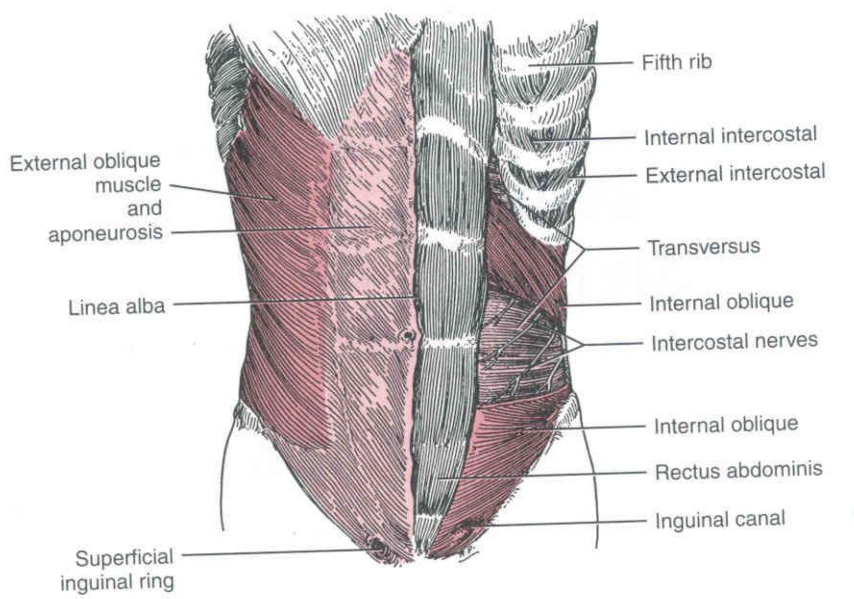

Figure 2 Muscles of the abdomen

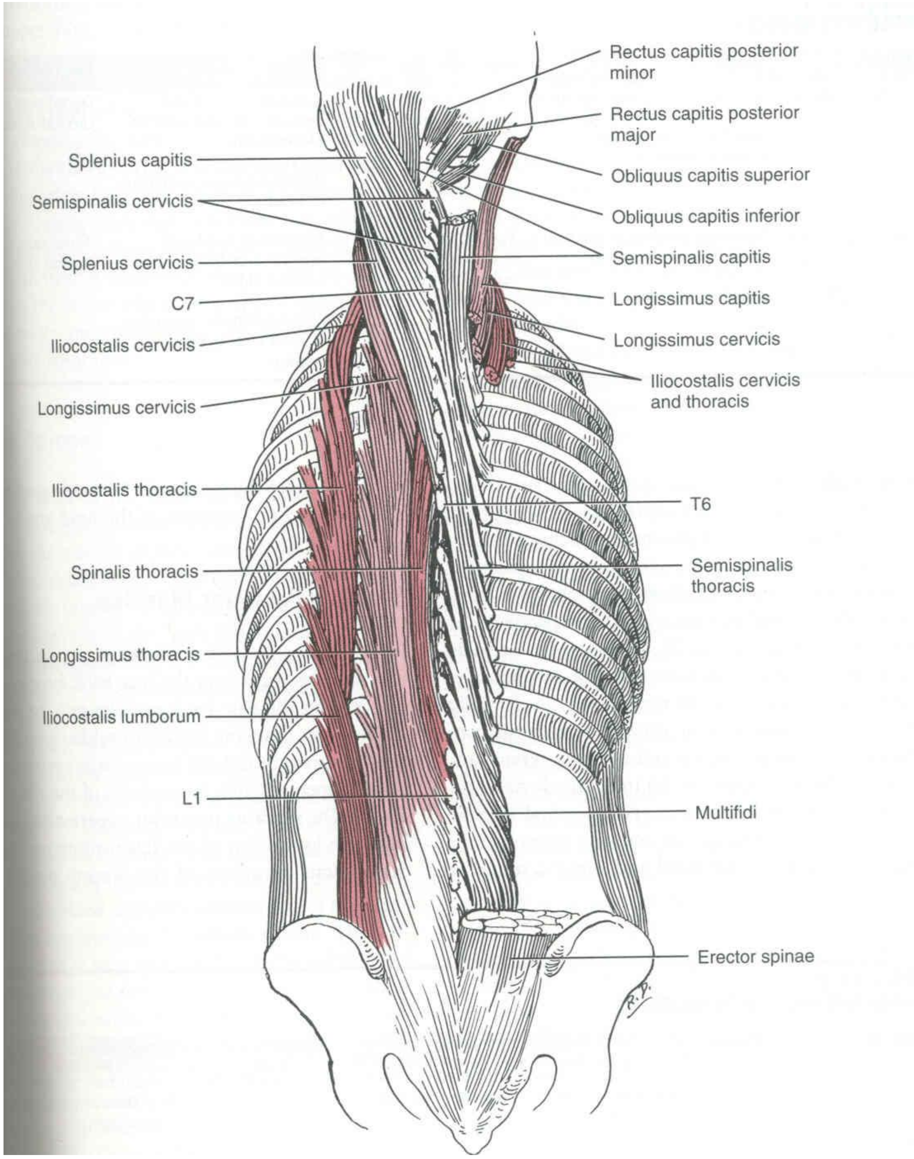

Figure 3 Internal muscles of the back

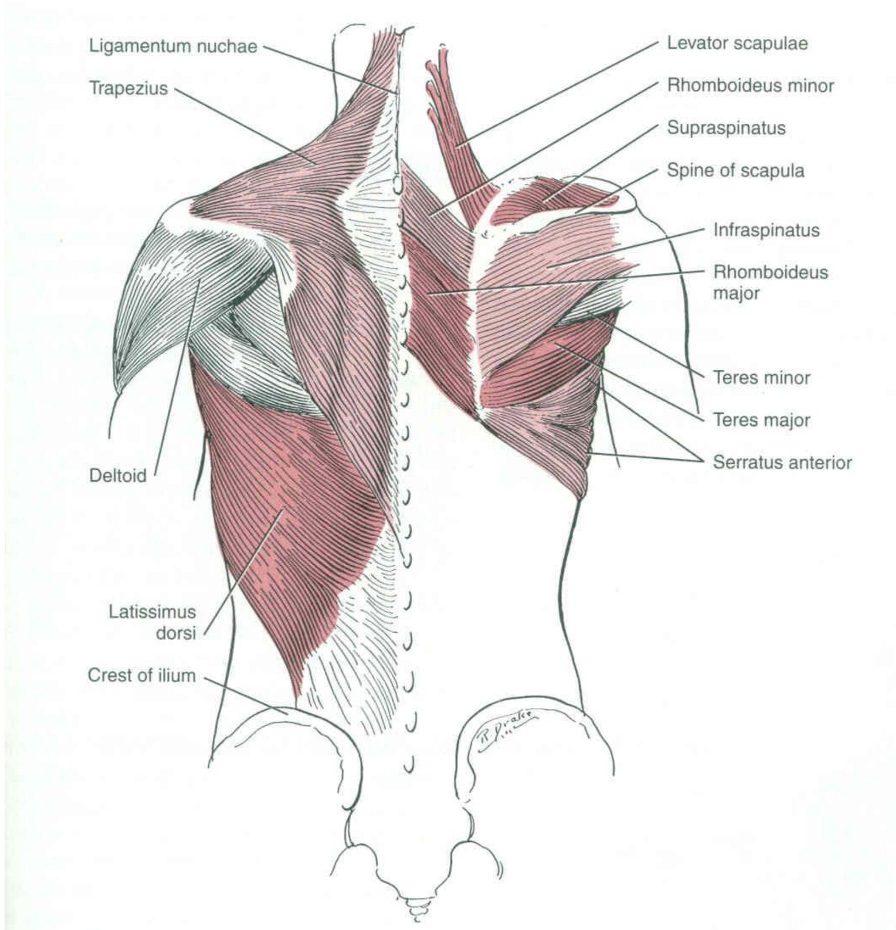

Figure 4 External muscles of the back

** Anatomy pictures taken from

Jenkins, DB. Hollinshead's Functional Anatomy of the limbs and back. 7th ed. Philadelphia. WB Saunders 1998

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