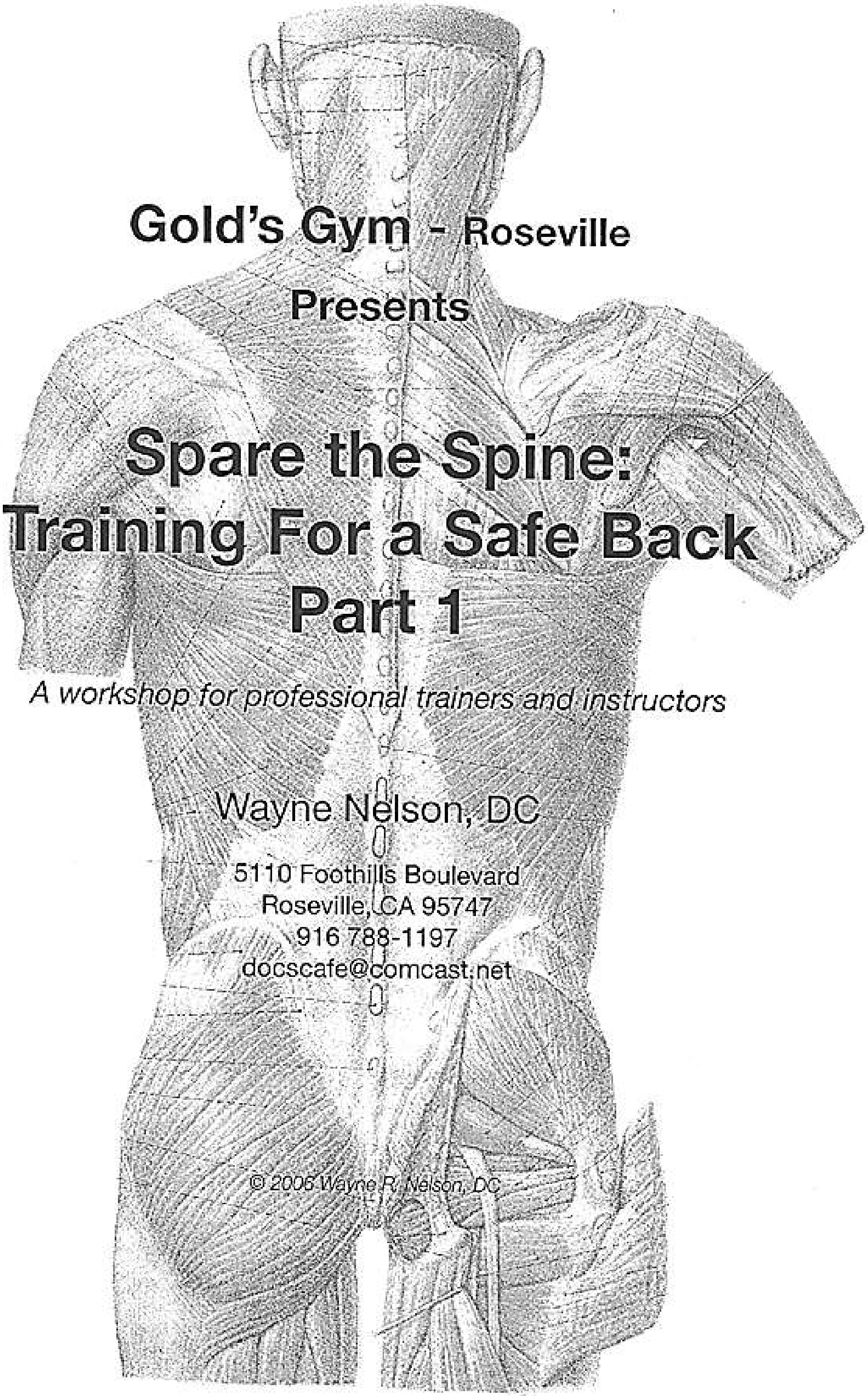

Gold's Gym - Roseville

Presents

Spare the Spine: Training For a Safe Back Part 1

A workshop for professional trainers and instructors

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Spare the Spine: Training for a safe back

"Practice makes permanent." Stewart McGill

Part 1

The Core and its Function

Introduction

Contemporary usage of the term core primarily concerns the trunk. However, some also include the hips as part of the core. Conceivably we could also include the neck and scapulae as part of the core because they function in a similar manner as the trunk and hips. The neck and scapulae create proximal stability for arm movement, they mainly require endurance rather than strength, and the musculature reacts in anticipation of movement of the arms. For this workshop however we are going to refer to the core as simply the trunk.

The Functional Approach To Training

Scientific evidence has shown that when training replecates the target activity the results are better.

Different body regions function in different ways:

Core – central stabilization
Lower extremities – closed chain movement (exception: kicking)
Upper extremities – open chain movements (exception: gymnastics).
Movements are multi planar: Combining Flx/Ext, Lat flx, and Rotation
Follow kinetic chains – often encompass the whole body

The core functions as a central stabilizer, transferring energy between the upper and lower extremities. The extremities are best suited for creating power. Functional training considers how the whole body participates in movement and creates programs that are directed towards goals related to the requirements particular to the client's needs.

Training begins by breaking the movement down into its parts and developing control throughout each part. Core control and endurance is addressed first, then strength of the extremities. With integration of the movement sections back into the functional activity, focus is on developing control and movement efficiency before strength. Because practice makes permanent, we want to groove movements that are safe and efficient before developing endurance and strength. Finally, respecting good control and proper sequencing of movement, after strength has progressed, advances towards developing power can begin.

Machines, by design, train muscle within a limited range of motion and in a limited direction. Machines are used mostly while seated or lying down. The mechanics of machines necessarily isolate and hypertrophy muscles. This is a bodybuilding approach. Many bodybuilding principles such as isolating a muscle during training, single planes of motion, the basic design of reps and sets and so forth, have little place when training for performance. Training a whole-body motion involves balance of force throughout the linkage. Too much force, or too little at a joint, or force applied at an incorrect time results in poor performance and injury.

Motor control is what separates the best athletes from the poorer competitors even though the poorer performers may have larger muscles. Functional training incorporates the goal of enhancing strength throughout the body segment linkage. This means that the strength be generated quickly, throughout complex motions and postures, and in an environment that preserves balance and joint stability, and that avoids injury risks etc.

Feedforward v/s Feedback

Feedforward control is a top-down trajectory mechanism, it anticipates the movement, an established sequence where the stabilizers act ahead of or about the same time as the primary mover. The timing of muscle activity in feedforward control is the result of central processing. Correct feedforward results in core stabilization before movement.

Feedback is a down-up mechanism. Feedback control is a position controller. It provides proprioceptive information about the movement quality to the brain which will, in turn, change the movement appropriately. These changes can occur during the movement, if the movement is slow enough, or for the next repetition. Feedback is important because of its influences on altering feedforward.

With increasing movement speed, the system shifts from a feedback position controller to a feedforward trajectory generator where movement depends on ingrained movement patterns. This means that initial training of a new movement should begin slowly so feedback can alter patterns and the movement can be mastered before increasing speed or resistance. This way we give feedback a better advantage to influence central programming.

Table 4.4
Low back moments, abdominal muscle activity, and lumbar compressive load during several types of abdominal exercises.
Note: MVC contractions were isometric. Activation values higher than 100% are often seen during dynamic exercise.

	Muscle Activation			
	Moment (Nm)	Rectus Abdominis (% MVC)	External Oblique	Compression (N)
Straight Leg Situp	148	121	70	3506
Bent Leg Situp	154	103	70	3350
Curlup feet Anchored	92	87	45	2009
Curlup Feet Free	81	67	38	1991
Quarter Situp	114	78	42	2392
Straight Leg Raise	102	57	35	2525
Bent Leg Raise	82	35	24	1767
Cross-knee Curlup	112	89	67	2964
Hanging Straight Leg	107	112	90	2805
Hanging Bent Leg	84	78	64	3313
Isometric Side Bridge	72	48	50	2585

Feedforward activation of stabilizers has been demonstrated to occur in the low back with the TrA, IO, EO, RA and MF, in the neck with the deep neck flexors, SCM and Ant Scal, and in the knee with the VMO. After an injury to the low back, neck or knee the feedforward mechanisms are compromised. This results in instability as movement begins. These changes do not resolve when the pain is gone resulting in overloading the thissues that are compensating.

Proximal stability before distal mobility

With proper movement control proximal stability occurs before movement of the extremities. If core stability does not occur at the right time less efficient muscles take on the load of stability. This overloads them, eventually resulting in pain or injury. Training needs to begin with core stability, control, and endurance.

Function of the core is different than how it is usually trained

Endurance	Strength
Type 1	Type 2
Slow Twitch	Fast Twitch
Smaller fibers, Weaker	Larger Fibers, Stronger
Resistant to Fatigue	Fatigue Easily
Trained by Holds	Trained by Repeats

The primary function of the core is to create cocontraction of the appropriate muscles to insure spinal stability throughout movement. This requires endurance: low contraction (10% MVC or less) over a long period of time. With joint injury, this requirement for cocontraction can increase to as much as twice.

Practice does not make perfect, it makes permanent. Ideally, good stabilization exercises that are performed properly groove motor and motion patterns that ensure spinal stability while satisfying all other demands. However, some stabilization exercises are better than others; again, it depends on the objectives. For example, the resultant load on the spine is rarely considered. The goals for an injured person are considerably different from the athlete:

The injured person: One key to improving bad backs is to select stabilization exercises that impose the lowest load on the damaged spine.

The high-performance athlete: The best stabilization exercise for a high-performance athlete will involve the grooving of a dynamic and complex motion pattern, all the while ensuring sufficient spine stability. An important requirement for many athletes is to ensure a stable spine while breathing hard, such as when playing high-intensity sports.

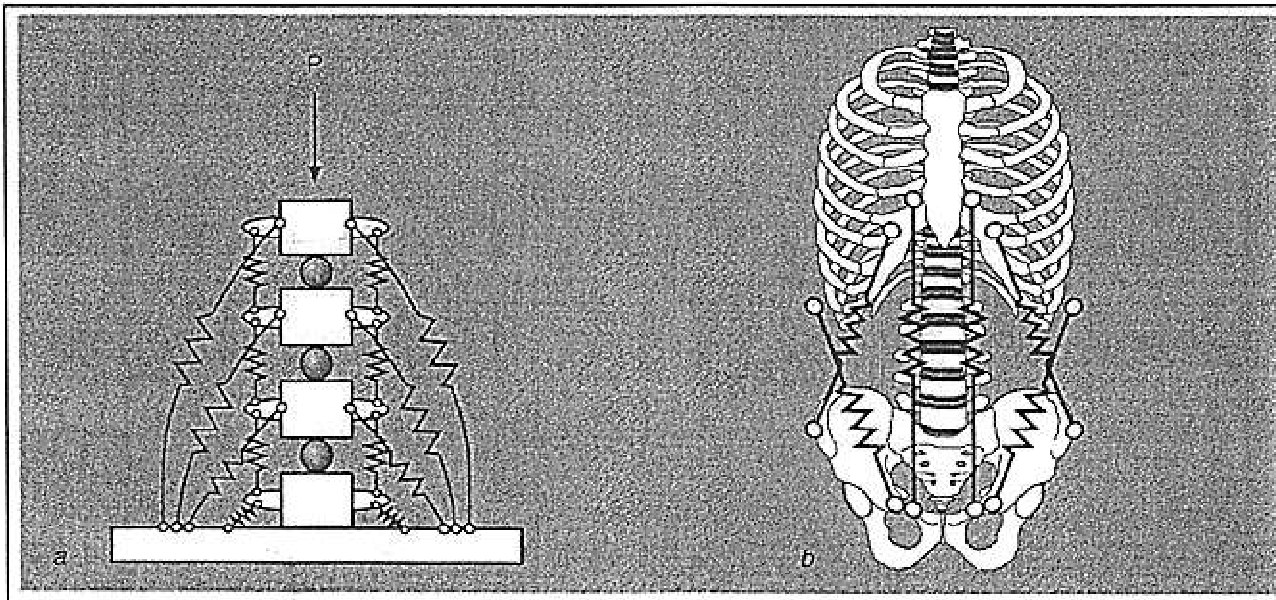
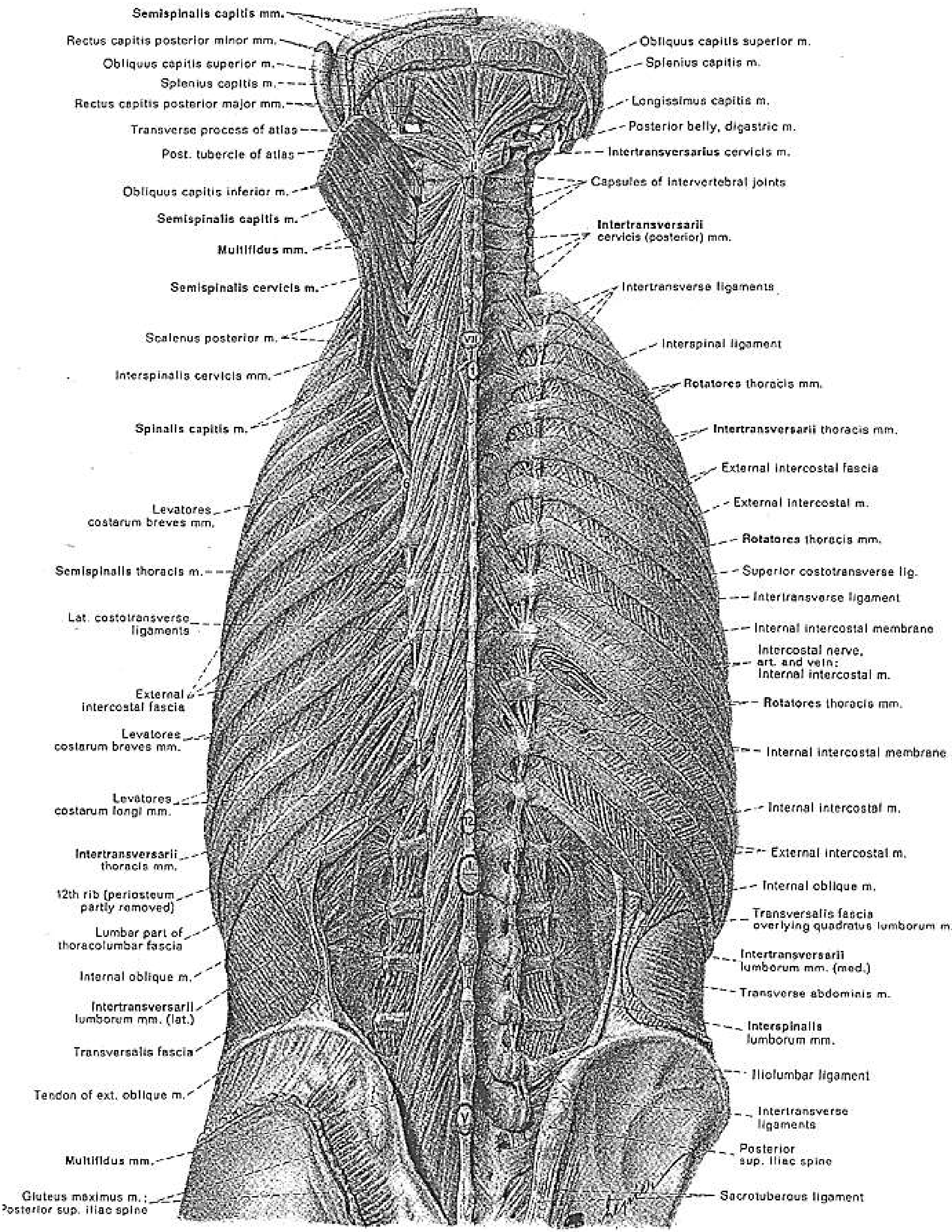


Figure 6.7 *(a)* Spine stiffness (and stability) is achieved by a complex interaction of stiffening structures along the spine and *(b)* those forming the torso wall. Balancing stiffness on all sides of the spine is more critical to ensuring stability than having high forces on a single side.

McGill S. Ultimate Back Fitness and Performance. Human Kinetics, 2004



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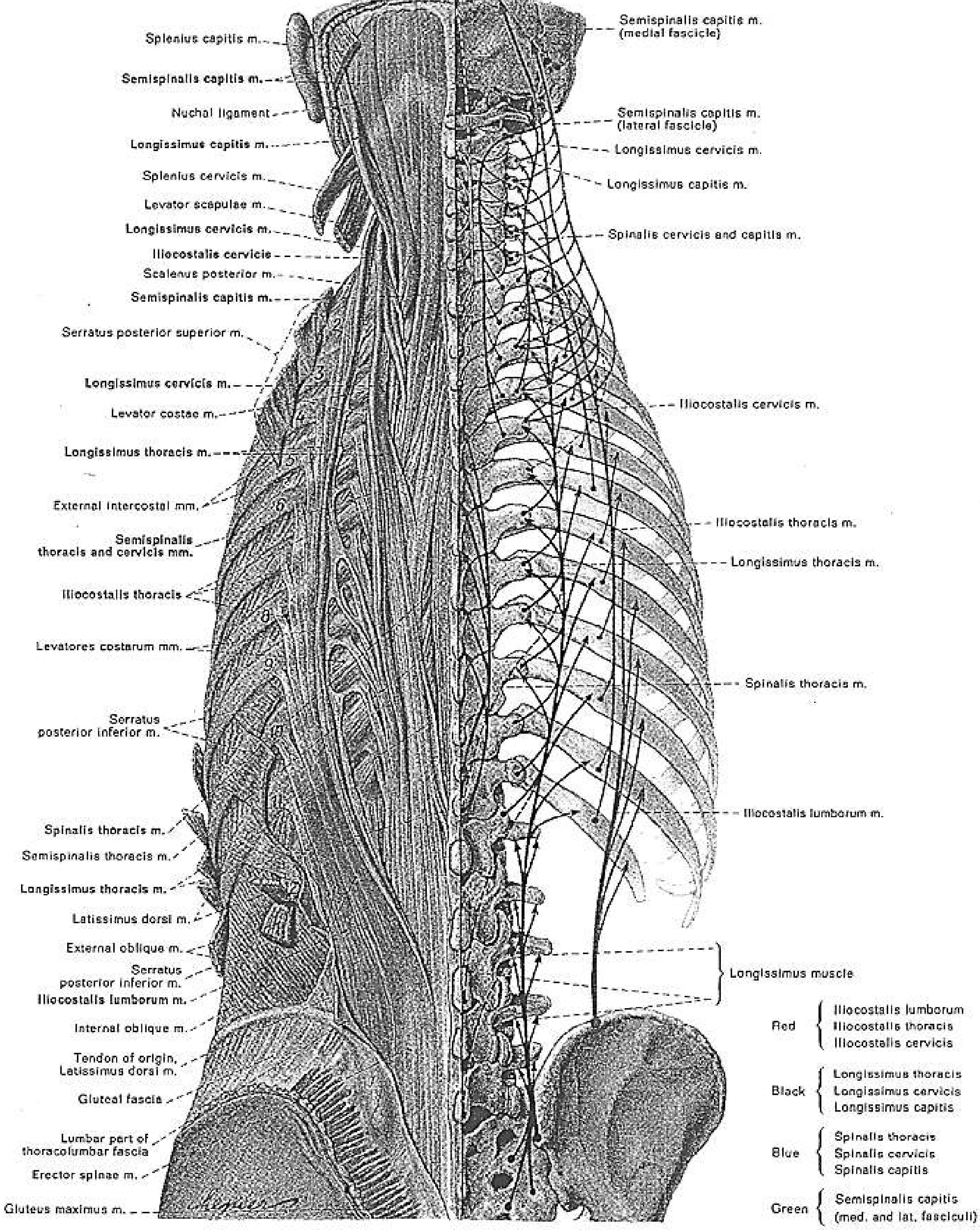

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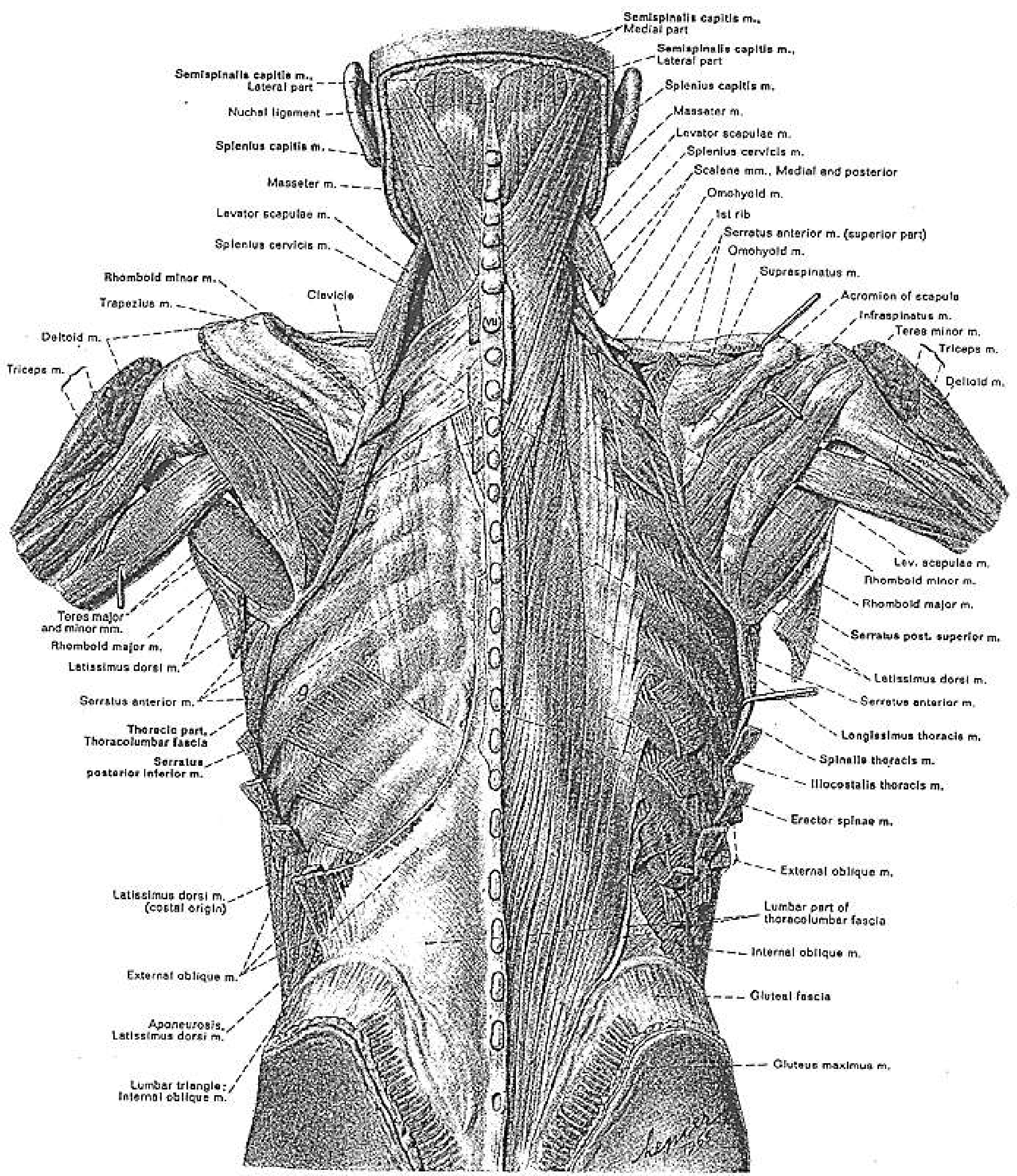

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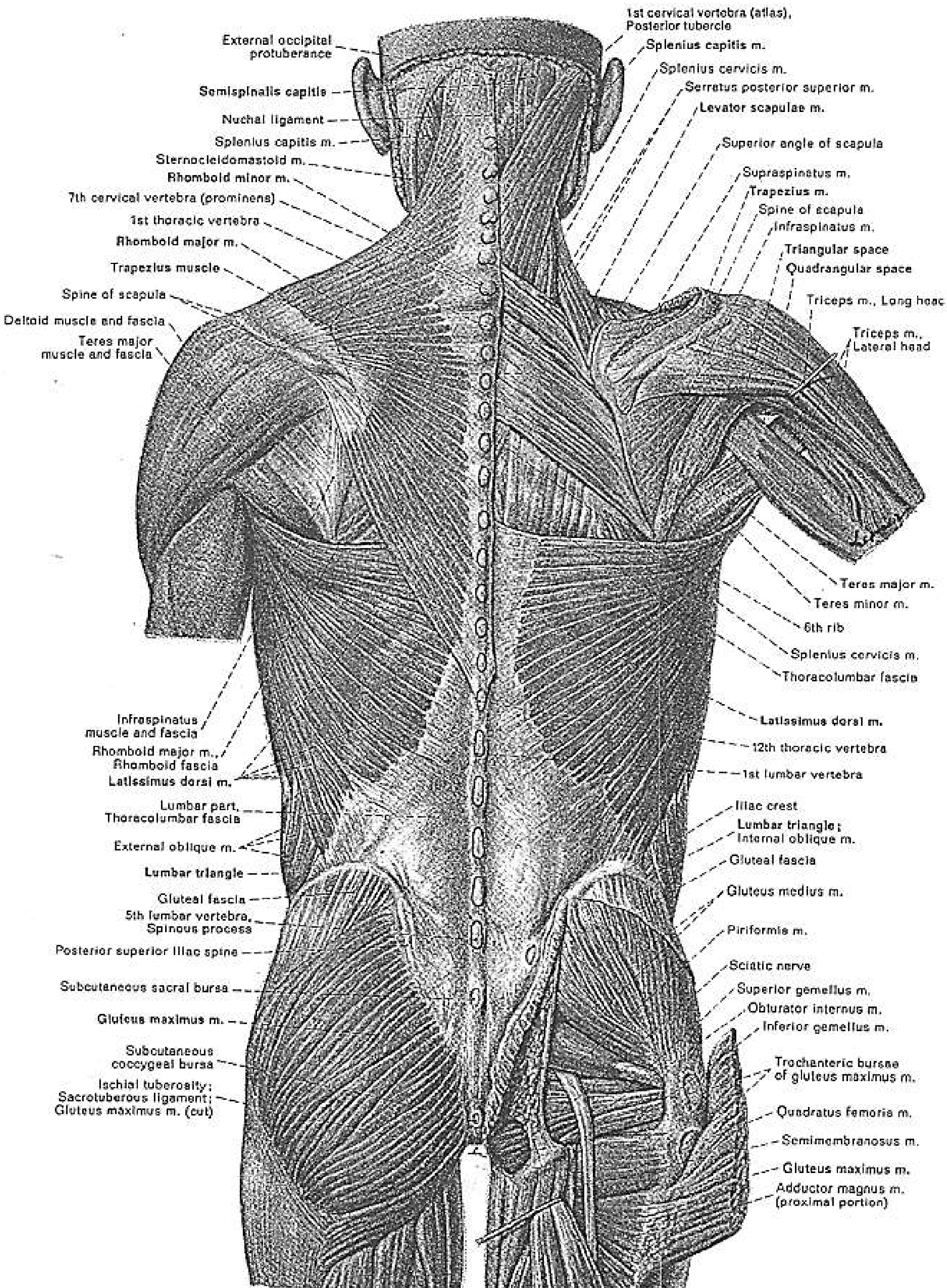

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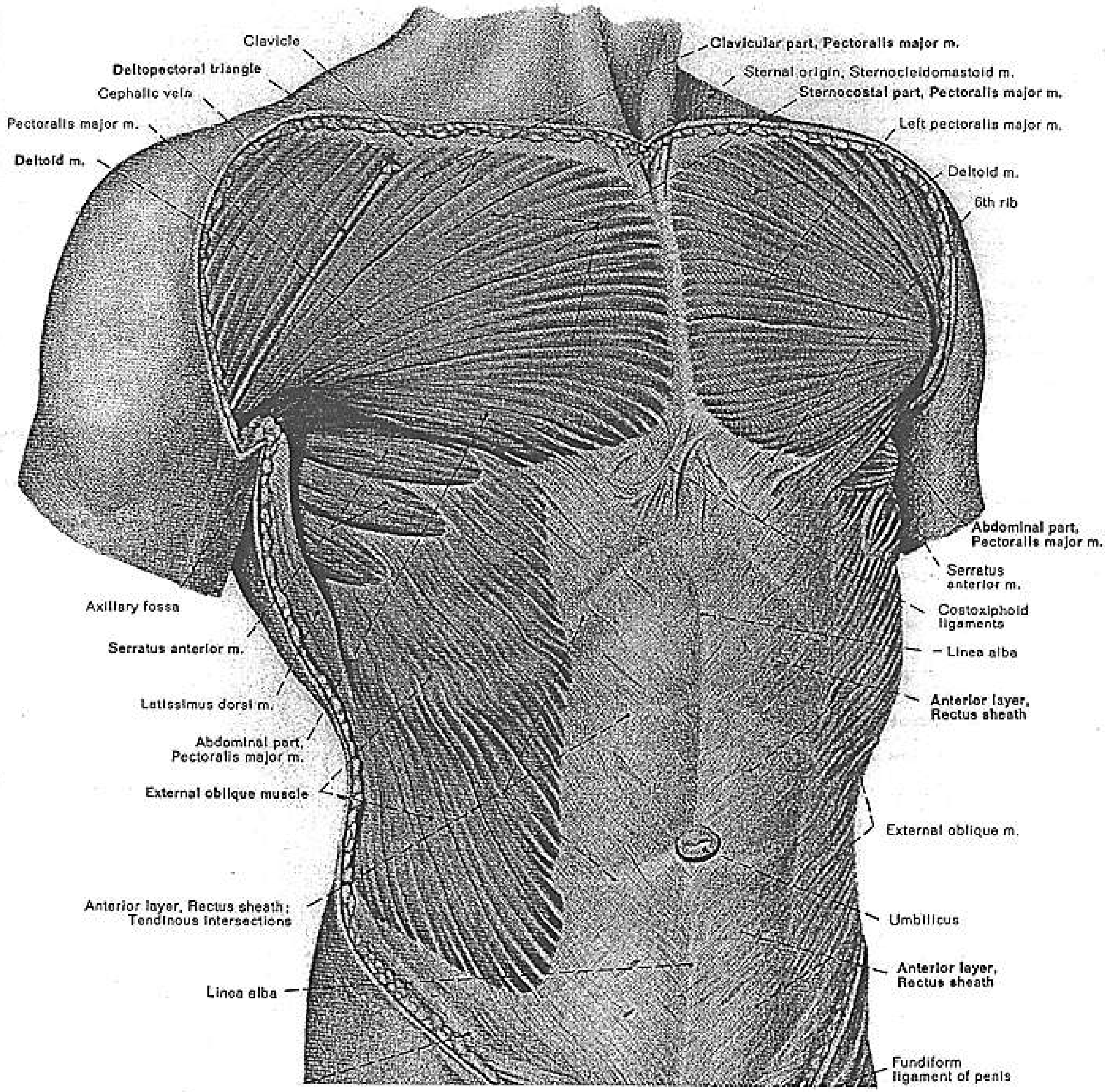

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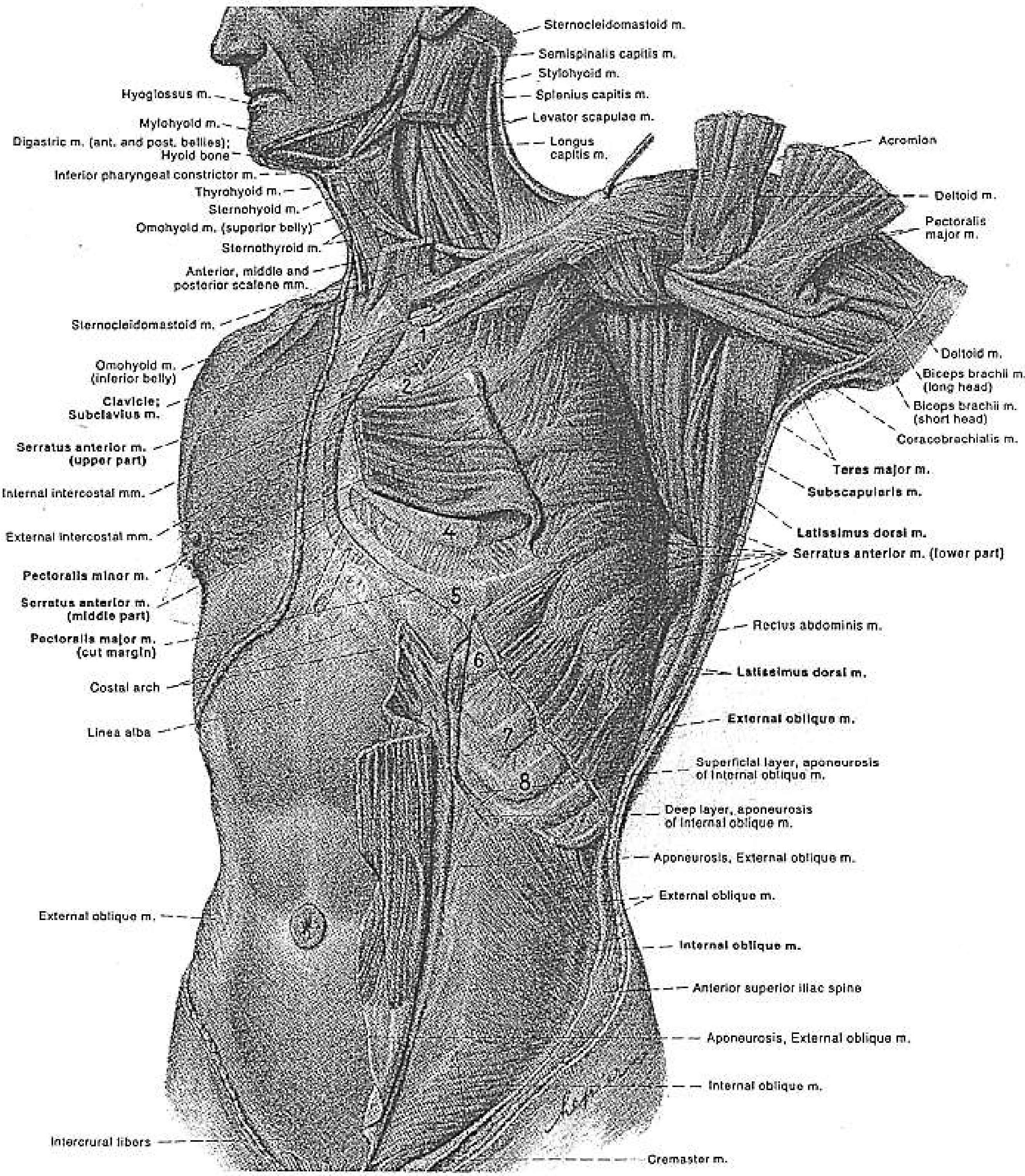

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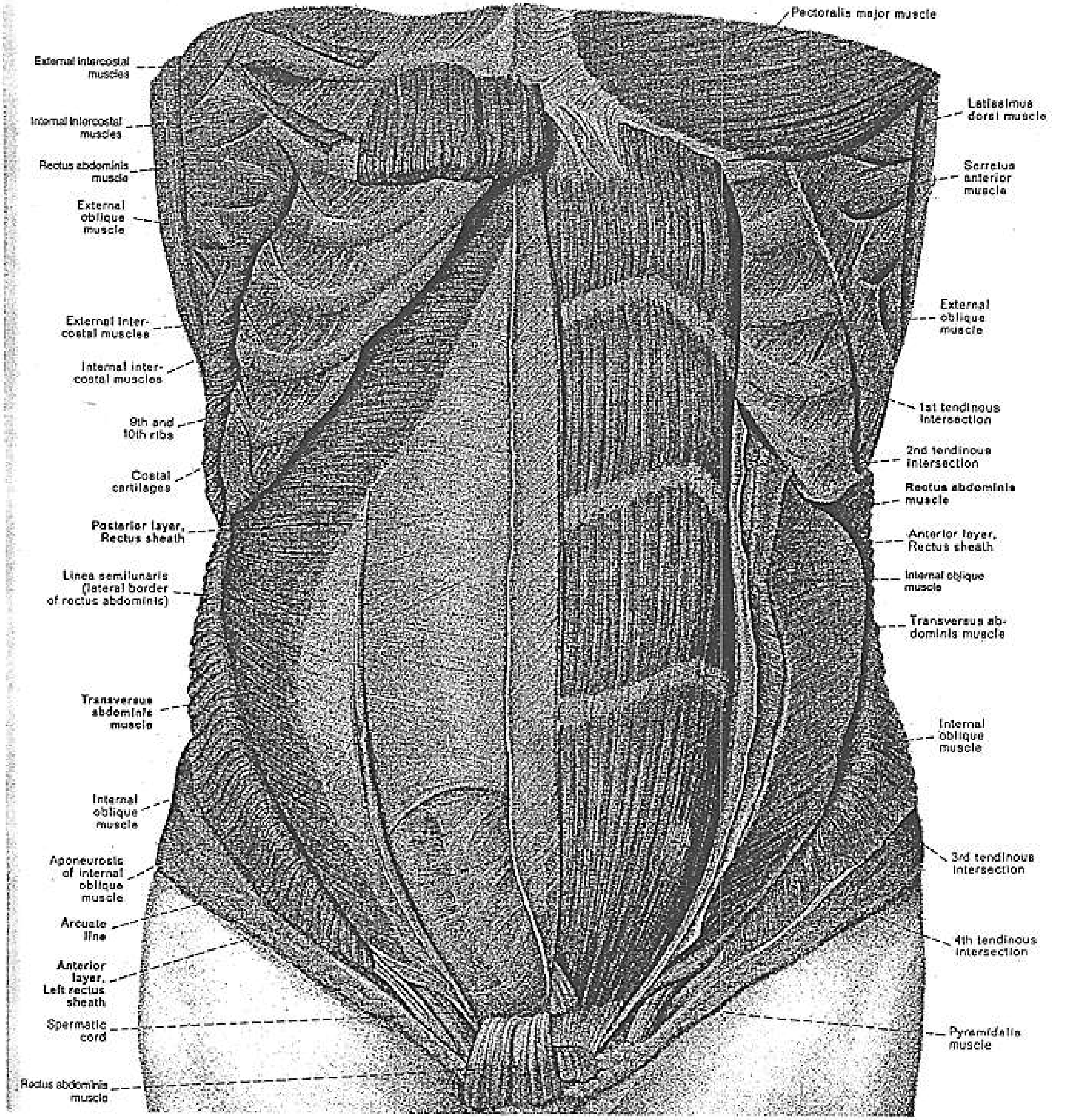

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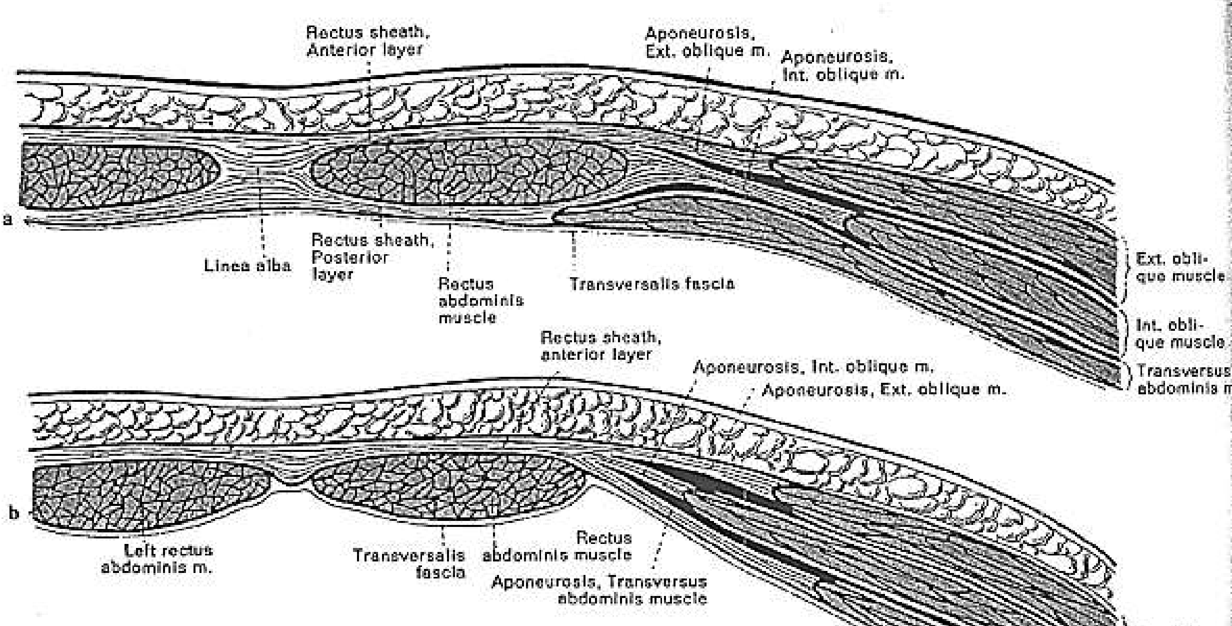
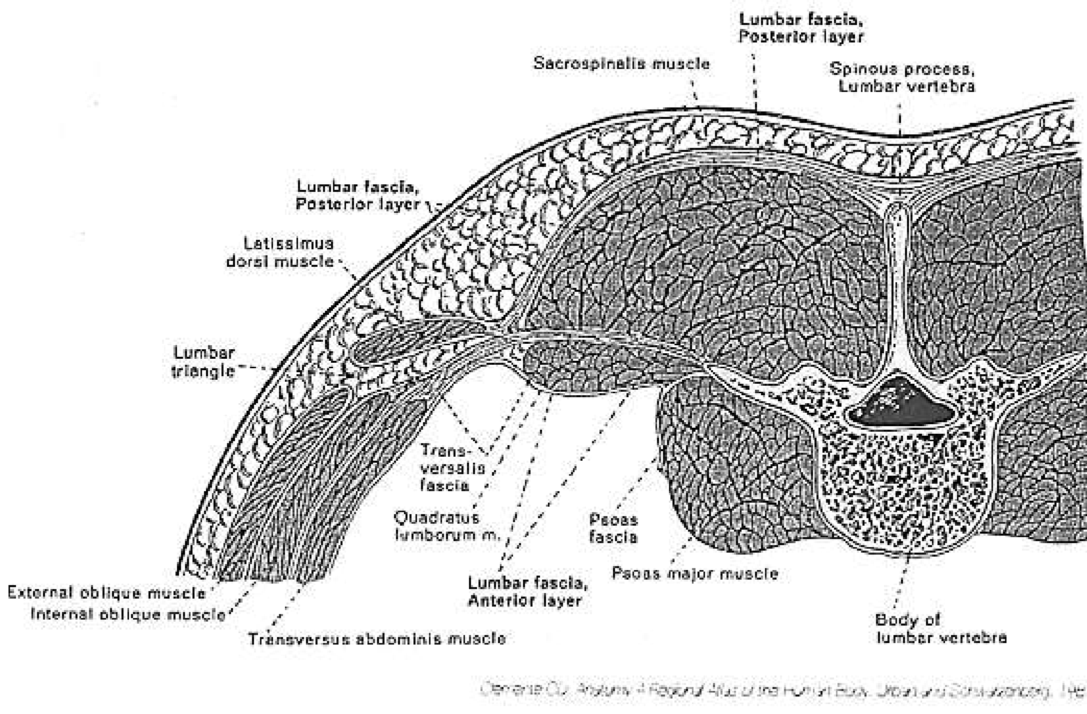


Fig. 241 a and b: Transverse Sections of the Anterior Abdominal Wall: Above the Umbilicus and Below the Arcuate Line

NOTE: 1) the sheath of the rectus abdominis is formed by the aponeuroses of the external oblique, internal oblique and transversus abdominis muscles.

2) the upper two-thirds of the sheath encloses the rectus muscle both anteriorly and posteriorly (a). To accomplish this, the internal oblique aponeurosis splits. Part of this aponeurosis joins the aponeurosis of the external oblique to form the anterior layer, while the other portion joins the aponeurosis of the transversus abdominis to form the posterior layer.

Clemente CD. Anatomy A Regional Atlas of the Human Body. Urban and Schwarzenberg, 1987



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Functional Anatomy of the Trunk

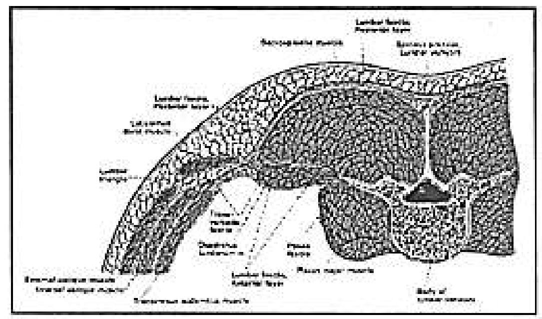
Back Muscles

Intrinsics - Rotatores and Intertransversarii: These two muscle groups are the intrinsic muscles of the spine. They are the deepest most group of muscles. There is not enough leverage of these muscels to produce significant movement. They function as active ligaments and position transducers to provide critical propiroceptive information for intersegmental stabilization.

Extensors - Longissimus, Iliocostalis, and Multifidus: These muscles produce the greatest amount of extensor moments with a minimum of compressive penalty to the spine. These muscles produce posterior shear to support any anterior reaction shear forces that are produced as the upper body is flexed forward in a typical lifting posture. However, these muscles reorient to the compressive axis of the spine during lumbar flexion so that a flexed lumbar spine is unable to resist damaging shear forces. These muscles actually relax as you perform a standing-to-full-flexion maneuver and become inactive at full flexion.

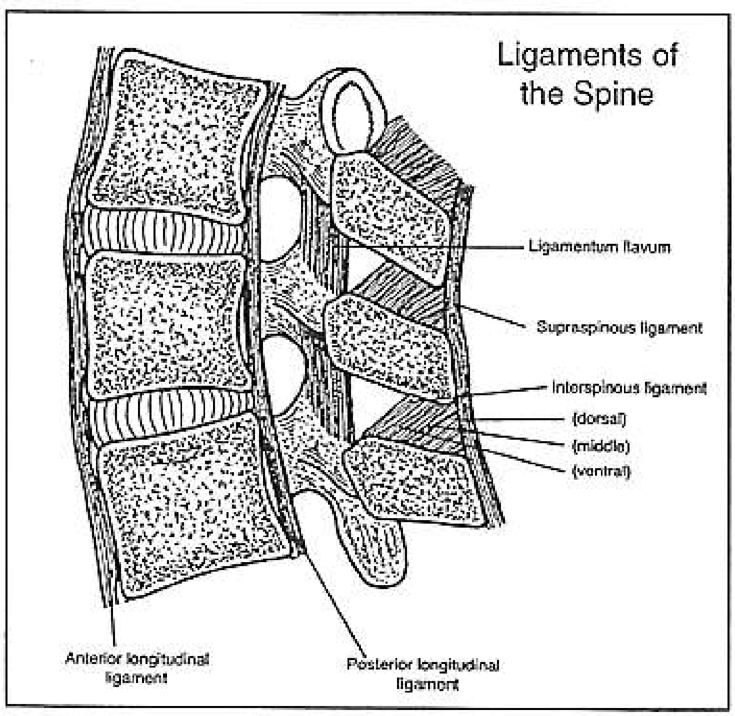
Quadratus Lumborum - Has a stabilizing role by attaching to each lumbar vertebra and to the pelvis and rib cage. The fibers of the QL cross link the vertebra and could buttress shear instability making them effective in stabilizing all loading modes. Furthermore, the QL does not relax at full flexion.

Abdominal Muscles



Abdominal Fascia - Contains the rectus abdominus and connects to the TrA, IO and EO. It is functionally important because it connects to the pectoralis major and transmits force to the fascia on the opposite side of the abdomen.

Rectus Abdominis - The RA is the major trunk flexor. It is interesting to consider why the rectus abdominis is partitioned into sections. The tendonous bands keep the muscle from bulking upon shortening and allows transmission of forces from the IO, EO and TrA, forming a continuous hoop around the abdomen. The tendons prevent the fibers of the rectus from being ripped apart laterally from these loop stresses. Of interest to note is that unlike the obliques that can be regionally activated, all sections of the rectus are activated together at similar levels during flexor torque generation.



Ligaments of the Spine

Abdominal Wall Muscles – External oblique, Internal Oblique, and Transverse Abdominis. All three are active during torso flexion. The obliques are involved in torso twisting and lateral bending, and play a role in lumbar stabilization. The TrA is invariably the first muscle to contract during core stabilization, while the activation of the obliques varies with direction of force. Furthermore, unlike the RA, these muscles have the ability to contract regionally.

Ligaments

Interspinous and Supraspinous Ligaments - Interspinous ligaments limit posterior shear but impose anterior shear forces during full flexion, they limit rotation. Supraspinous ligaments limit excessive flexion. Both ligaments have the important proprioceptive role of preventing excessive strain in fully flexed postures and under excessive shear load.

Lumbodorsal Fascia (LDF) - The LDF attaches to the spinous processes (except L5 in many individuals) and posterior-superior iliac spines. The TrA and IO attach to the fascia as do the Lats over the upper regions of the fascia.

"Hoop" Stabilization of the Spine

The obliques together with the TrA, the LDF posteriorly, and the abdominal fascia anteriorly form a "hoop" around the abdomen. The resulting "hoop stresses" and stiffness assist with spine stability.

The Posterior Loop

The facial alignments of the muscles and connective tissues of the trunk, hips and shoulder create an oblique loop that increases stability of the back. Dysfunction in any tissue of these kinetic chains can overload other parts of the loop to compensate. This produces tissue overload in those compensatory tissues.

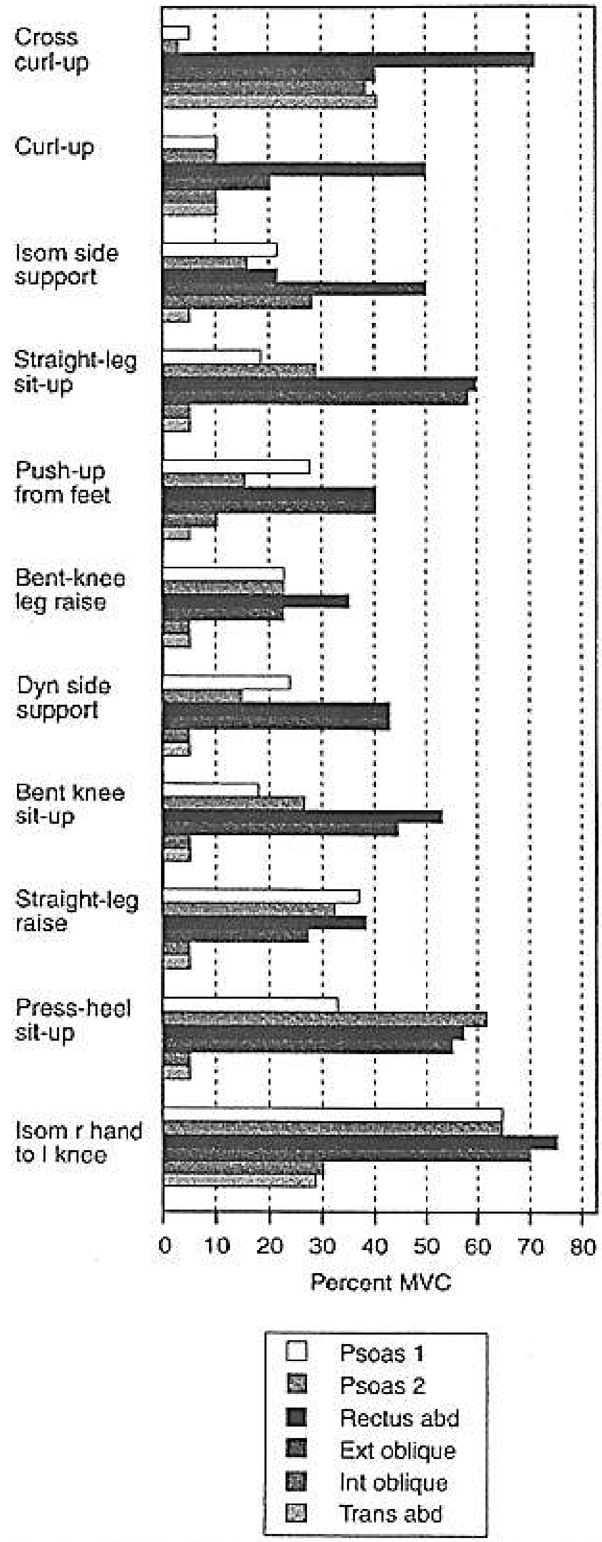


Figure 5.8 Activation of the psoas and the abdominal muscles in a variety of flexion tasks from a group of highly trained subjects (five men and three women).

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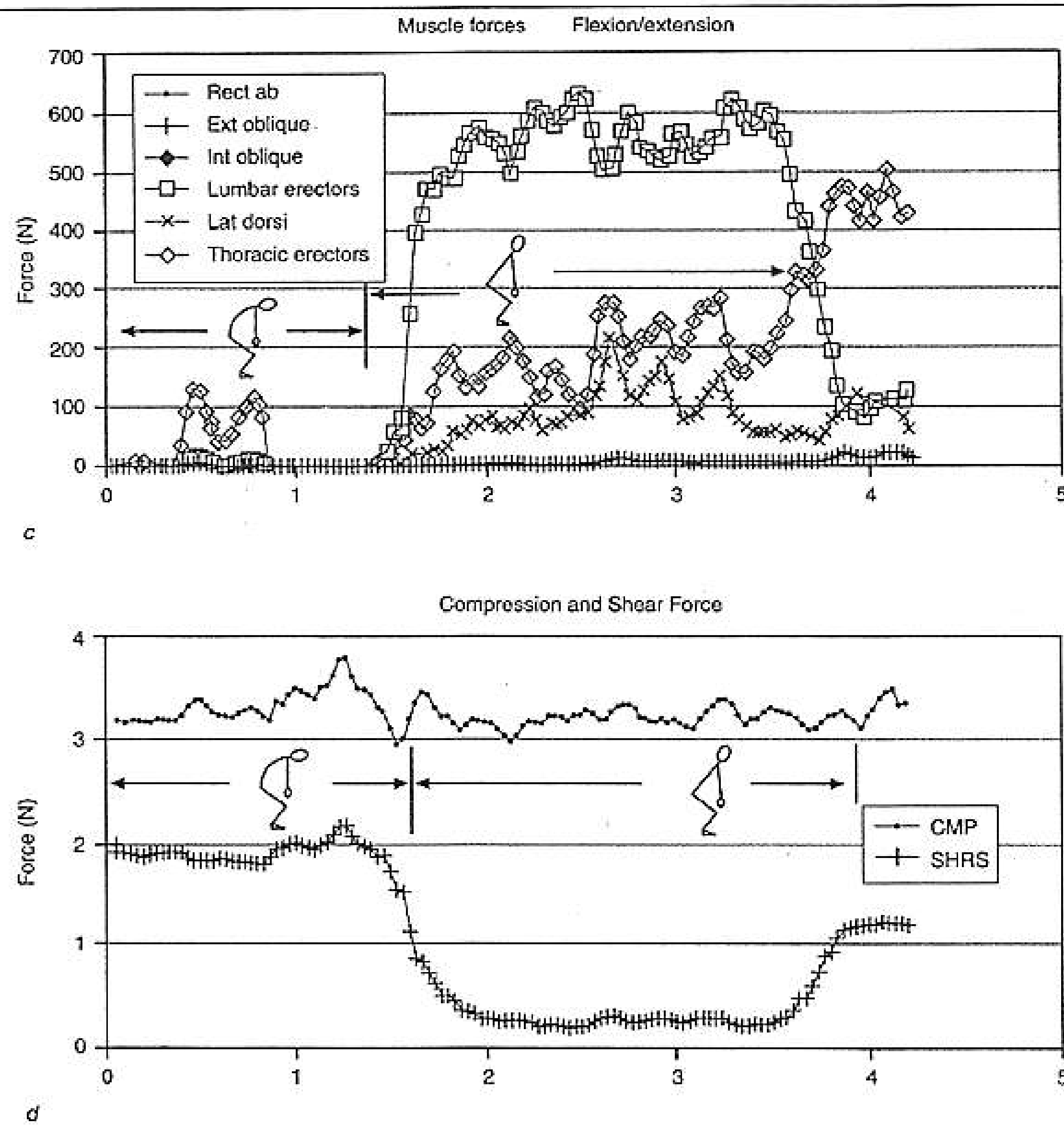

Figure 5.13 (continued) ...*(c)* to support the reaction shear (see figure 4.19) and thus reduces total joint shear *(d)* (to approximately 200 N in this example).

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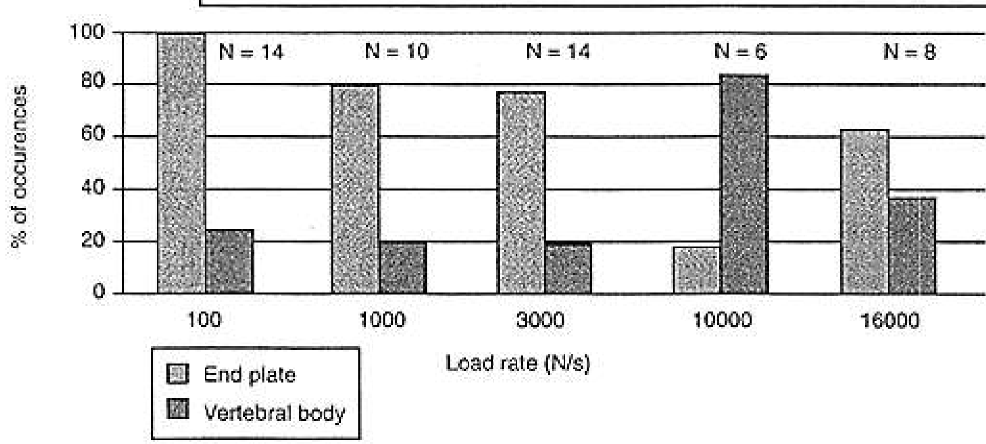

Figure 4.6 Compression injuries at different load rates. At low rates of compressive load the end plate appears to be the first structure to fail, but bone will fracture first under higher rates of load.

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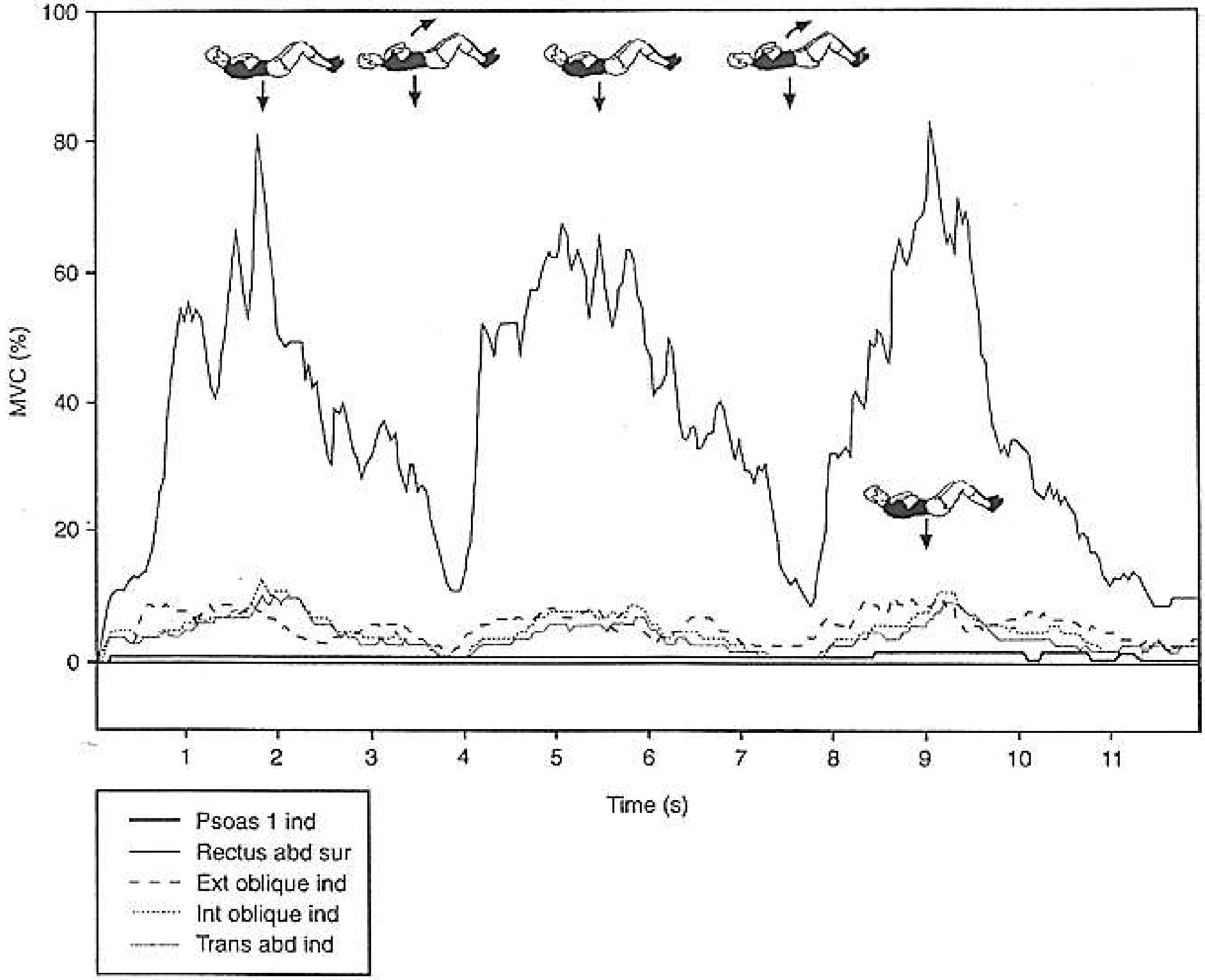

Figure 5.10 Activation-time histories for the same group performing curl-ups.

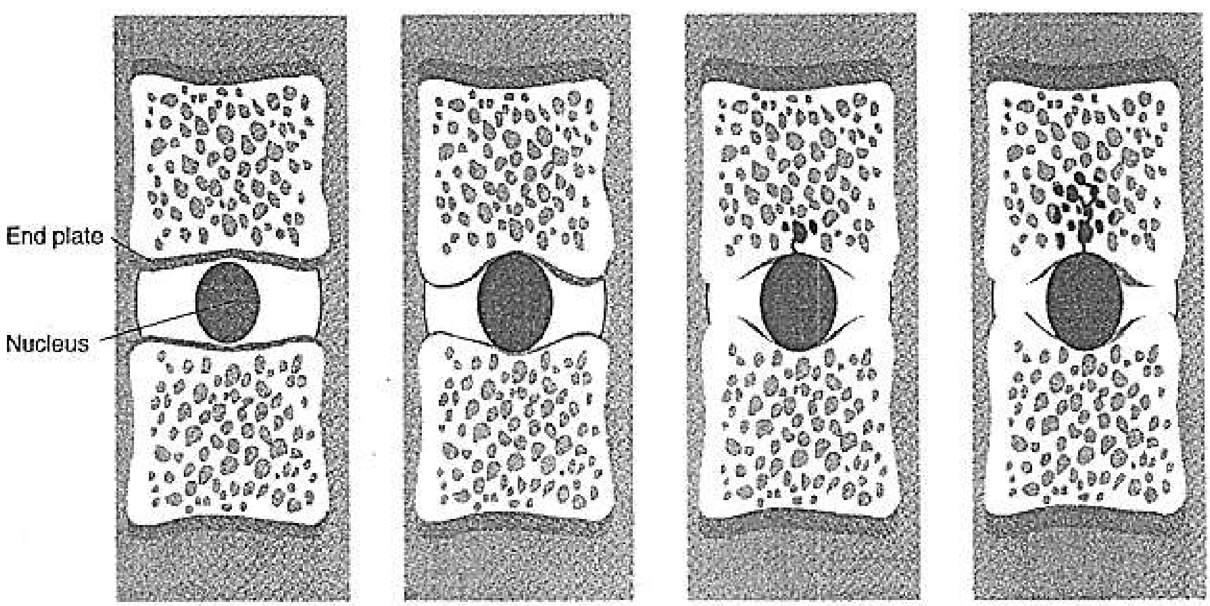

Figure 4.8 Under compressive loading the nucleus pressurizes, causing the end plate to bulge into the vertebral body. With excessive radial-tensile stress the end plate will fracture and the viscous nucleus will squirt through the crack into the vertebral body.

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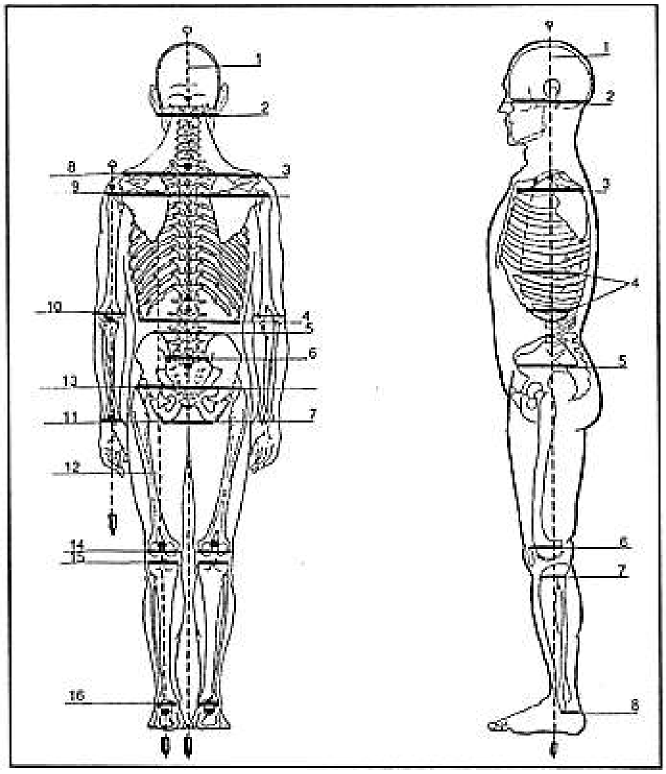
Functional Considerations For The Trunk

Posture Affects Stability and Overload

Proper posture results in minimal muscle activity. With good posture the muscles are often at rest. The muscles that are responsible to maintain proper posture are composed primarily of slow twitch, Type 1, endurance fibers. They tend to shorten with disuse. As posture deviates from optimum, the muscles remodel in response the changes. More stress is placed on the system to maintain upright positioning which requires increased muscle activity resulting in altered joint forces and increased ligament stress. This overloads the tissues resulting in increased tendency of injury or pain.



Coronal View Landmarks: External auditory canal, Acromion, greater trochanter, lateral condyle of the femur, a finger's breadth in front of the lateral maleolus.

Joint Stability

Stability of a joint is produced by cocontraction of the muscles around it. This cocontraction generally occurs before the prime mover. For the lumbar spine stabilization comes from the muscles of the trunk, the obliques, transverse abd, and the extensor muscles. For the neck, primarily the deep neck flexors. For the scapula it is the serratus anterior and mid and lower traps, and for the knee it is the VMO.

Neutral Spine

Power is described as how quickly strength is developed during movement.

$$\text{Power} = \text{Force}/t = (ma)/t$$

Power generated in the spine is therefore directly related to motion of the vertebrae. Generating power in the back increases the risk of injury and generally decreases performance. Generating high strength (or force) is much safer with a back that is not bending (i.e. low power). Undergoing spine motion is much safer when the forces are lower. Thus the object of most movement technique to spare the back, both in rehabilitation and during performance tasks, is to maintain low spine power. Generally good technique requires power to be developed about the hips and arms.

Neutral spine is a range of positions of low passive tissue stiffness, that is, with the least amount of tension:

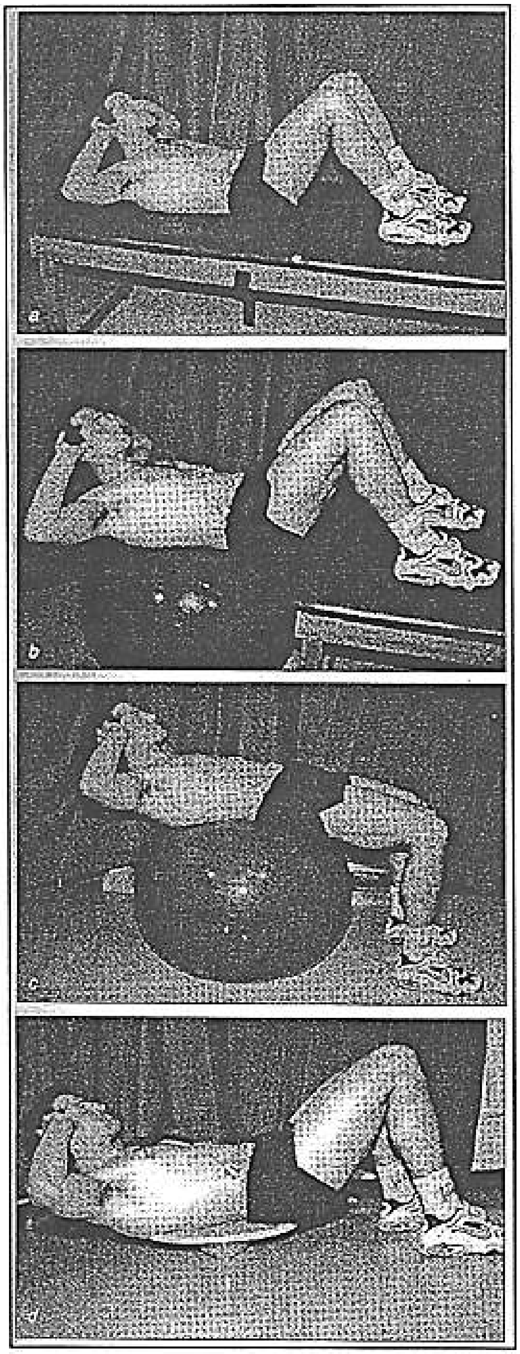
I=*tension*=I- - - minimal ligament tension - - -I=*tension*=I

Neutral spine is a spine that is neither fully flexed nor fully extended. It is within the pain-free range of motion. The neck and lumbar spine are more stable towards extension.

To find neutral spine we perform the chin poke/overcorrect and the slump/overcorrect procedures. One should be able to perform these techniques in almost all situations. To demonstrate neutral spine, place a straight edge along the spine. There should be contact at the sacrum, mid thoracic spine and back of the head.

Activating The Core

Core stability results from highly coordinated muscle activation patterns involving many muscles, and the recruitment patterns must continually change, depending on the task. With the exception of the TrA, no single muscle dominates in the enhancement of spine stability, and their individual roles are continuously changing across tasks. In stabilization of



a healthy spine, the TrA invariably activates with the same timing to initiate stabilization. Clinically, if the goal is to train for stability, enhancing motor patterns that incorporate many muscles rather than targeting just a few is justifiable.

Stiffness is required in every rotational movement to eliminate the possibility of unstable behavior. The abdominal brace ensures sufficient stability using the oblique cross-bracing. High levels of cocontraction are rarely required – probably about 5% maximum cocontraction of the abdominal wall during daily activities and up to 10% maximum during rigorous activity. We can activate the muscles of the abdominal wall in two ways: The Kegal which is an activation of the pelvic floor and is practiced by women for child bearing. The technique is often described as pulling the anus up or stopping flow during urination. The pelvic floor can be activated by simply pinching off the nose and trying to breath in. The second technique is activation of the TrA and is accomplished by drawing in the tummy not at the navel but lower at the level of the ASIS.

Breathing v/s Core Stability

Challenged breathing is often characterized by rhythmic contraction/ relaxation of the abdominal wall. Thus, the motor system is presented with a conflict: Should the torso muscles remain active isometrically to maintain spine stability, or will they rhythmically relax and contract to assist with active expiration (but sacrifice spine stability)? Fit motor systems appear to meet the simultaneous breathing and spine support challenge; unfit ones may not.

An important feature of stable and functional backs is the ability to cocontract the abdominal wall (abdominal brace) independently of any lung ventilation patterns. Good spine stabilizers maintain the critical symmetrical muscle stiffness during any combination of torque demands and breathing patterns. Grooving muscular activation patterns so that a particular direction in lung air flow is entrained to a particular part of an exertion is not helpful, in fact it would be counterproductive.

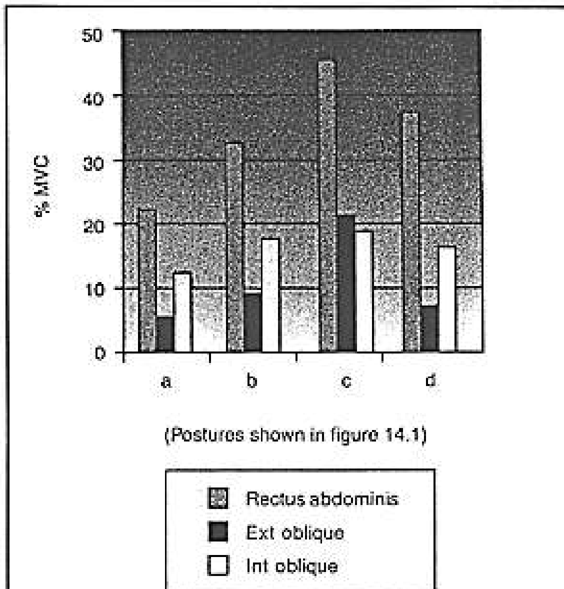


Figure 14.2 The % MVC caused by each of the postures shown in figure 14.1. A curl-up with the body over a ball and the feet on the floor (figure 14.1c) virtually doubles the abdominal muscle activation seen in a curl-up on a stable surface (figure 14.1a) and, correspondingly, the spine load. Note that the % MVC required of the three muscles studied is also much higher in curl-ups with the body over a ball and the feet on a bench (figure 14.1b) and with the body on a wobble board (figure 14.1d) than on a stable surface. Clearly, a gym ball can be wonderful for advanced training but is contraindicated for many patients.

Train to breathe freely while maintaining the stabilizing isometric abdominal wall contractions.

Improving The Endurance of The Abdominal Core

Abdominal exercises should increase trunk/lumbar stability with the intent of reducing spinal stress during movement. To do this it is best to target the muscles best fit for lumbar stability: Obliques, Transverse abd, Multifidus and the other erector muscles, and the Quadratus lumborum. There are many ways that this can be done. However, there is no one exercise that can train the entire core.

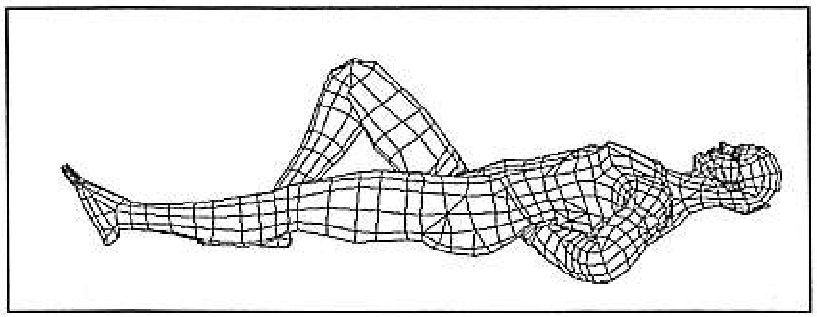
The Gym Ball

When exercises are performed sitting on a bench the pelvis is fixed and requires very little trunk stabilization. The use of a gym ball can greatly increase the activity of the trunk muscles. In healthy individuals quiet sitting is ineffective in activating the trunk. However, if we throw in some movement this scenario changes considerably. Also, less contact with the ground, the greater the instability and the greater the activation of the trunk muscles. This could apply to sitting on the ball: going from two feet far apart to close together; or from two feet on the ground to only one foot on the ground. This technique could also apply to prone and supine postures on the ball as well.

We also see that when exercises are performed unilaterally the activation of the trunk muscles increases. This could apply to virtually all upper body exercises such as bicept curls, lat pull downs, shoulder presses or, if lying down, bench press .

The Curl-Up

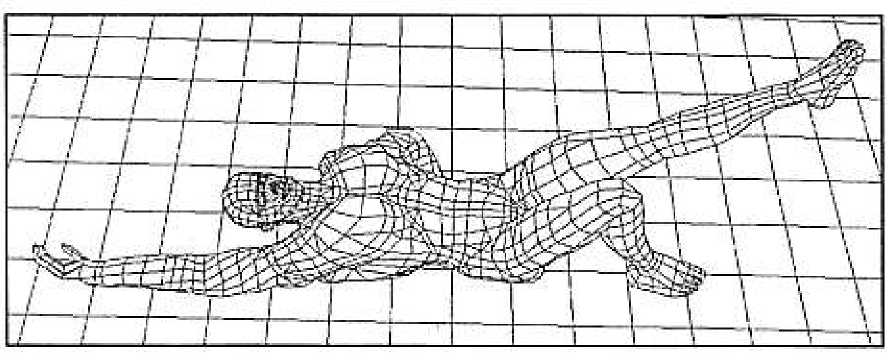
The curl-up activates predominately the RA; there is very little activation of the obliques and TrA, no activity of the psoas. Consequently, the curl-up does not directly stabilize the lumbar spine. The RA is part of the core muscles and counters the extensors. However it must be kept in mind that most people overtrain the RA creating an imbalance between the trunk flexors and extensors. In fact, this very condition is predominant in individuals with a history of back problems.



As to how the curl-up is generally performed, the curl-up is rarely performed respecting neutral spine, which overloads the spine and reinforces inappropriate posture. Additionally, the curl-up, by its repetitive nature, trains Type 2 fibers for strength not Type 1 for endurance. Finally, repeatitive spinal flexion has been demonstrated to cause disk injury. This affect is increased with increasing spinal compressive loads. The sit-up imposes high spinal compressive loads and includes repeatitive flexion movement. If a person has a history of lumbar disc disorders or is deconditioned the curl-up should not be performed.

What are the indications for curl-ups? In a healthy individual with balanced trunk muscles the endurance time of the erector group should be 30% greater than the flexor group. When the flexors need to be improved the curl-up can be prescribed with a few modifications:

1. The curl-up should be performed with neutral spine.
2. The curl-up should be held for 8 – 10 second intervals, which usually equals two breaths.
3. If the proper curl-up cannot be performed without excessive shaking then the exercise needs to be peeled back to one that is less strenuous.



In a person with a history of back injury who has weak abdominal flexors the curl-up will probably be contraindicated. It is best to begin with an abdominal exercise of less intensity and lower spinal compression such as the dying bug (see below). Then progress into the curl-ups when the person has adequate endurance.

The Dying Bug

A good exercise of less intensity than the curl-up is the Dying Bug (Dead Bugs don't move). Included in the Appendix is the Dying Bug track. Try this exercise when you want to target the RA more but still include the other core muscles. The crossover action of alternate arm/leg activates the abdominal muscles very well. The key elements of this exercise are:

Set up includes depression of the lower rib cage and holding that posture throughout the exercise. This activates the RA and other abdominal muscles.

All effort should be felt to come from the core, not the "shell."

Progress the client through the track to find the level at which fatigue occurs (feels it at the shell). This is the level that begins dysfunction..

Sets of 20 reps train for motor control and endurance.

Fatigue: When is enough, enough?

There can not be too much core training. However, it is very important to recognize the fatigue point. When training during fatigue compensation by other muscles occurs. This produces inappropriate stabilization, trains inappropriate movement patterns, and risks injury. The ball is very useful for determining fatigue when performing upper body work.

- When the client begins to move around on the ball the core is unable to stabilize and they should end the set.
- When the client is unable to hold Brugger posture, neutral spine, or abdominal brace, core fatigue has occurred.
- Finally, when working from the core, effort should be felt to come from the core. When it feels like the extremities are doing the work (the "shell"), the core is no longer in control. A rest period is called for. If the client is unable to perform the exercise from the core it needs to be peeled back to one they can.

Signs of general core fatigue are:

- Excessive shaking
- Feeling it in the "shell"
- Low back pain, neck pain, or any other inappropriate pain

"Train the movement, not the muscle." Stewart McGill

Looking Forward

The next workshop will discuss core evaluation and correlate exercises for dysfunction in greater detail. We will also look at extending the abdominal core tracks to exercises that are extremely challenging.

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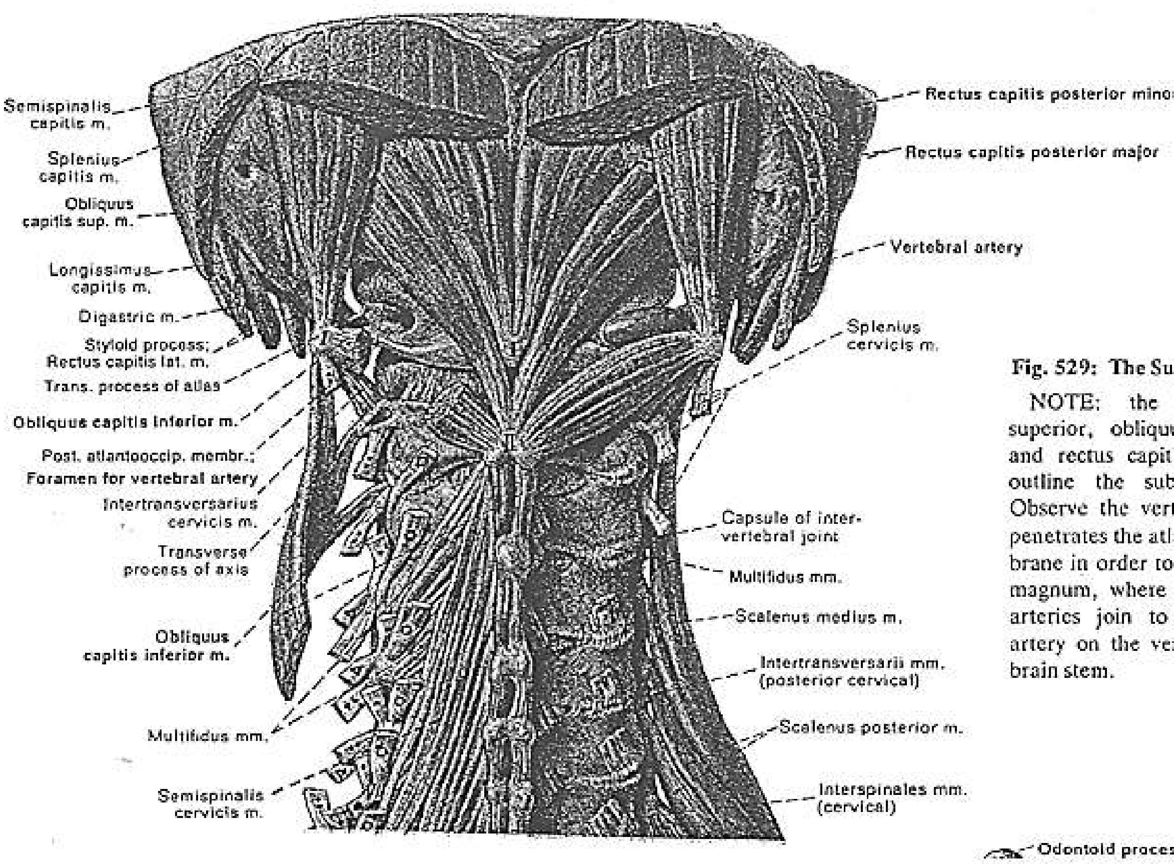
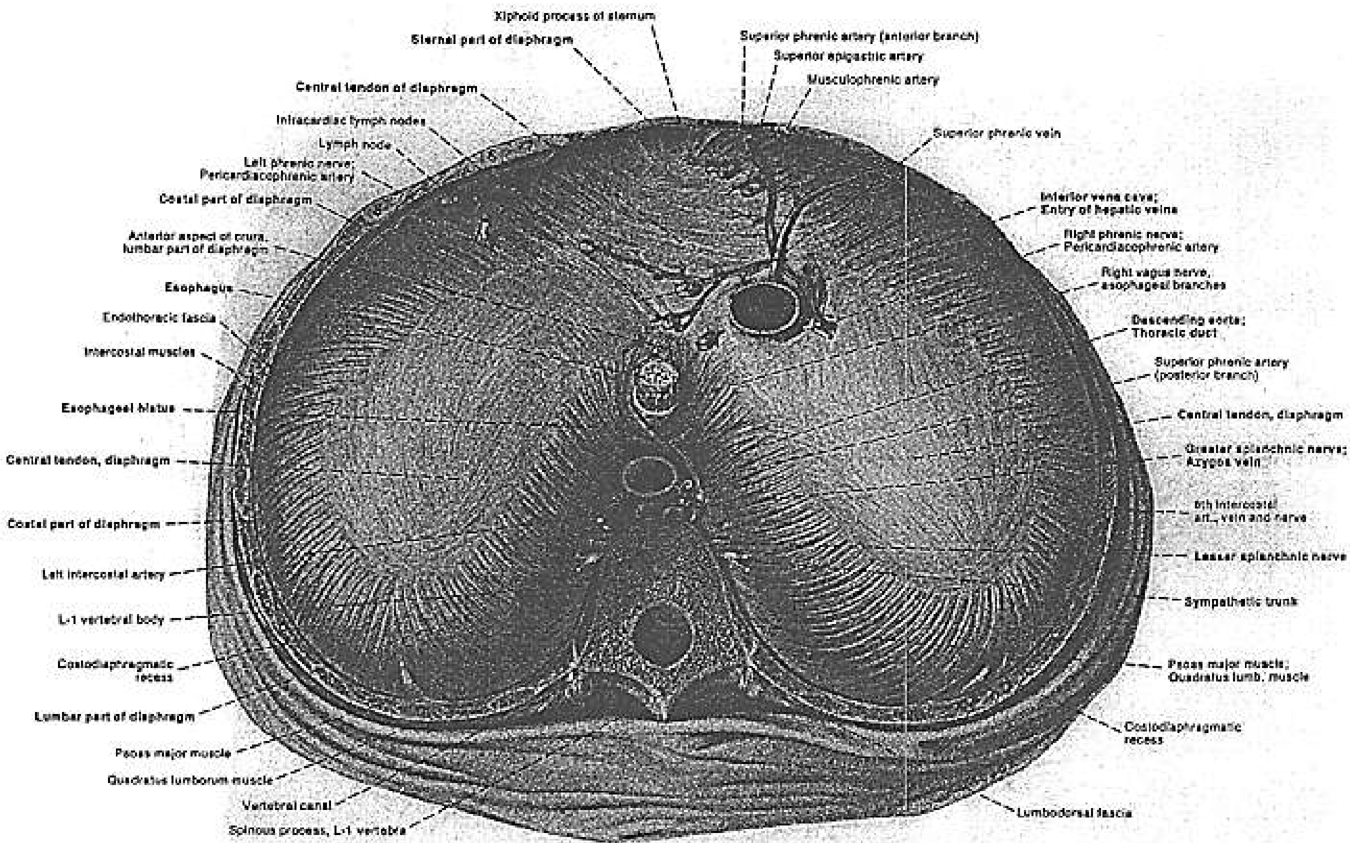


Fig. 529: The Suboccipital Triangle

NOTE: the obliquus capitis superior, obliquus capitis inferior and rectus capitis posterior major outline the suboccipital triangle. Observe the vertebral artery, as it penetrates the atlantooccipital membrane in order to enter the foramen magnum, where the two vertebral arteries join to form the basilar artery on the ventral aspect of the brain stem.



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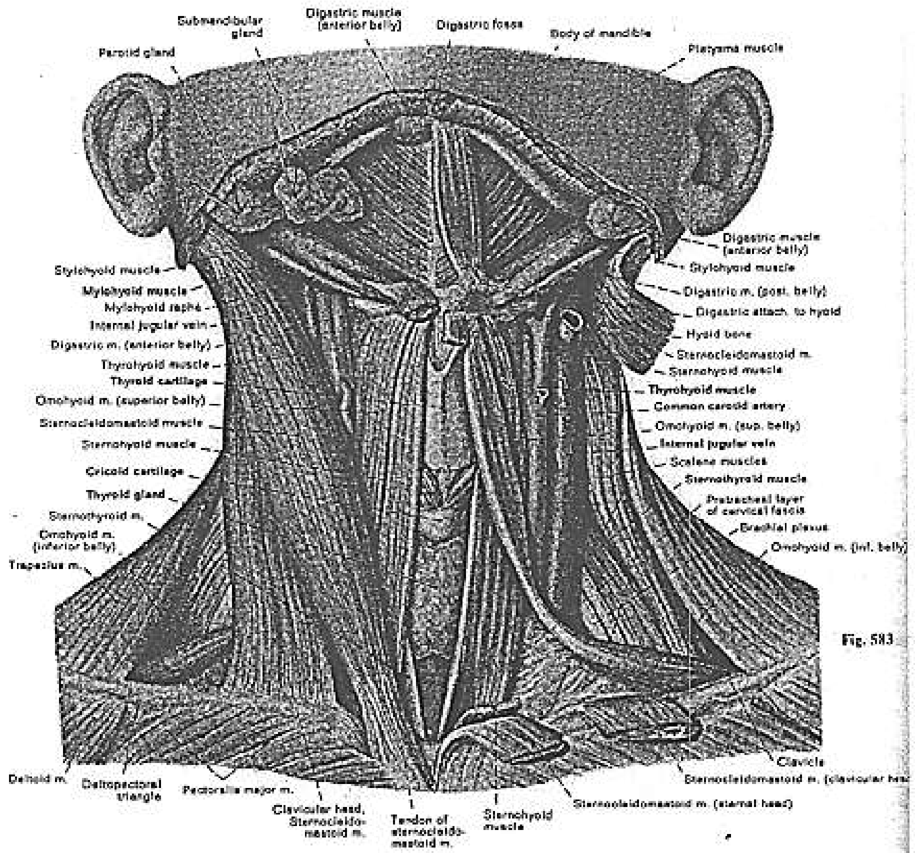
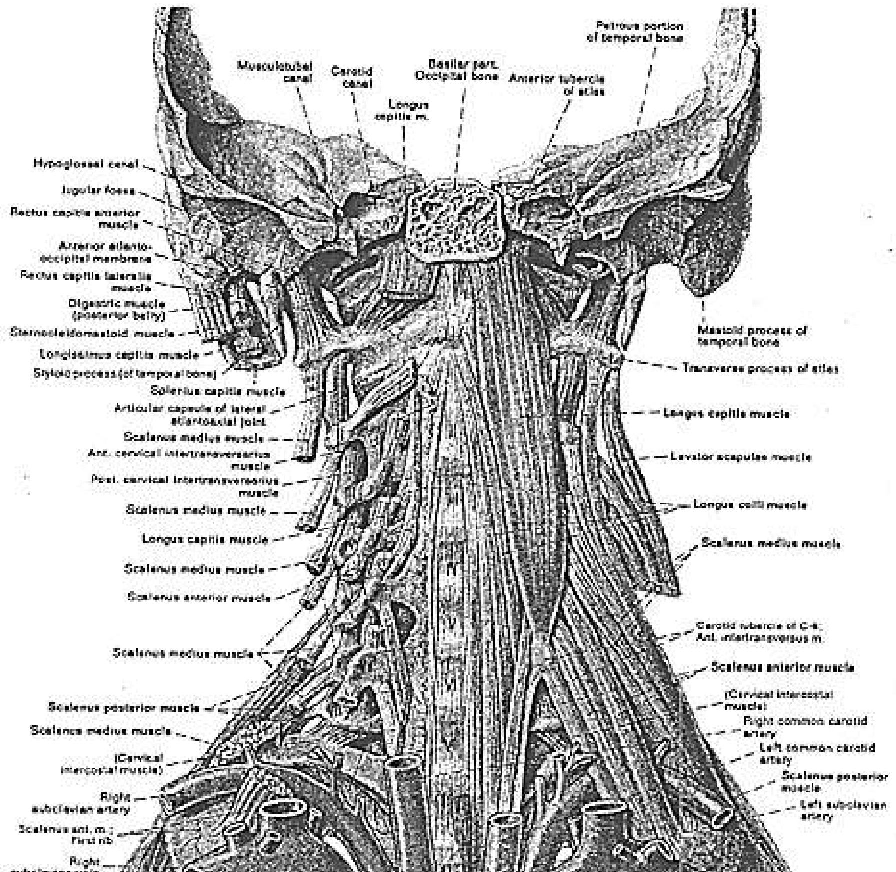


Fig. 583



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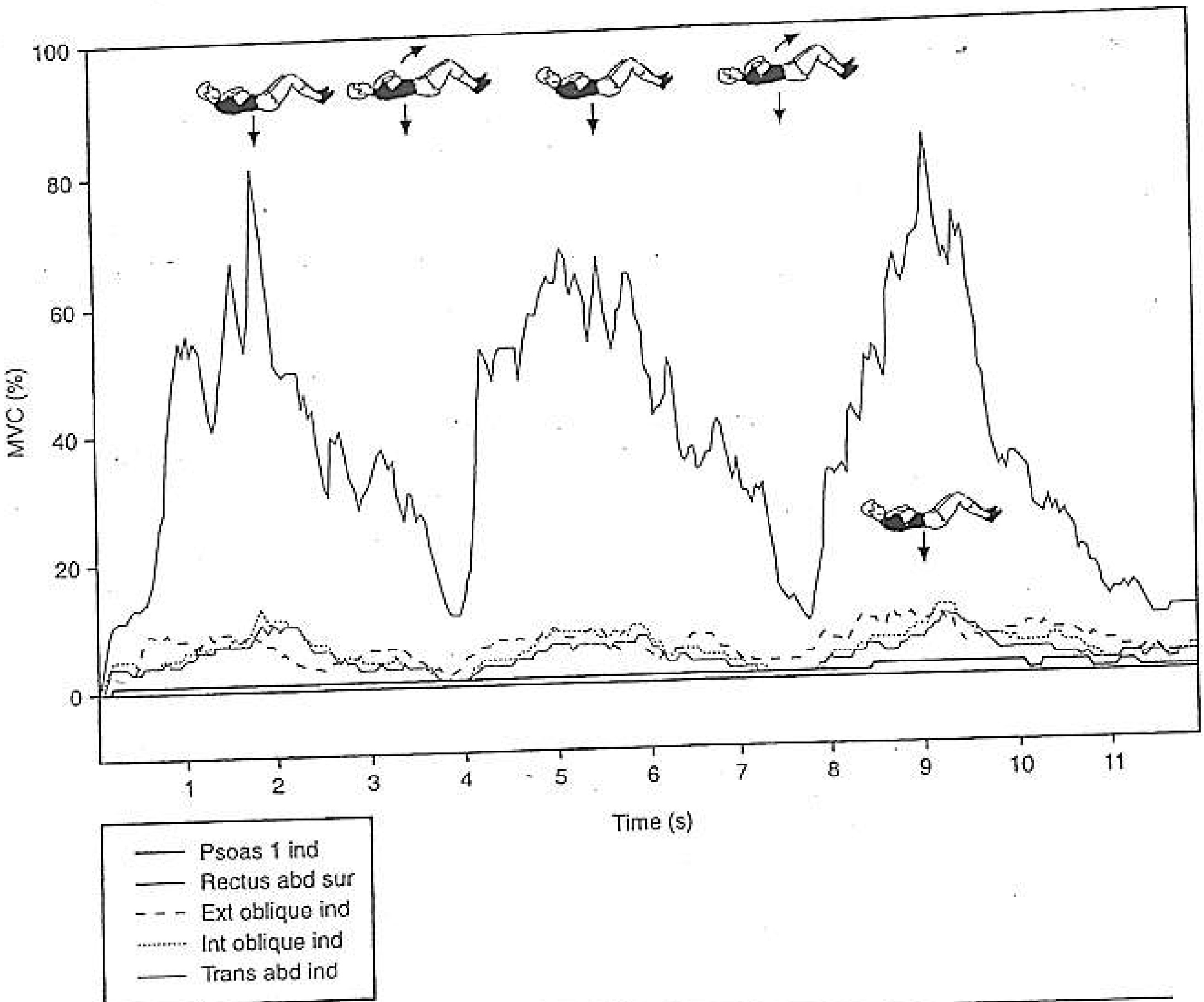


Figure 5.10 Activation-time histories for the same group performing curl-ups.

Gunning, and McGill (1998) attempted to rank extension exercises on the muscle challenge, the resultant spine load, and their optimal ratio. The key to preserving a therapeutic muscle activation level while minimizing the spine load is to activate only one side of the spine musculature at a time. The previous muscle anatomy section in chapter 4 describes the functional separation of the thoracic and lumbar portions of the longissimus and iliocostalis. For the purposes of this discussion, we can think of the extensors in four sections—right and left thoracic portions and right and left lumbar portions. The common extension task of performing torso extension with the legs braced and the cantilevered upper body extending over the end of a bench or Roman chair (figure 5.11a) activates all four extensor groups and typically imposes over 4000 N (about 890 lb) of compression on the spine. Even worse is the commonly prescribed back extension task *in clinics, in which the patient lies* prone and extends the legs and outstretched arms; this again activates all four extensor sections but imposes up to 6000 N (over 1300 lb) on a hyperextended spine (figure 5.11b). This is not justifiable for any patient! Several variations of exercise technique can preserve activation

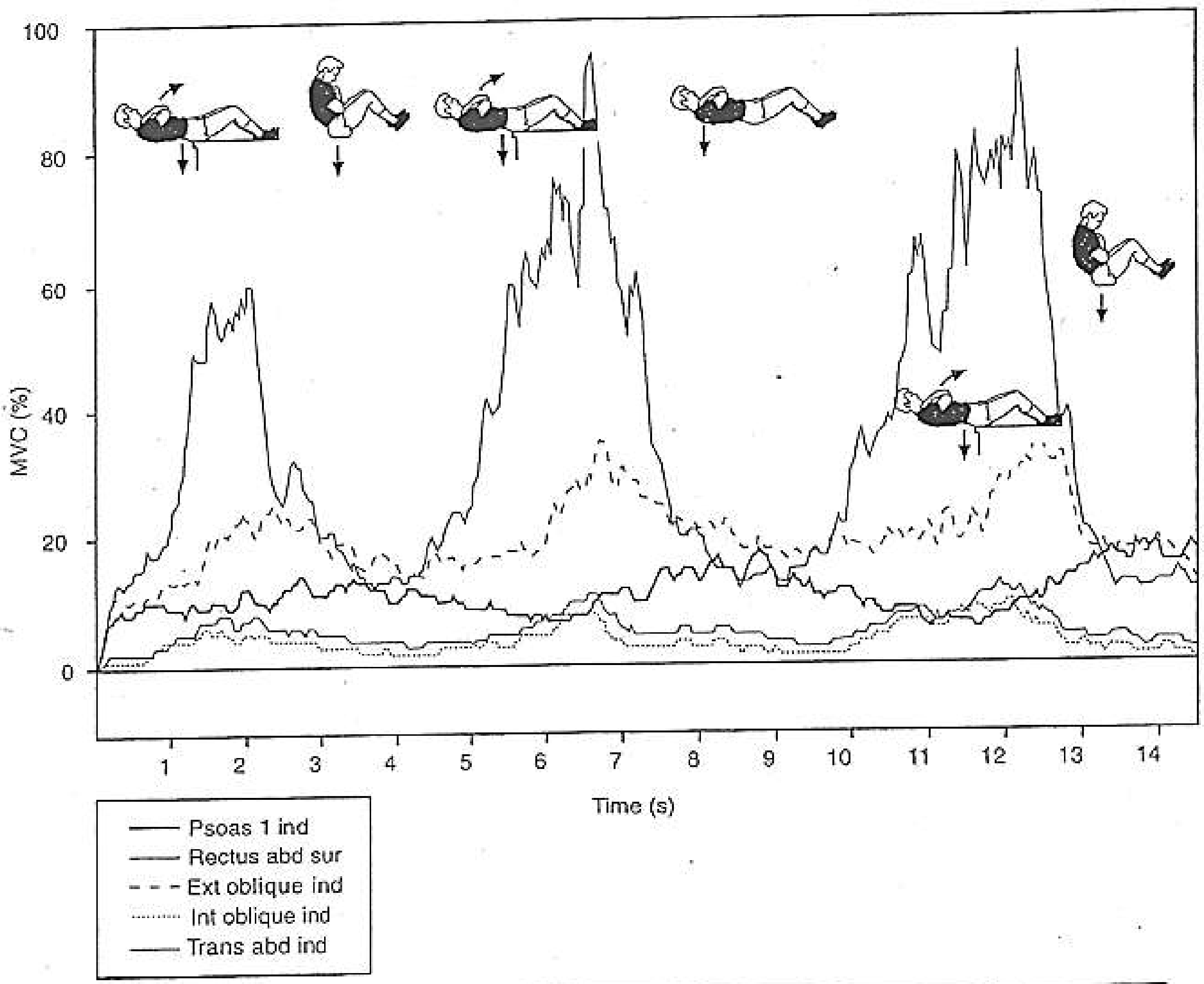


Figure 5.9 Activation-time histories of the same subjects as in figure 5.8 performing a bent-knee sit-up. Surface and indwelling electrodes are indicated.

Having stated this, those not interested in sparing their back and who are training with performance objectives may benefit from the high psoas challenge, together with rectus abdominis and oblique activity. Clearly, the curl-up primarily targets the rectus (both upper and lower), and generally other exercises should be performed to train the obliques. Some have suggested a twisting curl-up to engage the obliques, but this results in a poor ratio of oblique muscle challenge to spine compression compared to the side bridge exercise (Axler and McGill, 1997)—making the side bridge a preferred exercise.

Loads on the Low Back During Extension Exercises

As with the flexion exercises discussed in the previous paragraph, plenty of EMG-based studies have explored extension exercises, but only one attempted to quantify the resulting tissue loads. Exercise prescriptions will not be successful if the spine loading is not constrained for bad backs. Using the virtual spine approach, Callaghan,

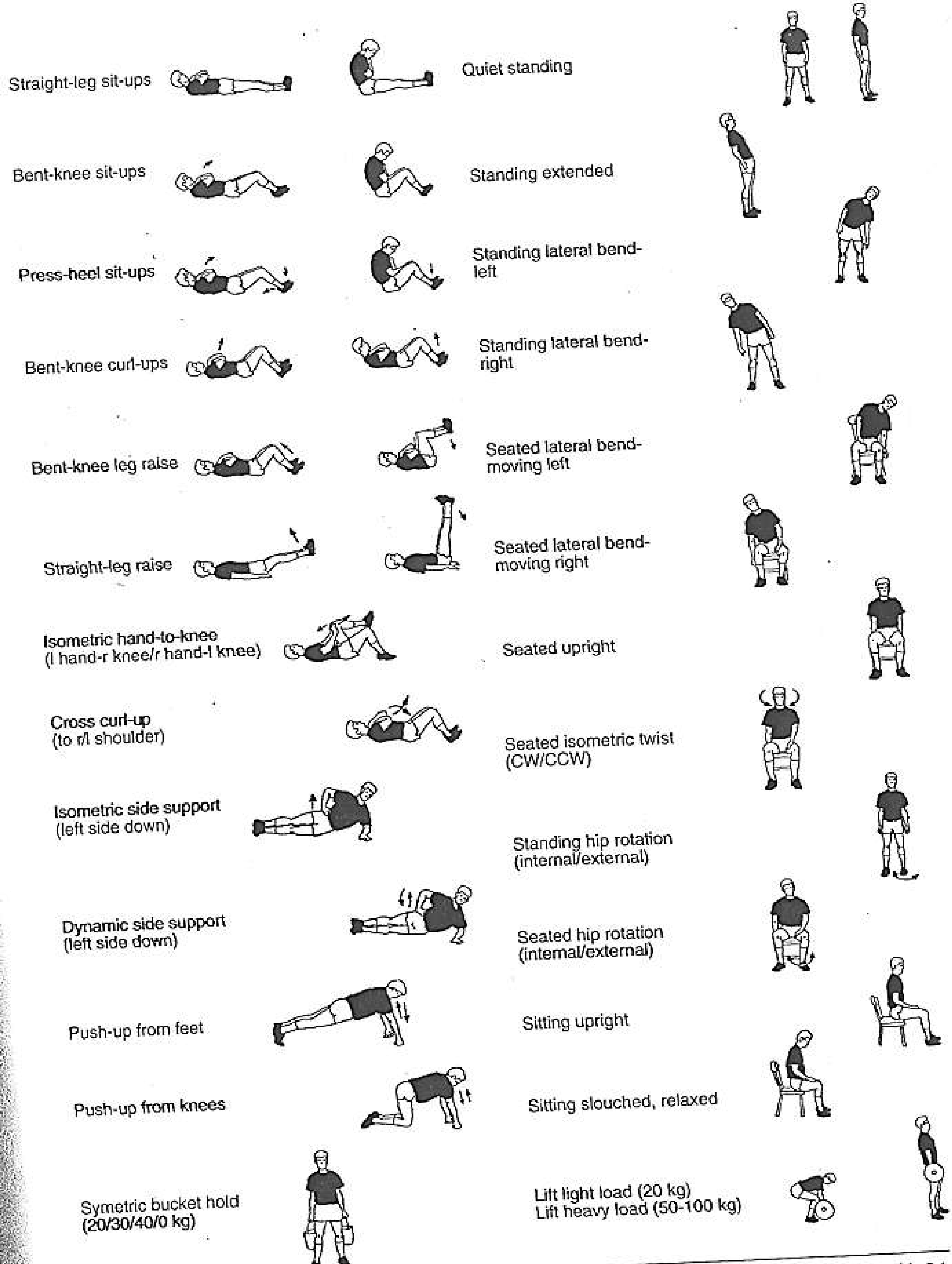


Figure 5.3 Schematic documenting various tasks during which EMG signals were obtained. They are listed in table 5.4.

Reprinted, by permission, from D. Juker, S.M. McGill, S.M. Kropf, T. Steffen, 1998, "Quantitative intramuscular myoelectric activity of lumbar portions of psoas and the abdominal wall during a wide variety of tasks," *Medicine and Science in Sports and Exercise* 30(2): 301-310. © Lippincott, Williams, and Wilkins.

Table 5.4 *(continued)*

Task	Psoas 1	Psoas 2	EOi	IOi	TAi	RAs	RFs	ESs
Symmetric bucket hold, 20 kg (44 lb)	2(±4)	1(±1)	7(±4)	5(±3)	5(±1)	10(±7)	3(±3)	3(±6)
30 kg (66 lb)	3(±4)	1(±1)	9(±5)	6(±4)	6(±1)	10(±8)	3(±3)	4(±7)
40 kg (88 lb)	3(±5)	1(±1)	10(±6)	8(±6)	6(±2)	10(±8)	3(±3)	3(±2)
0 kg	1(±2)	0(±1)	2(±1)	2(±2)	2(±1)	10(±9)	2(±1)	2(±1)
Seated isom. twist CCW-	30(±20)	17(±15)	18(±8)	43(±25)	49(±35)	17(±22)	7(±4)	14(±6)
Seated isom. twist CW	23(±20)	11(±8)	52(±13)	15(±11)	18(±19)	13(±10)	9(±10)	13(±8)
Standing hip internal rotation	21(±18)	10(±9)	18(±12)	24(±23)	33(±20)	13(±9)	9(±7)	18(±6)
Standing hip external rotation	27(±20)	22(±19)	17(±13)	21(±19)	31(±17)	13(±8)	19(±11)	17(±9)
Sitting hip internal rotation	19(±15)	21(±18)	36(±31)	30(±30)	31(±29)	18(±8)	20(±19)	12(±8)
Sitting hip external rotation	32(±25)	25(±20)	11(±9)	15(±17)	16(±13)	15(±9)	16(±13)	8(±8)
Sitting upright	12(±7)	7(±5)	3(±6)	3(±3)	4(±2)	17(±9)	4(±2)	5(±8)
Sitting slouched/relaxed	4(±4)	3(±3)	2(±5)	2(±2)	4(±3)	17(±11)	3(±2)	5(±8)
Quiet standing	2(±1)	1(±1)	3(±4)	5(±3)	4(±2)	5(±5)	3(±3)	11(±11)
Standing extended	3(±2)	2(±1)	12(±9)	6(±3)	5(±3)	11(±5)	4(±3)	7(±8)
Standing lateral bend, left	9(±10)	1(±2)	11(±8)	18(±14)	12(±7)	13(±7)	3(±2)	11(±13)
Standing lateral bend, right	6(±5)	1(±2)	19(±18)	18(±14)	25(±20)	14(±9)	3(±1)	8(±8)
Seated lateral bend moving left	2(±3)	1(±1)	21(±19)	7(±7)	7(±11)	13(±8)	4(±3)	6(±7)
Seated lateral bend, moving right	18(±12)	12(±2)	15(±26)	10(±7)	12(±7)	17(±20)	5(±4)	5(±8)
Upright	14(±9)	8(±4)	6(±4)	5(±3)	5(±5)	19(±23)	5(±3)	6(±8)

... 1998 "Quantitative intramuscular myoelectric activity of lumbar portions of psoas and the abdominal wall during a wide variety

Table 5.4 Subject Averages of EMG Activation Normalized to That Activity Observed During a Maximal Effort (100%)—Mean and (Standard Deviation in Parentheses)

Psoas channels, external oblique, internal oblique, and transverse abdominis are intramuscular electrodes while rectus abdominis, rectus femoris, and erector spinae are surface electrodes.

Task	Psoas 1	Psoas 2	EOi	IOi	TAi	RAs	RFs	ESs
Straight-leg sit-up	15(±12)	24(±7)	44(±9)	15(±15)	11(±9)	48(±18)	16(±10)	4(±3)
Bent-knee sit-up	17(±10)	28(±7)	43("12)	16(±14)	10(±7)	55(±16)	14(±7)	6(±9)
Press-heel sit-up	28(±23)	34(±18)	51(±14)	22(±14)	20(±13)	51(±20)	15(±12)	4(±3)
Bent-knee curl-up	7(±8)	10(±14)	19(±14)	14(±10)	12(±9)	62(±22)	8(±12)	6(±10)
Bent-knee leg raise	24(±15)	25(±8)	22(±7)	8(±9)	7(±6)	32(±20)	8(±5)	6(±8)
Straight-leg raise	35(±20)	33(±8)	26(±9)	9(±8)	6(±4)	37(±24)	23(±12)	7(±11)
Isom. hand-to-knee (left hand → right knee,	16(±16)	16(±8)	68(±14)	30(±28)	28(±19)	69(±18)	8(±7)	6(±4)
right hand → left knee)	56(±28)	58(±16)	53(±12)	48(±23)	44(±18)	74(±25)	42(±29)	5(±4)
Cross curl-up (right shoulder → across,	5(±3)	4(±4)	23(±20)	24(±14)	20(±11)	57(±22)	10(±19)	5(±8)
left shoulder → across)	5(±3)	5(±5)	24(±17)	21(±16)	15(±13)	58(±24)	12(±24)	5(±8)
Isom. side support (left side down)	21(±17)	12(±8)	43(±13)	36(±29)	39(±24)	22(±13)	11(±11)	24(±15)
Dyn. side support (left side down)	26(±18)	13(±5)	44(±16)	42(±24)	44(±33)	41(±20)	9(±7)	29(±17)
Push-up from feet	24(±19)	12(±5)	29(±12)	10(±14)	9(±9)	29(±10)	10(±7)	3(±4)
Push-up from knees	14(±11)	10(±7)	19(±10)	7(±9)	8(±8)	19(±11)	5(±3)	3(±4)
Lift light load (20 kg)	9(±10)	3(±4)	3(±3)	6(±7)	6(±5)	14(±21)	6(±5)	37(±13)
Lift heavy load (50-110 kg)	16(±18)	5(±6)	5(±4)	10(±11)	10(±9)	17(±23)	6(±5)	62(±12)

(continued)

(28)

Table 5.9 Individual Muscle and Passive Tissue Forces During Full Flexion and in a More Neutral Lumbar Posture Demonstrating the Shift from Muscle to Passive Tissue

The extensor moment with full lumbar flexion was 171 Nm producing 3145 N of compression and 954 N of anterior shear. The more neutral posture of 170 Nm produced 3490 N of compression and 269 N of shear.

	Fully flexed lumbar spine	Neutral lumbar spine
	Force (N)	Force (N)
Muscle		
R rectus abdominis	16	39
L rectus abdominis	16	62
R external oblique 1	10	68
L external oblique 1	10	40
R external oblique 2	7	62
L external oblique 2	7	31
R internal oblique 1	35	130
L internal oblique 1	35	102
R internal oblique 2	29	88
L internal oblique 2	29	116
R pars lumborum (L1)	21	253
L pars lumborum (L1)	21	285
R pars lumborum (L2)	27	281
L pars lumborum (L2)	27	317
R pars lumborum (L3)	31	327
L pars lumborum (L3)	31	333
R pars lumborum (L4)	32	402
L pars lumborum (L4)	32	355
R iliocostalis lumborum	58	100
L iliocostalis lumborum	58	137

(continued)

Table 5.9 *(continued)*

	Fully flexed lumbar spine	Neutral lumbar spine
	Force (N)	**Force (N)**
Muscle *(continued)*		
R longissimus thoracis	93	135
L longissimus thoracis	93	179
R quadratus lumborum	25	155
L quadratus lumborum	25	194
R latissimus dorsi (L5)	15	101
L latissimus dorsi (L5)	15	115
R multifidus 1	28	80
L multifidus 1	28	102
R multifidus 2	28	87
L multifidus 2	28	90
R psoas (L1)	25	61
L psoas (L1)	25	69
R psoas (L2)	25	62
L psoas (L2)	25	69
R psoas (L3)	25	62
L psoas (L3)	25	69
R psoas (L4)	25	61
L psoas (L4)	25	69
Ligament		
Anterior longitudinal	0	0
Posterior longitudinal	86	0
Ligamentum flavum	21	3

(31)

Table 5.9 ***(continued)***

	Fully flexed lumbar spine	Neutral lumbar spine
	Force (N)	**Force (N)**
Ligament *(continued)*		
R intertransverse	14	0
L intertransverse	14	0
R articular	74	0
L articular	74	0
R articular 2	103	0
L articular 2	103	0
Interspinous 1	301	0
Interspinous 2	345	0
Interspinous 3	298	0
Supraspinous	592	0
R lumbodorsal fascia	122	0
L lumbodorsal fascia	122	0

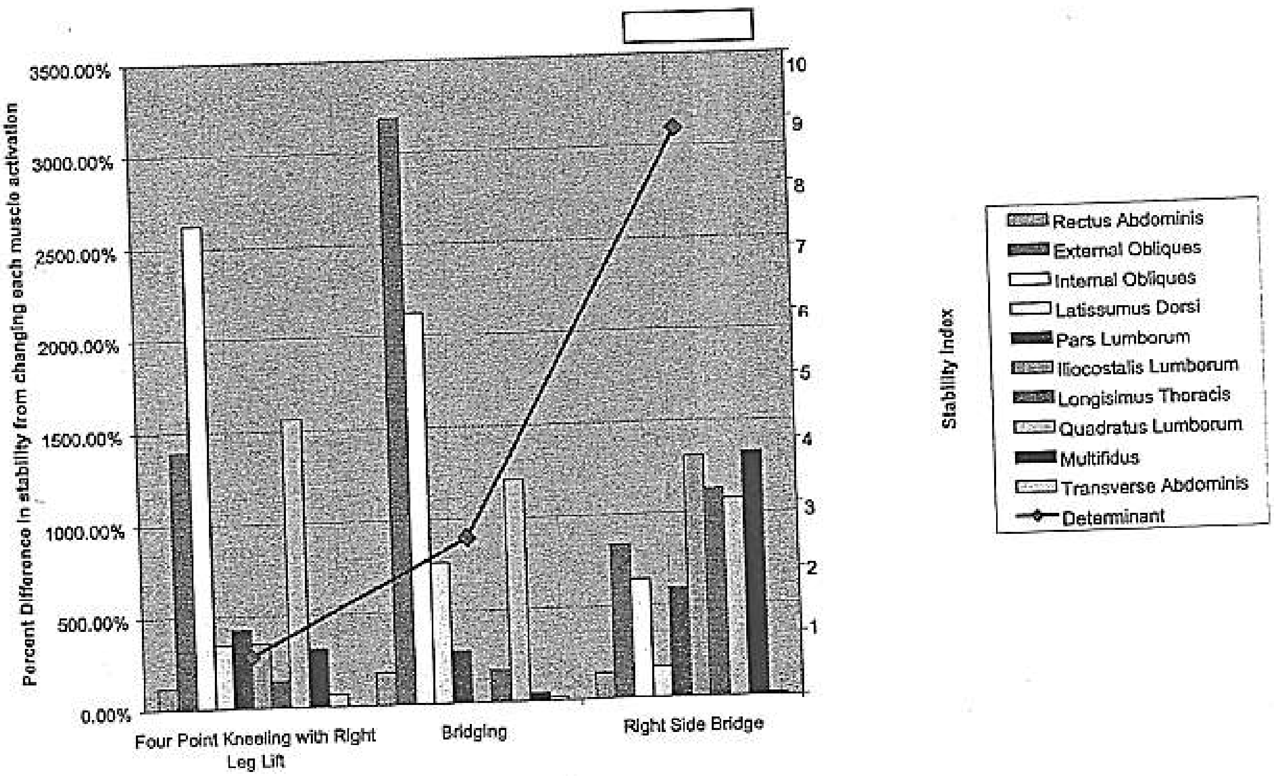
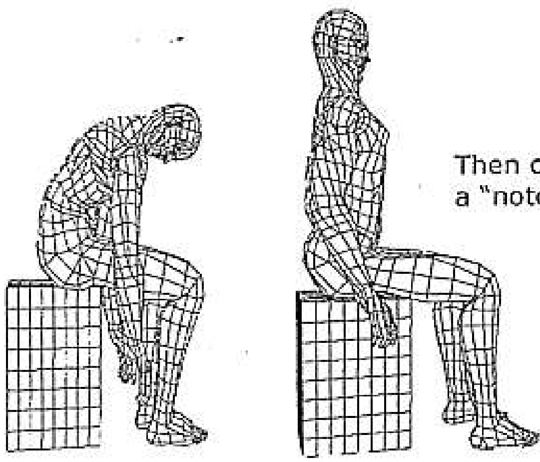


Figure 5.6 The contribution of some torso muscles to spine stability is shown in three exercises performed by a single person. The most important contributors continually change. In this individual, the four point kneeling and back bridge show that the obliques of the abdominal wall together with quadratus are most important. Changing the task increases the role of quadratus lumborum, latissumus dorsi, iliocostalis, longissimus and multifidus as seen in the side bridge exercise. Subtle shifts in posture and technique would change these relative contributions.

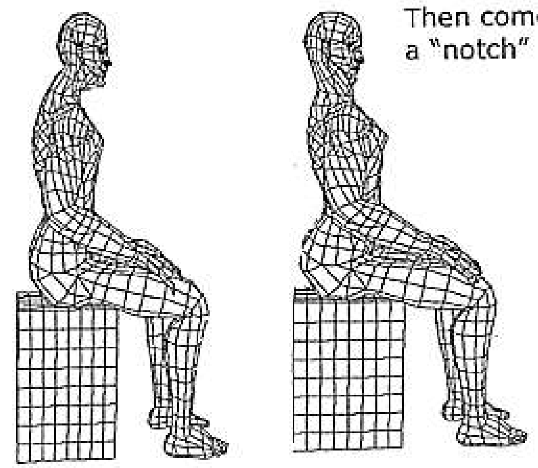
Posture

Establishing good posture is critical to stability and minimal muscle activity.

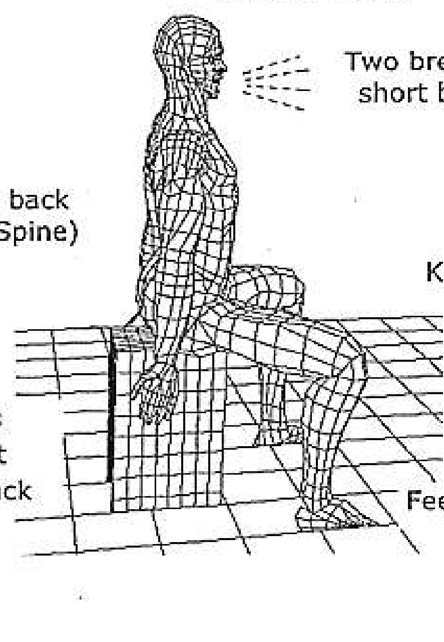
Neutral Spine
Slouch Over-Correct



Neutral Neck
Chin Poke Over-Correct



Brugger Relief Posture



Holds:__________ Rep:_____ Sets:_____ Times/day:_____ Times/wk:_____

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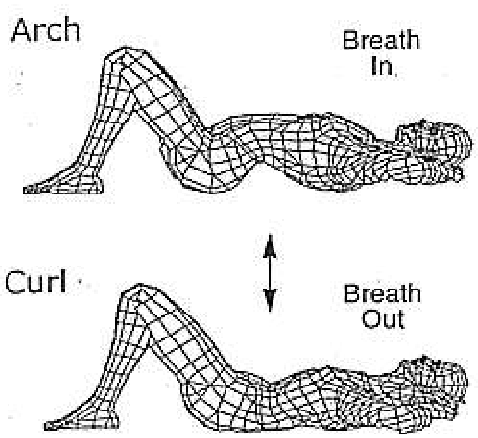
Spinal Mobility

Freedom of Full Spinal Movement

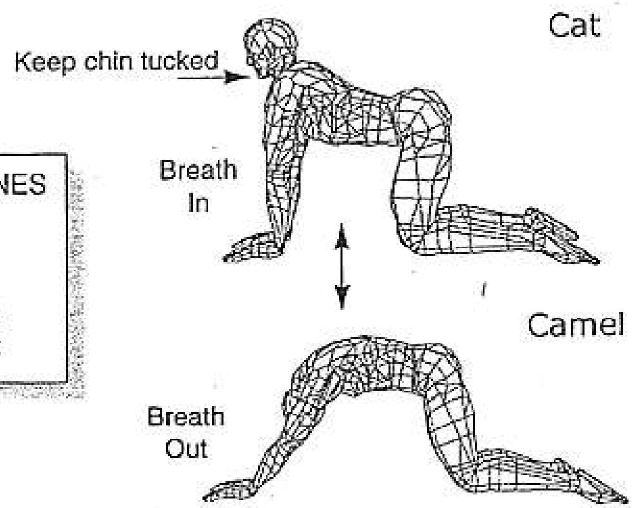
Arch and Curl

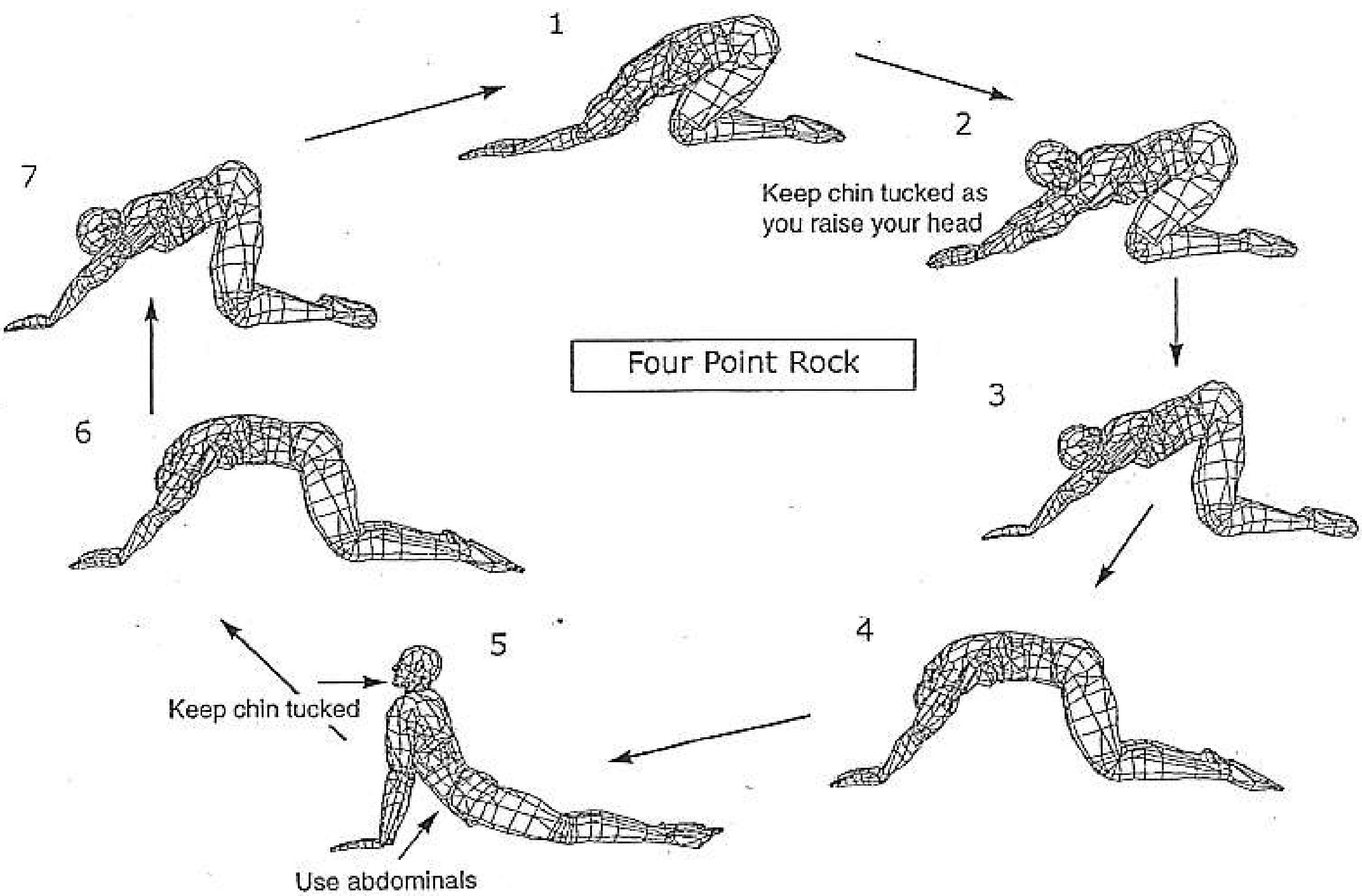


GUIDELINES

1. No Pain
2. Control:
   Smooth
   Straight

Cat/Camel





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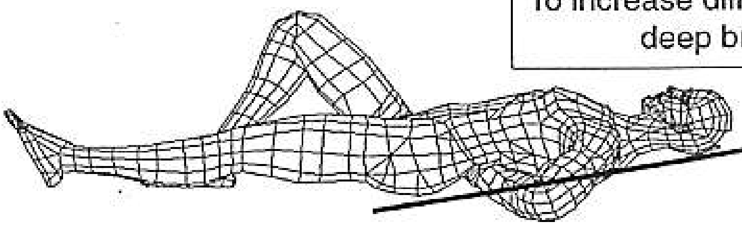
Curl-Up

Rectus Abdominus

Curl-Up On Floor-Level 1

To increase difficulty add two deep breaths

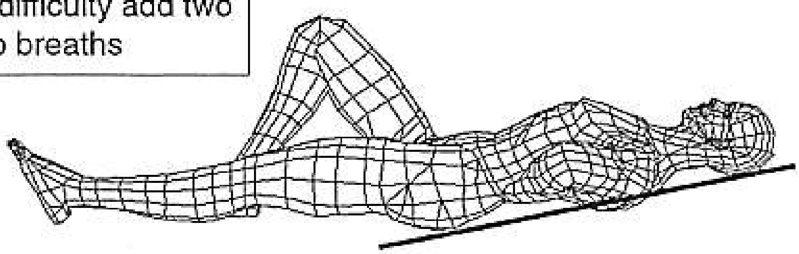


At All Times Maintain:

- Neutral Spine
- Abdominal Brace

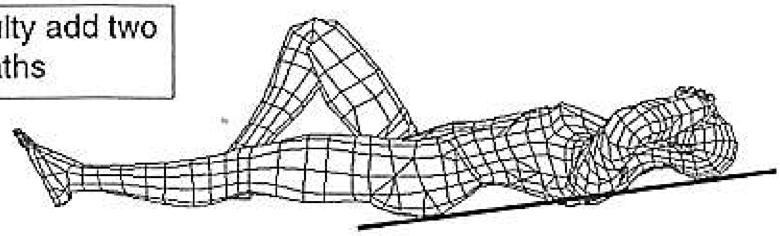
Curl-Up On Floor-Level 2

To increase difficulty add two deep breaths



Curl-Up On Floor-Level 3

To increase difficulty add two deep breaths



Holds:________________ Rep:______ Sets:______ Times/day:_______ Times/wk:_______

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The Curl-Up

Beginners

The curl-up technique is critical to spare the spine. The basic starting posture is supine with the hands supporting the lumbar region. Do not flatten the back to the floor, which takes the spine out of elastic equilibrium and raises the stresses in the passive tissues. While elastic equilibrium is desired in the lumbar region, the hands can be adjusted to minimize pain if needed. One leg is bent with the knee flexed to 90° while the other leg remains relaxed on the floor. This adds further torque to the pelvis to prevent the lumbar spine from flattening to the floor. The focus of the rotation is in the thoracic spine; many tend to flex the cervical spine, which is poor technique. Rather, picture the head and neck as rigid block on the thoracic spine. Individuals who report neck discomfort may try isometric exercises for the neck. In addition, particularly for patients experiencing neck discomfort, the tongue should be placed on the roof of the mouth behind the front teeth, and pushed upwards activation the digastric muscles, which help to promote stabilizing neck muscle patterns. Leave the elbows on the floor while elevating the head and shoulders a short distance off the floor. The tendency for many is to rise up too far. The rotation is focused in the mid-thoracic, or mid sternum region. The head/neck is locked onto the rib cage. No cervical motion should occur – either chin poking or chin tucking. The intention is to activate rectus and not to produce spine motion.

Advanced-

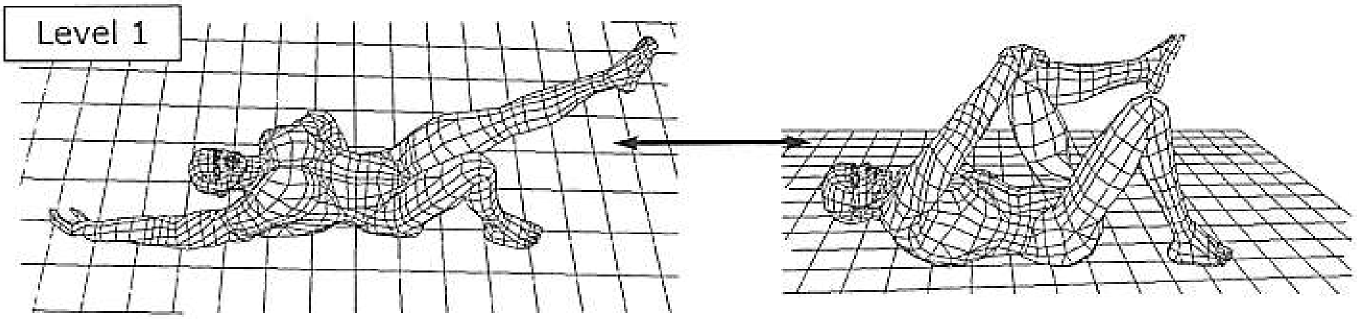
Even the most serious athletes can increase the challenge of the curl-up to ultimate training levels. First the entire abdominal wall performs a pre-brace. It is simply maximally activated – neither sucked in or blown out. The secret is to curl (slightly) against the abdominal brace in such a way that the large resistance is provided by the activated abdominals – not by raising any higher from the floor. I have had some of the heavy pro athletes unable to master this curl-up. Some will perform a variation of an advanced curl-up where the hands are placed beside the head (never behind the head) as long as lumbar posture is controlled and no pressure is applied to the head by the hands.
Note: The head and neck must move as a unit, maintaining their rigid-block position on the thoracic spine. But is emphasized again that the resistance comes form curling against the heavy abdominal pre-brace. This makes the exercise as challenging as the athlete wishes.

McGill S. Ultimate Back Fitness and Performance. Human Kinetics, 2004

Dying Bug

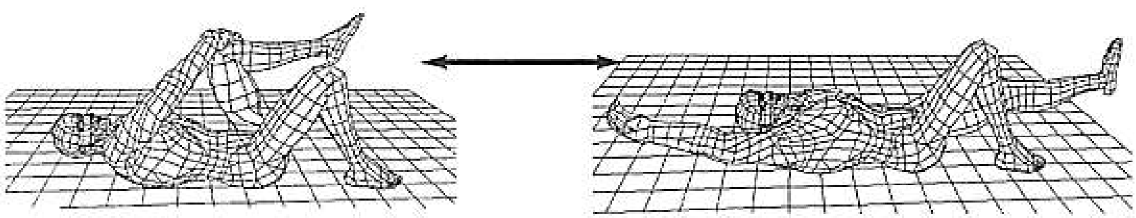
Rectus Abdominus, Core Stability

Level 1

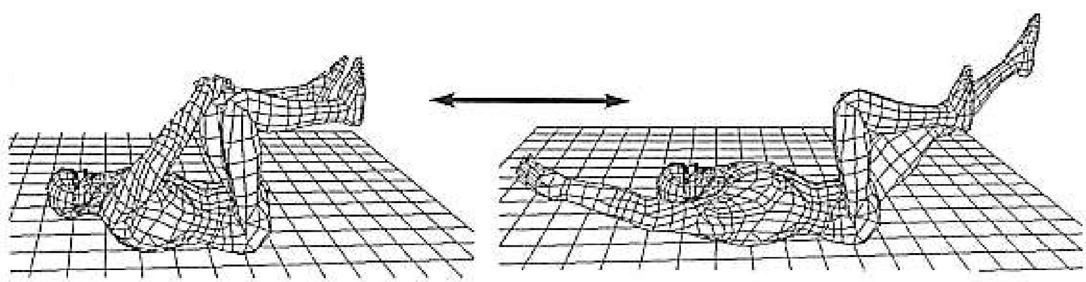


1. Depressing the lower rib cage facilitates the Rectus abd.
2. Place hand under the lumbar spine to preserve neutral.

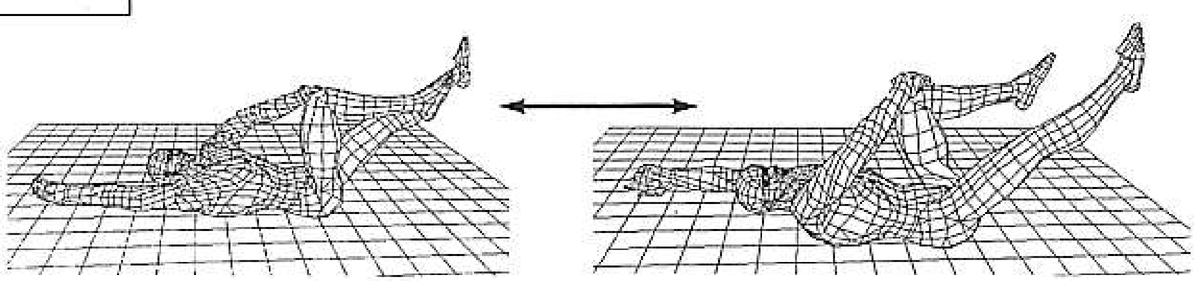
Level 2



Level 3



Level 4



Rep: ______ Sets: ______ Times/day: ______ Times/wk: ______

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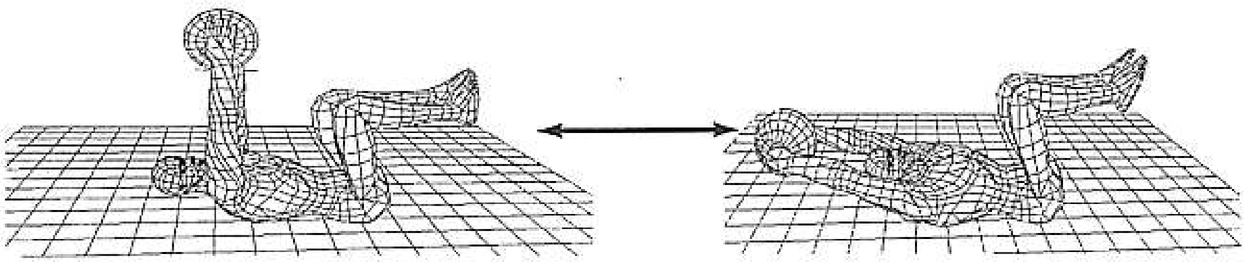
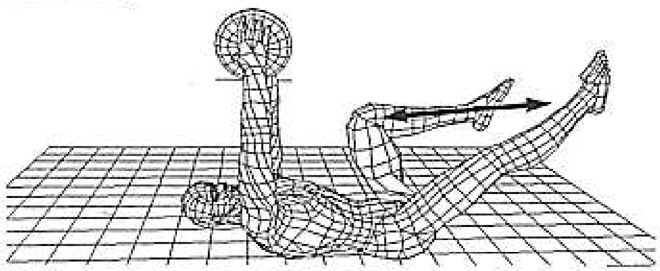
Dying Bug

Rectus Abdominus, Core Stability

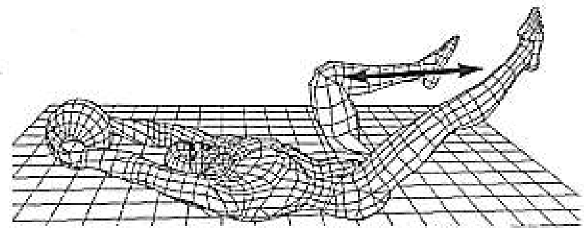
Level 5



Level 6.



Level 7



Rep:______ Sets:______Times/day:______ Times/wk:______

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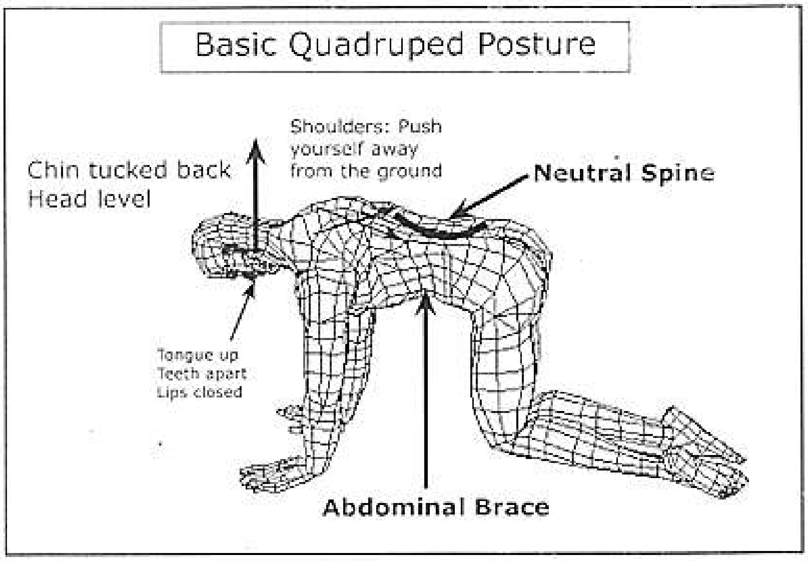
Birddog

lintrinsic muscles of the spine



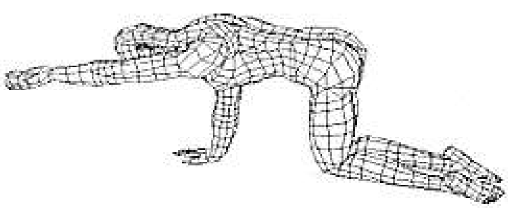
There should be no rocking of pelvis or loss of lordosis during any of the movements.

This is primarily an exercise for the trunk. However, neck and scapular stability can be concurrently trained if the above posture is observed: no droping between the shoulder blades or loss of neutral neck.

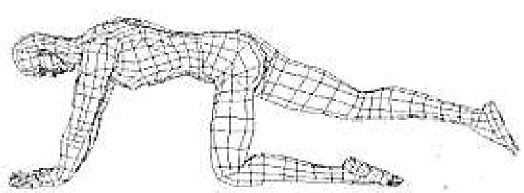
To develop endurance the swing is repeated up to 20 reps or until fatigue occurs.Then swith sides.

3 sets, twice a day.

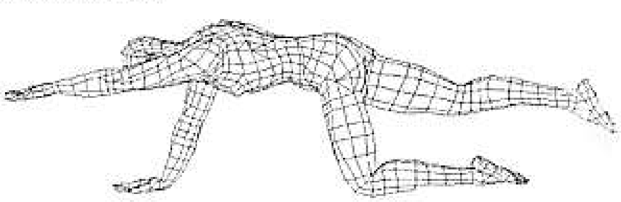
Remedial



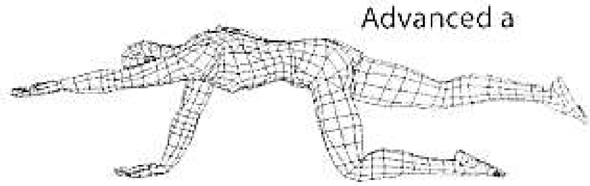
Beginner's



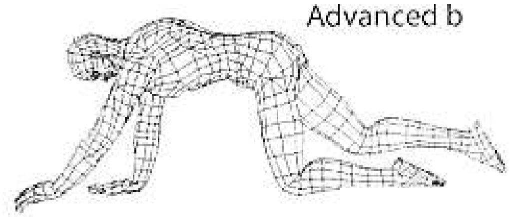
Intermediate



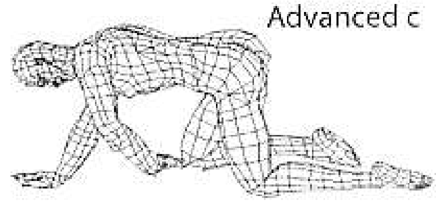
Advanced a



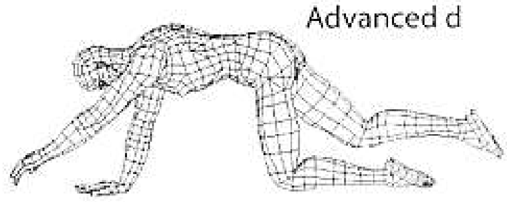
Advanced b



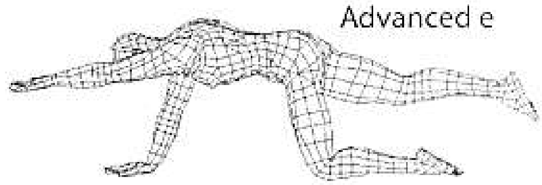
Advanced c



Advanced d



Advanced e



Position: ______________	Rep: ______	Sets: ______	Times/day: ______	Times/wk: ______

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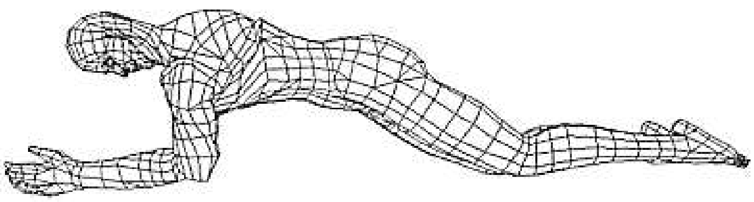
Prone Abdominal Brace

Rectus abdominis, Abdominal obliques, Transverse abdominis

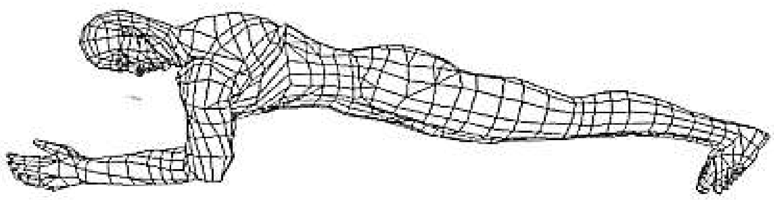


Prone abdominal brace on knees

Goal: 10 reps/2 forced slow breaths
Twice per day

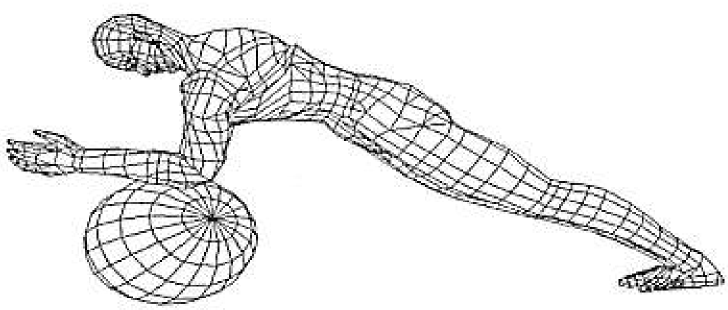
TEST TO MOVE TO NEXT LEVEL

3 reps of 30 sec holds
-- Without Shaking --



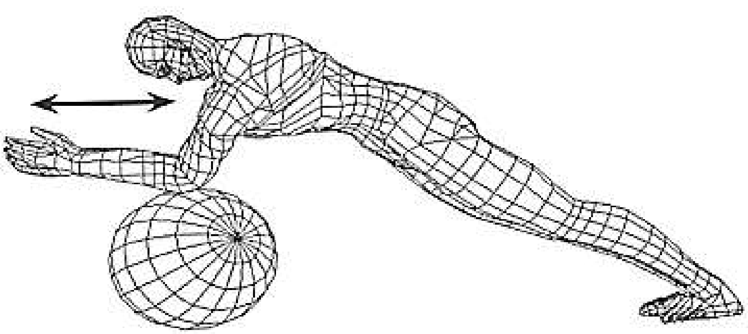
Prone abdominal brace on toes

Goal: 10 reps/2 forced slow breaths
Twice per day



Prone abdominal brace on ball

Goal: 10 reps/2 forced slow breaths
Twice per day

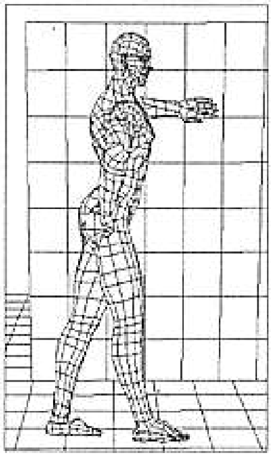


Prone abdominal brace on ball rolling forward and backwards (or around)

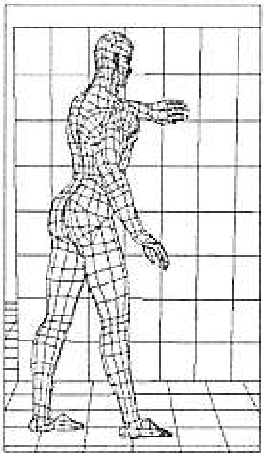
Goal: 10 reps/2 forced slow breaths
Twice per day

Side Bridge

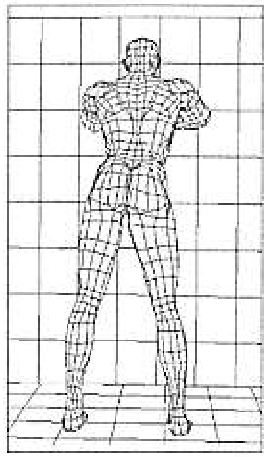
Quadratus lumborum, Abdominal obliques, Transverse abdominis



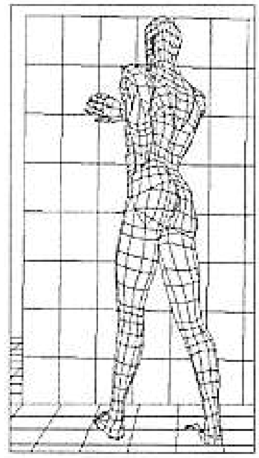
A



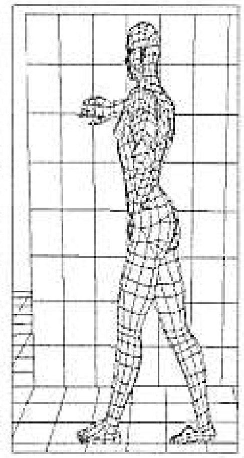
B



C

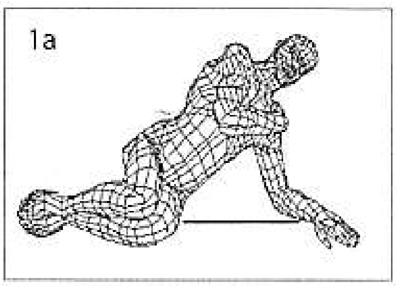


D

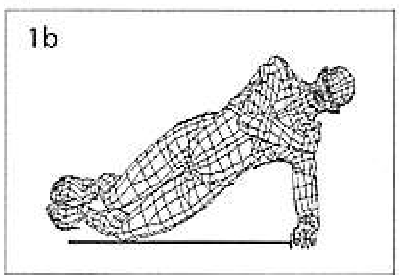


E

1a



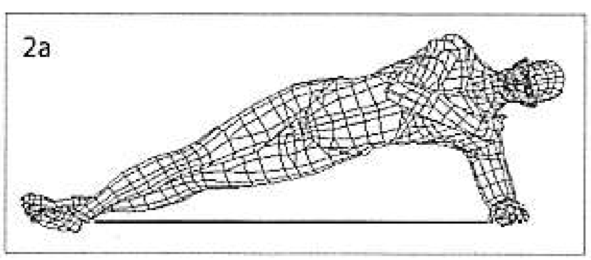
1b



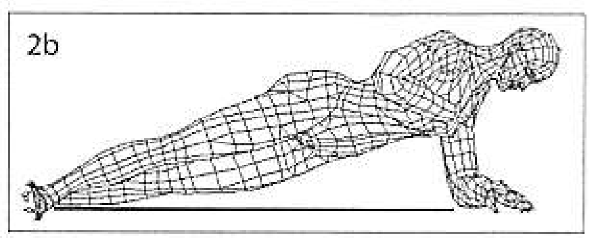
To build endurance you should hold the neutral position of this exercise.

Holds should be about 8 seconds (2 moderate breaths) with a touch-down between repetitions. After you are able to perform 10 repetitionswithout shaking move to the next level.

2a



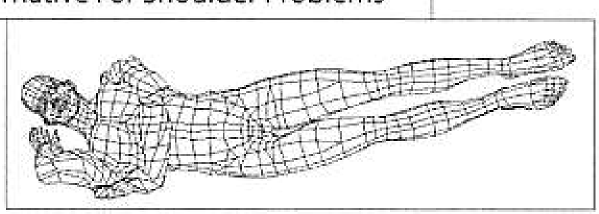
2b



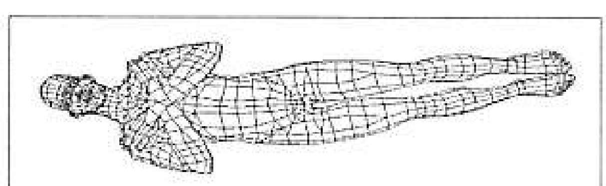
Your shoulder and hips should remain parallel throughout the twisting motion of this exercise.

Alternative For Shoulder Problems

A



B



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