WILLIAM E. MORGAN

TREATMENT OF THE WARRIOR ATHLETE

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Bethesda Spine Institute

Dear Chiropractors,

It is both an honor and a privilege to join you this weekend. In this manuscript, I've compiled selected writings from my work over many years. Many of these "chapters" were originally published in *Dynamic Chiropractic*, *ACA News*, or one of my books.

While the chapters in these notes do not follow the exact order of my presentation, they contain the majority of the information covered, organized in a way that should be more conducive to reading and reflection. I should note that these notes were created for my two day, 12 hour course on Treating the Warrior Athlete.

Please feel free to reach out to me if you need clarification or wish to discuss any of the concepts shared this weekend.

Note: These notes were written nearly a decade ago, and while the core principles remain relevant, some information may now be dated. For instance, not all experts today agree on the necessity of maintaining lordosis during squats. Similarly, our understanding of the deep spinal muscles and their functions continues to evolve with ongoing research. I encourage you to approach these materials with curiosity and a willingness to integrate new insights as they emerge.

With warm regards,

William E. Morgan

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Hallmarks of Excellence: What is the path to Clinical Mastery?

Hint: It is not CE

Continuing education may be replaced with a new model of life long growth: Continuing Development.

There is certainly a need to ensure that doctors remain competent and their knowledge current after graduation. But what is the best way to do this? In an attempt to ensure that doctors remain competent, and that they stay abreast of current trends and advancements, licensing boards began several decades ago to dictate a prescribed number of approved continuing education (CE) class hours. But the required CE, in the form of formal didactics, is often disjointed from clinical practice. CE is often a class taken by a doctor over the weekend with the hope that some of the new knowledge may be implemented into practice on Monday morning.

Built In, Not Bolted On

Continuing development (CD) or continuing professional development (CPD) by contrast is a system intent on developing several core competencies and engraining them into the practice of the physician. CD has a goal of changing behavior and improving clinical outcomes. CD is a journey that, if done correctly, will last a lifetime and will engage the physician to learn and grow on a daily basis.

You Can Lead a Horse to Water, but…

Regardless of the intent and implementation of a continuing development program, it will fall short of its goals if the individual doctors are not invested in the process. The motivation for professional development must come from within the individual doctor. We can encourage doctors to pursue CD and to honor its concepts, but ultimately the responsibility rests squarely on the shoulders of the physician. Rules and regulations will provoke a physician to obey the letter of the law, but cannot ensure total compliance.

Characteristics of successful lifelong learners in clinical practice include:

- The drive to be a master clinician and to provide excellent patient care
- The pride in the enduring value of professional competencies and scholarly growth
- The need to expand and grow in knowledge and clinical application

Continuing development requires the heartfelt desire to grow and blossom throughout a career. Doctors must embrace the concept of lifelong learning and be knowledge seekers.

This stands in contrast to passive learning. Passive learners sit in a classroom and are taught, they are directed what to read and what to study. They do what is required of them without seeking to learn more. Passive learners can be straight A students and may be difficult to differentiate from active knowledge seekers in the classroom setting. How can we inspire passive learners to become active knowledge seekers?

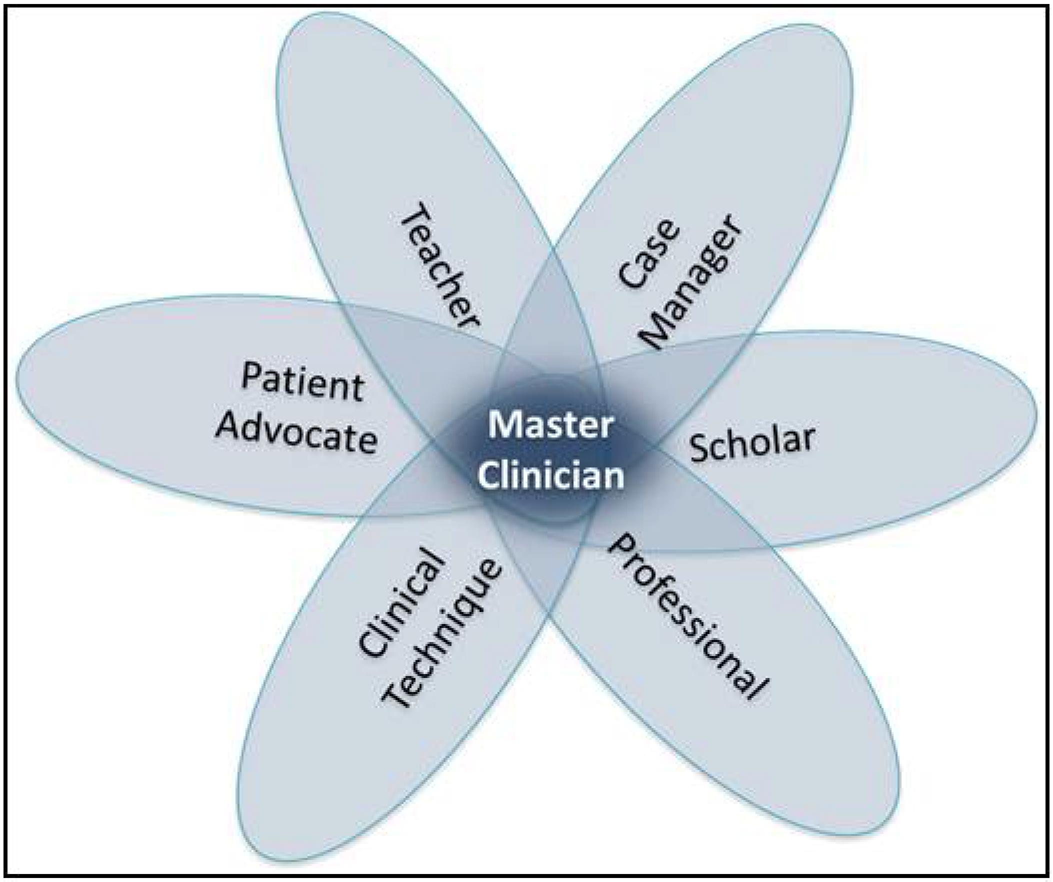

Figure 1. Combining a variety of core competencies into an organized framework of well-defined and attainable skills will empower the doctor to continually travel toward clinical mastery.

The Role of Chiropractic Colleges

Chiropractic colleges should use criteria to identify lifelong learners and actively attract and recruit these knowledge seekers. Colleges should also inspire students to continually seek knowledge rather than regurgitate lectures or board review material. They should introduce students to the tools that they will need to continue to learn and develop throughout their career. As students approach graduation, classroom-based didactics should be replaced with active clinical rotations which require students to seek knowledge while clinically active. This should translate to doctors in the field who continue to grow and learn daily through clinical encounters. Daily learning in the student clinic should be a model for daily learning throughout a chiropractor's career.

Continuing development has many benefits for the doctor, the patients, and society. The doctor benefits from career satisfaction, and patients benefit from superior healthcare. A doctor who is continually being challenged is less likely to suffer from burnout.

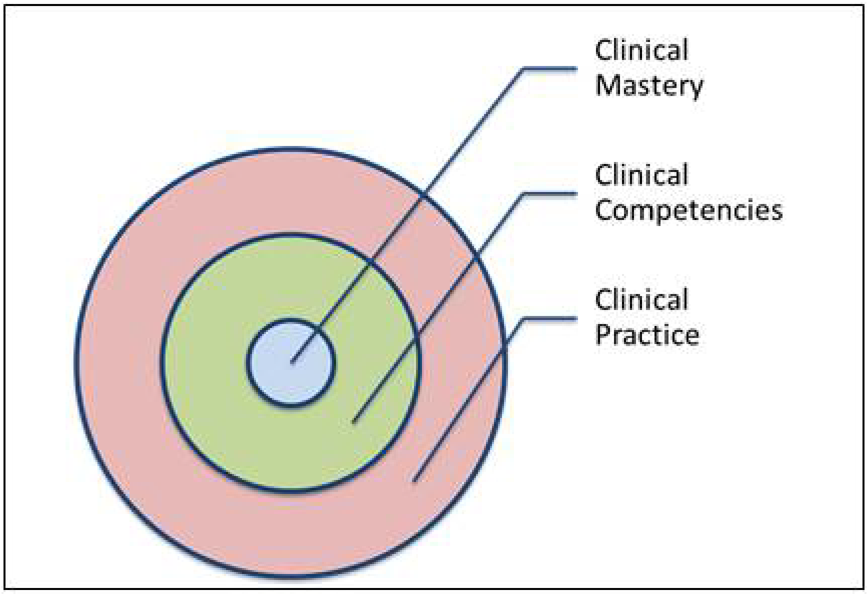

Figure 2. Clinical mastery requires that continuing clinical development resides not in separate silos of CE and clinical practice, but in an integration of competencies and mastery within the clinical practice.

The Role of Chiropractic Licensing Boards

Chiropractic licensing boards should embrace the new model of lifelong learning while modifying their policies to enhance it. However, these agencies cannot leave chiropractors to their own devices to maintain clinical competencies. The agencies and boards still need to maintain structure and accountability in their regulation of professional education and competencies. But there are ways that the boards can encourage larger goals and enhanced continuing professional development.

Many state boards are increasing the number of CE hours, but allowing more time to acquire those hours. This rewards those who seek diplomate status and certification programs. Instead of having twenty hours per year a state may require forty hours of CE every two years. This encourages doctors to pursue certifications or diplomates that may take multiple years to complete. Innovations like these reward doctors working toward larger professional goals. I should note that CE should be part of a larger plan of continual lifelong grow and development.

The Master Clinician

Those who know me well recognize that I value the pursuit of clinical mastery and that I often refer to the goal of becoming a *Master Clinician*, someone who is grounded in a variety of relevant core competencies. Continuing professional development is a conduit that can aid those seeking the life goal of growing into a *Master Clinician.*

The Cross-Fitness Craze: Ultra-fitness breakthrough or mega-injury nightmare?

This article is reproduced from the original publication in *Dynamic Chiropractic.*

By William E. Morgan, DC and Chris Feil, DC

If you have not yet been introduced to the new fitness phenomenon known as "cross-fitness training" (not to be confused with cross-training), you are one of only a few in the world of physical culture who have not. This trend is sweeping across the globe and revolutionizing the way we look at fitness. Cross-fitness is a counterculture movement that departs from the current entrenched fitness training model based mainly on power-lifting, body-building, and running conventions and lore. Cross-fitness shifts to a more diverse form of athleticism. Leading this change are several organizations, kettlebell promoters, sandbag fitness programs, cross-fitness videos and fitness boot camps. One cross-fitness organization has chapters worldwide and has become particularly popular with military service members.

Contrasting Methodologies

In the mainstream fitness world of body-builders, trainers, gyms, runners, and fitness magazines, there is an orthodoxy that prevails. This orthodox standard promotes static stretching, strength training based on muscle isolation, and aerobic fitness based on running, biking or walking slowly for 40 minutes, three to four times per week. Unquestionably, our mainstream fitness culture has been hijacked by the body-building training philosophy of muscle isolation, sets and repetitions.

Muscle isolation is when natural complex functional motion patterns are replaced by attempts to exercise individual muscles. Examples of isolated exercises include preacher curls, triceps extensions, leg extensions, leg curls, calf raises and lateral shoulder raises. The fitness industry for the most part has also bought into the concept of sets and reps for training isolated muscle groups.

This dominant fitness methodology stands in contrast to the current groundswell towards cross-fitness. In truth, we cannot train our muscles with isolated movements and then expect to have them respond synergistically with other muscles when athleticism is required.

McGill and Santana[1] demonstrated that a static horizontal exercise such as a bench press does not necessarily translate to increased power and performance in an upright athletic stance. Their research concluded that the limiting factor in power output in a standing one-arm cable press was the activation and neuromuscular coordination of torso muscles, not maximal muscle activation of the chest and shoulder muscles. This type of knowledge has led to a resurgence of training that emphasizes functional movements, such as Olympic lifting, gymnastics and kettlebell programs.

Cross-fitness uses compound exercises such as pull-ups, power cleans, plyometrics, agility drills, calisthenics, gymnastic training, medicine ball drills and even tractor tire flipping, to train muscles to work in composite, synchronized motor patterns. Compound exercises are used to emphasize functional movements and are intended to create coordinated athletic patterns of strength, agility and stamina. The workouts are designed to constantly challenge fitness with varying exercises, patterns of rest and resistance.

Maintaining Physiological Turbulence

The only routine in cross-fitness training is the lack of routine. The goal of most, if not all physical training programs is to increase fitness. This is done through progressive exercise programs that provoke adaptation of the individual's physiology. In orthodox programs, this adaptation is a slow progression through a routine of exercises. In the cross-fitness movement, gains are made by never performing the same workout twice in a row. Physiological confusion and turbulence ensure that the body never fully adapts to an exercise program - resulting, in theory, in increasing levels of fitness.

An Example "Workout of the Day" for Three Days
Day 1 For time: 1 mile run, 100 pull-ups, 200 push-ups, 300 squats, 1 mile run **Day 2** With a continuously running clock, do one 135-pound clean and jerk the first minute, two 135-pound clean and jerks the second minute, three 135-pound clean and jerks the third minute, and so on, continuing the progression as far as possible. **Day 3** Complete four rounds for time: 400-meter run, 15 handstand push-ups, 15 ft. rope climb (two ascents) *Source:* Crossfit.com, reproduced with permission.

Potential Concerns

With all of the benefits from cross-fitness training, what is the downside? As heard often in physical training, "This exercise is perfectly safe if you use proper technique. However, if improperly performed injury may occur." In cross-fitness culture, improper technique is the problem; in fact, it is rampant. When I observe cross-fitness devotees at the four gyms that I frequent (don't ask why I go to four gyms), I rarely see proper form by the trainers, let alone the layperson. Even when someone does understand the fundamentals of proper form, their form often degrades with exercise-induced fatigue.

For example, when performing sets of timed 50 kettlebell squats, it is common to see fatigue-induced degradation of proper form. The participants' gluteal muscles fatigue so they begin using any means to perform the exercise, including curling the spine in a manner that is potentially injurious to the lumbar disc.

If most cross-fitness devotees are receiving their instruction from an online video clip, it is unlikely they are receiving adequate instruction in proper form. To properly perform these exercises requires knowledgeable coaching, and there are not enough knowledgeable coaches right now to cover all of the groups performing this type of exercise program. We know how hard it is to train one person to perform a proper squat, or even the proper way to rise from a chair. How can we expect tens of thousands to learn form from online video instruction?

A more serious complication of performing any exercise program with too much rigor or without an adequate fitness base is rhabdomyolysis: the rapid breakdown of skeletal muscle resulting in the release of intracellular material into the plasma. The intracellular material is filtered by the kidneys, resulting in renal damage and, in some cases, death. While rare, exertion-induced rhabdomyolysis has been linked through the popular press to the cross-fitness trend. Statin drugs have also been attributed to onset of rhabdomyolysis, and the combination of overexertion and statin use has been linked to cases of rhabdomyolysis. It may be wise for patients taking statins to abstain from rigorous exercise such as cross-fitness programs.

Our Role as Chiropractors

In addition to treating the injuries incurred while performing cross-fitness programs, we should be well-versed in preventing injuries through teaching proper body mechanics. Future articles on this topic will address concepts of form and function for performing compound exercises and specific areas of focus for use of our manual skills, and also address the role of the core stabilizers in athleticism and exercise, the importance of the gluteal muscles, spinal mechanics, the mechanics of the shoulder in compound exercises.

Reference

1. Santana JC, Vera-Garcia FJ; McGill Stuart M. A kinetic and electromyographic comparison of the standing cable press and bench press. *Journal of Strength and Conditioning Research*, 2007;21(4):1271-7.

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense or the U.S. Government. This is the first in a series of articles addressing cross-fitness.

Cross-Fitness Injury Prevention: Protecting the Lumbar Disc in Squatting Motions

This article is reproduced from the original publication in Dynamic Chiropractic

By William E. Morgan, DC and Chris Feil, DC

Editor's note: This is the second in a continuing series on cross-fitness training. The first article appeared in the Sept. 9 issue.

With the rising number of people joining the cross-fitness movement and the lack of adequately trained coaches, there is a high likelihood that we will continue to experience an increase in cross-fitness-related injuries.

While the cross-fitness movement has many positive benefits and we do not want to discourage people from exercising, we need to be able to protect those interested in this increasingly popular exercise program.

Cross-fitness, as stated in our previous article, is based largely on the implementation of compound motion patterns that use groups of muscles, rather than isolated muscles. The workouts are varied and seek to maintain physiological confusion and turbulence to continually challenge participants' bodies to adapt to higher levels of fitness. A mainstay of these programs is squatting motions.

Our first article provided an overview of this fitness phenomenon. Now let's discuss some specific biomechanical considerations of the exercises commonly performed in cross-fitness training, with specific emphasis on the principles of protecting the lumbar disc while squatting.

Perfect Practice Makes Perfect; Practice Just Makes Permanent

Squatting is required to perform dozens of exercise variations used in cross-fitness programs: squats, dead-lifting, power cleans, clean and jerks, truck tire flipping, kettlebell presses, bends and thrusts (aka, burpees), lunge walking, box jumping, jumping lunge squats and more. These exercises are frequently performed rapidly while striving to execute a high number of repetitions as part of a timed workout. Exercising in this manner quickly fatigues the participants, increasing the likelihood of form degradation. This is usually manifested in flexion of the lumbar spine.

We know from Alf Nachemson's work[1] that curling the lumbar spine forward increases disc pressure, especially when lifting. We also know that lumbar flexion encourages migration of the nucleus pulposa posterior toward the spinal nerves (**Figure 1**). Maintenance of normal lumbar lordosis is protective for preventing disc injuries (**Figure 2**).

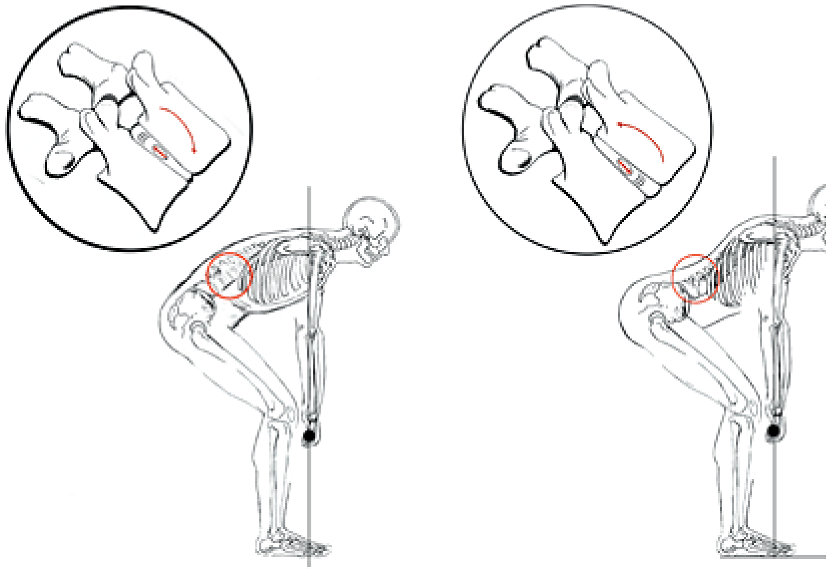

Figure 1 (left): This lifter curls their spine forward. This method of lifting causes the nucleus of the disc to migrate posterior, increasing the likelihood of a lumbar disc derangement. This method of lifting is dangerous and should be avoided. **Figure 2 (right)**: Maintenance of a normal lumbar lordosis when squatting is protective for preventing disc injuries. Note that this lifter bends forward pivoting only at the hips, not the spine. In this manner, forward truncal flexion can safely take place and lumbar disc injury is avoided.

It is important to maintain the lumber spine in lordosis whenever squatting or bending. The lower you bend, the more likely you are to flex the spine. The more you flex your spine, the more likely you are to sustain a disc injury. Truck tire flipping and sandbag lifting, both of which are popular cross-fitness exercises, require squatting deep enough to allow the back of your hand to reach the ground prior to lifting. This is more dangerous than dead-lifting a barbell that is 10-12 inches above the floor. Rapid tire flipping while competing against a stopwatch further increases the likelihood of injury.

Proper squatting technique will reduce the likelihood of spine injury. The primary components of a proper squat include: maintaining lumbar lordosis, proper hip motion, gluteal activation, and core stiffening. These are all integral parts of the squatting motion and are difficult to tease out into individual components. For the sake of clarity, we will address each component in separate articles while alluding to the other components.

It is our contention that before anyone begins a cross-fitness program, they should know how to perform a proper squatting motion, and have practiced it enough times to establish an enduring neurological "groove" - a neurological motor pattern that has been practiced to the point of becoming the dominant sequence of motion for a particular action. In regards to neurologic motor patterns, practice does not make perfect. *Perfect practice makes perfect*. Practice just makes permanent.

Cross-fitness aspirants should practice proper squatting to the point that they virtually cannot squat wrong. Only after a safe squatting groove is established should a participant progress to more advanced programs.

The Proper Squat

Begin by locking the lumbar spine into natural lordosis while standing with your feet slightly wider than shoulder-width apart and your toes turned out slightly. The chest should be held out and the abdominal muscles stiffened. Continue to hold the lumbar spine in a stiff lordosis and use the movement of your hips to lower your body. Your buttocks should travel inferior and posterior as you squat.

Figure 3: An effective method to enforce proper squatting technique is the use of a rod held against the spine as a proprioceptive feedback tool. If the subject varies from proper technique, they will feel their back change positions in relation to the rod. It cannot be emphasized enough that hip motion is more important than spine motion when it comes to protecting the lumbar spine. Virtually all lumbopelvic motion of squatting should come from the hips. As you descend and ascend during the squat, attempt to engage your gluteal muscles by maintaining a constant low-level contraction of external rotation of the hips. (We will discuss gluteal activation more fully in a subsequent article.)

An effective method to enforce proper squatting technique is the use of a rod held against the spine as a proprioceptive feedback tool (**Figure 3**). If the subject varies from proper technique, they will feel their back change positions in relation to the rod. When done correctly, the spine will maintain the same contact with the rod throughout the entire squatting motion and the hips will do virtually all of the movement.

In addition to proper technique, it is important to identify the most hazardous time of day to challenge the lumbar discs. Due to the diurnal effects of disc hydration, discs hydrate at night and lose hydration throughout the weight-bearing hours of the day; discs are larger and more prone to injury in the early morning. For this reason, we recommend that strenuous activities such as rigorous squatting exercises be avoided for the first 1 1/2 hours after rising.

Components of Proper Squatting

Stiffen the core muscles.
Maintain a lumbar lordosis.
Use your hips, not your spine.
Activate the gluteal muscles.

Whether you are an 85-year-old woman with osteoporosis or the most avid cross-fitness devotee, proper squatting technique is important. Learning how to squat safely should be part of virtually every patient's program of spinal hygiene. Squatting is not just an exercise; it is an integral part of human existence and is important for independent living. (One of the factors that will compel the elderly or infirmed to relocate into an assisted living community is the inability to squat onto a commode or to rise from it.) Aside from helping cross-fitness enthusiasts, your increased knowledge of the technicalities of squatting motions should help virtually all of your patients enjoy healthier and more fulfilling lives.

Reference

1. Nachemson AL. In vivo discometry in lumbar discs with irregular nucleograms. *Acta Orthop Scand*, 1965;36;426.

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Core Stiffness and Cross Fitness: Without the Stiffness There Is No Fitness

This article is reproduced from the original publication in *Dynamic Chiropractic*.

By William E. Morgan, DC and Chris Feil, DC

The rising tide of cross-fitness popularity, for all of its potential fitness benefits, has the potential to cause a tsunami of lumbar spine injures if improperly implemented. In this third installment in our series on cross-fitness, let's discuss the importance of core muscle activation during cross-fitness exercise. Much has been written about the role of the core muscles in protecting the spine from injury in recent years, but this information is taking too long to trickle down to the gyms and cross-fitness clubs around the world. Properly engaging the core can enhance athleticism and reduce the risk of injury when performing rigorous exercise.

The Core

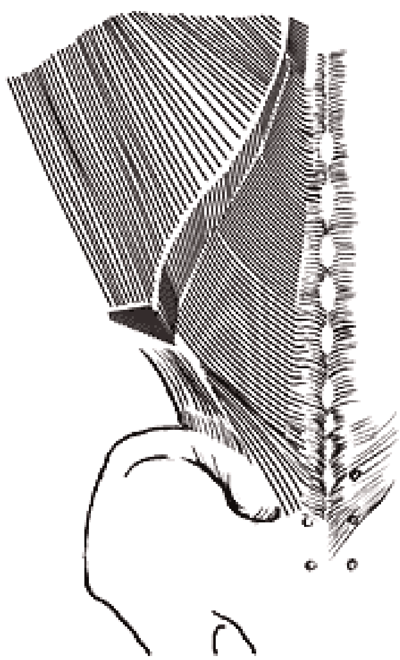

Figure 1: The posterior/superficial fibers of the thoracolumbar fascia angle up and away from the spine. Though these fibers are continuous with the latissimus dorsi, they are connected to the transverse abdominis (TrA) through the lateral raphe (based on Bogduk11). The term *core* is bantered about in all corners of the health and fitness industry, yet to most people who use this word it remains a vague, almost nebulous description of supportive stomach and back muscles. We would like to solidify the term and provide a workable definition of the core, at least as we currently understand the term: *The core muscles are the truncal muscles that support and stabilize the torso, protect the spine, and allow power transfer through the torso*.

The core includes global stabilization muscles such as the transverse abdominis (TrA), the internal oblique (IO), and external oblique (EO); and intersegmental stabilizers such as the multifidus muscles.1 Since the list of muscles composing the core is a moving target depending on authorship, we would rather concentrate on core function than try to generate a composite list of the core muscles. However, certain muscles are central to any discussion of the core: the TrA, OI, OE, multifidus, rectus abdominis (RA), quadratus lumborum (QL), and the muscles of the erector spinae. Some would add the iliopsoas, latissimus dorsi, gluteal muscles, hip adductors, and hamstrings to this list.

The individual muscles of the core are each capable of contributing to several different functions, and no function is isolated to an individual muscle. The core is a complex and integrated network of muscles that work in synchrony to support the torso with stiffness and strength. It is impractical to try to isolate the function of individual muscles such as the TrA. In fact, when the core muscles stiffen in concert, their total strength surpasses the sum of the individual muscles.

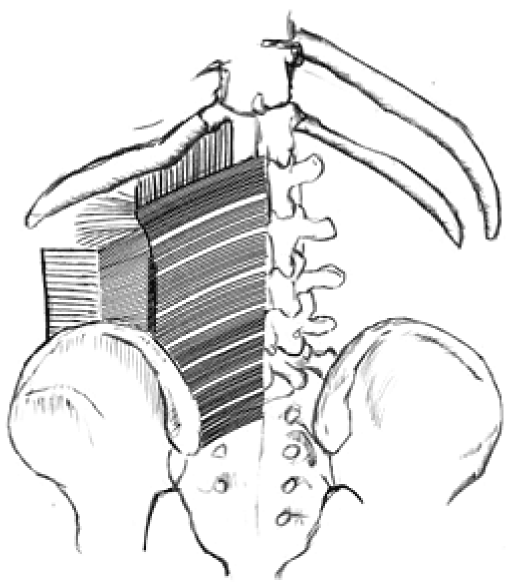

Figure 2: The anterior/deeper fibers of the thoracolumbar fascia angle downward and away from the spine from L2- L5. They are also connected to the TrA and the internal oblique (IO) by means of the lateral raphe (based on Bogduk11). In recent years, there has been a movement afoot that promotes abdominal hollowing,[1] pulling in the abdominal muscles in an attempt to isolate the TrA and indirectly activate the multifidus muscles. Stuart McGill, PhD, has found that *core bracing* is superior to abdominal hollowing in regards to protecting the spine from injury. Vera-Garcia (with McGill as a co-author) found that hollowing actually inhibits the multifidus' response to perturbation,[2] actually reducing core stabilization.

Your Internal Weight-Lifting Belt

Weight-training belts are no longer the rage they once were and their use is ebbing in most of the realm of physical culture. This is due in part to the knowledge that weight-lifting belts are not necessary. One study revealed that the advantage in using belts may come from perceived rather than actual protection and performance enhancement.[3] Belts essentially increase the amount that lifters are *willing* to lift. Belts interfere with the natural intrinsic stabilization of the trunk without substantial benefit and should generally be avoided.[4-9]

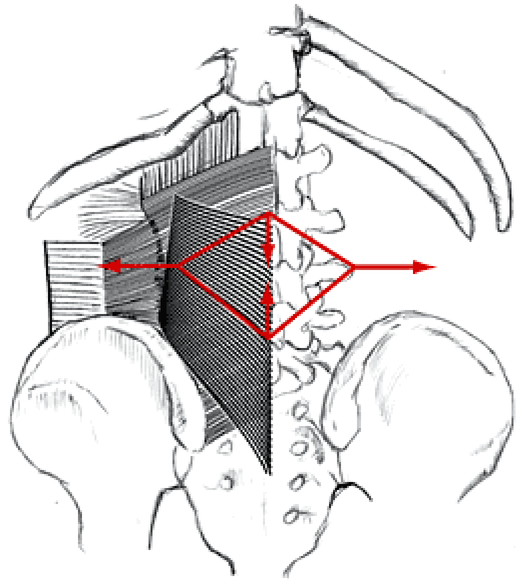

Figure 3: When the TrA and IO contract, the anterior and posterior layers of the thoracolumbar fascia are pulled taut, approximating the spinous processes [from L2-L5], and a stiffening effect takes place (based on Bogduk11). We each possess a natural, built-in weight belt that is activated by the muscles of the core. Your intrinsic stabilization corset consists of a combination of the TrA and the thoracolumbar fascia. The posterior layer of the thoracolumbar fascia angles up away from the spine (**Figure 1**), whereas the anterior layer of the thoracolumbar fascia angles down and away from the spine (**Figure 2**). They both are joined to the TrA by the lateral raphe. So, when the TrA stiffens, the contraction produces a Poisson's effect,[10] which causes the spinous processes to approximate in a protective manner (**Figures 3 and 4**).[11]

A collateral benefit of TrA contraction is activation of the multifidus muscle.[12] The multifidus provides intersegmental stabilization through its stiffening effect, but is difficult to contract voluntarily. Together, the global and intersegmental stabilizers protect the spine from excessive shear and torsional forces.[13]

Bracing the Core with Muscular Stiffness

Learning to brace the core is an important component in protecting the spine and enhancing athletic performance. While many athletes intuitively brace their core during athletic exertion, others require training. It takes only a few minutes to learn how to coax the core muscles into a protective stiffened brace, but may take months to imbed a permanent neurological groove of bracing into a particular athletic motion pattern.

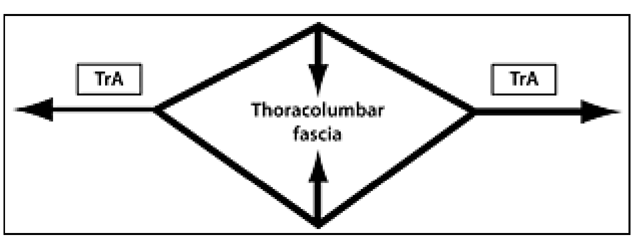

Figure 4: This schematic amplifies the concept of Poisson's effect. The contraction of the transverse and oblique abdominal muscles pulls on the lateral raphe, which produces a mild approximating tension of the lumbar spinous processes. Begin in a relaxed standing posture; place the fingertips of one hand on the lumbar paraspinal muscles just to the side of the spinous processes. The other hand

should be positioned on the abdominal muscles at the level of the ASIS. Bend at the waist until you feel the muscles of your lower back contract under the fingers on your back. Note how this feels and then arch your spine until the spinal muscles relax under your fingers. While maintaining this position, stiffen the abdominal muscles as if you were about to be punched in the gut. You should feel your spinal muscles contract like they did when you bent over at the waist. Note how this feels with both hands. Practice engaging these muscles until it takes little conscious effort.

If bracing in this manner aggravates a spinal condition, reduce the degree of abdominal contraction. Maximal stiffness is not required. Practice in the range of 10 percent to 25 percent of maximal stiffening. Stiffening should accompany strenuous athletic exertion. When establishing neurological groove patterns for compound motor patterns, make sure to include bracing. For squatting motions, stiffen the core throughout the entire motion, even when no weight is used.

A dilemma that often accompanies core stiffening exercises is interference with diaphragmatic breathing. When first learning to stiffen the core, consciously engage in diaphragmatic breathing until it becomes routine. Once core bracing and diaphragmatic breathing are mastered, they should be practiced or rehearsed while in exertion-induced respiratory distress until it becomes natural. Practice performing cardiovascular interval training while concentrating on core bracing and diaphragmatic breathing. In time, these two activities will be imbedded in your neurology to the point of not requiring conscious intercession.

Core Stiffness Is Fundamental to Cross Fitness

Core bracing fits into one of the creeds of the cross-fitness movement*:* integration of compound motion patterns rather than muscle isolation. A properly functioning and reactive core is required for high levels of athleticism whether you are an elite athlete, a cross-fitness devotee, or even an average weekend golfer. Certainly cross-fitness injuries will be curtailed if athletes maintain proper form and utilize core bracing when performing athletic activities such as squatting, tire flipping, dead-lifting, plyometric jumping drills, kettlebell drills and agility drills. If our patients are going to engage in cross-fitness programs, it is our duty to prepare them properly through treatment, prevention and education.

References

1. Richardson C, Jull G, et al. *Therapeutic Exercise for Spinal Segmental Stabilization in Low Back Pain*. Churchill Livingstone, Edinburgh, 1999:22-25.
2. Vera-Garcia FJ, Elvira JL, Brown SH, McGill SM. Effects of abdominal stabilization maneuvers on the control of spine motion and stability against sudden trunk perturbations. *J Electromyogr Kinesiol,* 2006 Sep 20;17(5):556-67.
3. McCoy MA, Congleton JJ, Johnston WL, Jiang BC. The role of lifting belts in manual lifting. *Int J Ind Ergonomics,* 1988;2:259-266.
4. Majkowski GR, Jovag BW, Taylor BT, Taylor MS, Allison SC Stetts DM, Clayton RL. The effect of back belt use on isometric lifting force and fatigue of the lumbar paraspinal muscles. *Spine*, 1998;23(19):2104-2109.
5. National Institute for Occupational Safety and Health. *Workplace Use of Back Belts: Review and Recommendations*. Rockville, MD: Department of Health and Human Services (National Institute of Occupational Safety and Health), Publication No. 94-122, 1994.

6. Mitchell LV, Lawler FH, Bowen D, Mote W Asundi P, Purswell J. Effectiveness and cost-effectiveness of employer-issued back belts in areas of high risk for back injury. *J Occup Med*, 1994 Jan;36(1):90-94.
7. Thomas JS, Lavender SA, Corcos DM, Andersson GB. Effect of lifting belts on trunk muscle activation during a suddenly applied load. *Hum Factors*, 1999 Dec;41(4):670-6.
8. Reyna JR, Leggett SH, Kenny K, Holmes B, Mooney V. The effect of lumbar belts on isolated lumbar muscle strength and dynamic capacity. *Spine*, 1995;20(1)68-73.
9. McGill SM, Norman RW, Sharratt MT. The effect of an abdominal belt on trunk muscle activity and intra-abdominal pressure during squat lifts. *Ergonomics*, 1990 Feb;33(2):147-60.
10. See www.ecourses.ou.edu/cgi-bin/view_anime.cgi?file=m1421.swf&course=me&chap_sec=01.4
11. Bogduk N. *Clinical Anatomy of the Lumbar Spine and Sacrum, 3rd Edition*. Churchill Livingstone, Edinburgh, 2001.
12. Hides JA, Jull GA, Richardson CA. Long-term effects of specific stabilizing exercises for first-episode low back pain. *Spine*, 2001;26*:*E243-8.
13. Moseley GL, Hodges PW, Gandevia SC. Deep & superficial fibers of lumbar multifidus are differentially active during voluntary arm movements. *Spine*, 2002;27(2):E29-36.

Functional Integrity of the Pelvis & Hips: Gluteal Activation Enhances Athleticism and Injury Prevention

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By Chris Feil, DC and William E. Morgan, DC

For most athletes, success is largely dependent on optimal functioning of the gluteal muscles (gluteus maximus, medius and minimus), and functional integrity of the hips and pelvis. Unfortunately, functional training and evaluation is not well-understood by many practitioners and athletes. Appropriate gluteal activation and pelvic-hip control is not only important to the rising number of cross-fitness devotees for generating maximal athletic power; it is also important to virtually every chiropractic patient. In addition to generating athletic power, proper hip function is valuable in the prevention of injuries to the knees, hips, pelvis and lower back. The cross-fitness activities of squatting, cleans, kettlebell swings, tire flipping, medicine ball tossing, and sprinting are all multi-joint movements that require hip involvement. Let's discuss methods to maximize proper hip motion and form during these activities.

Many in modern society have what Stuart McGill, PhD, calls "gluteal amnesia."[1] Dr. McGill has identified that when athletes [or any of us] lose the ability to engage our hips during athletic activities or exercises (such as cross-fitness programs), this adversely affects performance and increases the likelihood of injury. What Dr. McGill calls "gluteal amnesia," we might identify as loss of functional hip integrity: essentially the loss of the normal volitional ability to move one's hips through their range of motion with appropriate muscle activation.

In addition to muscular inhibitions, other factors that may contribute to motion dysfunctions are soft-tissue contractures or restrictions and articular fixations. While chiropractic adjustments may directly affect these restrictive lesions, knowledge of gluteal activation is also required to teach patients how to properly activate these muscles.

Function of the Gluteus Maximus

The gluteus maximus (GM) is the largest muscle of the body, and it is the major driver in lifting, throwing, swinging, pushing and running (particularly when sprinting and running hills). The GM originates at the crest of the pelvis, the dorsal sacral ligament, along with some fibers that originate from the thoracodorsal fascia. The [distal] insertions attach to the femur and to the iliotibial band. The GM helps stabilize the sacroiliac (SI) joints by causing *force closure*, essentially forming a self-bracing, protective compressive force to maintain the alignment and reduce shear forces on the SI joint. The GM attachment to the sacral ligaments may aid in pelvic stability due to active ligament tightening by gluteal contraction.[2]

The late professor Vladimir Janda associated decreased GM control in his theory of lower cross syndrome.[3-4] This muscle imbalance is associated with the pelvic posture variation called *anterior* *pelvic tilt.* Observing anterior pelvic tilt during a postural examination of a patient should provoke you to further screen for gluteal dysfunction.

The gluteal muscles are the primary extensors of the hip, but hip extension is only part of their role in true athletic function. The muscle fibers of the GM are oriented diagonally, sloping laterally and caudally from their origin. With this orientation, the GM muscles contribute to external rotation and abduction of the thigh. Both hip extension and thigh external rotation are the "concentric" motions of the GM muscle.

It is important to remember that muscles have two contractile functions: concentric contractions (muscle shortening) and eccentric contractions (muscle lengthening). Eccentric muscle contraction is actually more powerful and more efficient than concentric contractions. The eccentric function of the GM muscle will limit and control hip flexion and thigh internal rotation.

Because of its fiber orientation, the GM serves as a primary muscular shock absorber for the hip and knee joint. Just as the hydraulic shock compresses and dampens the load in a car, the GM dissipates the forces in the athletic movements of jumping, landing, and lateral agility motions by eccentrically absorbing forces and limiting movements endangering joints of the lower extremities.[5] The link between GM dysfunction and uncontrolled valgus and internal rotation motions of the knee has particular clinical significance and will be discussed in greater detail in an upcoming article.

Tremendous loads can be transmitted through the acetabulofemoral joint if the force is not dampened by the adjacent muscles. This shock absorption function is important to understand in a culture in which so many degenerative hip disorders occur. As many desk-bound workers with inadequate GM control participate in cross-fitness programs, they are unknowingly placing themselves at greater risk for osteoarthritis in their hips.

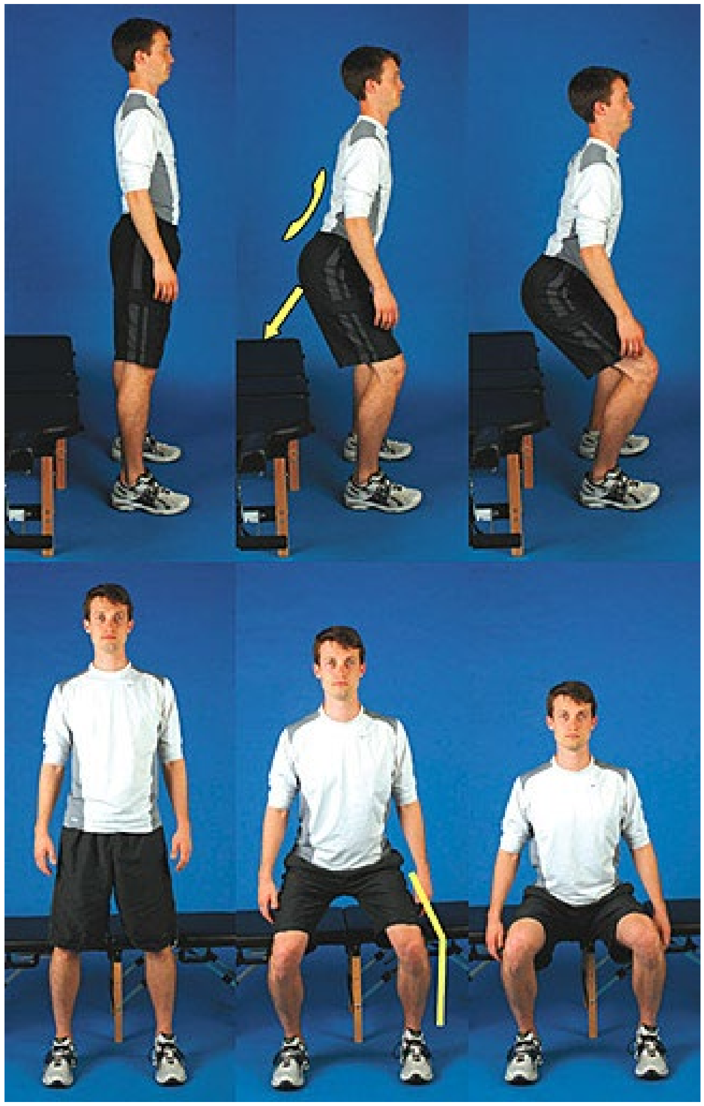

Figure 1: Squat Functional Screen: Passing**.** Normal lumbar lordosis, posterior travel of hips, varus knee position, and limited anterior travel of knees. Initiating Movement at the Hip and GM Activation

Elite power-lifters are able to squat more than 1,000 lbs. injury-free through very purposeful activation of the GM and maximizing hip motion with the hip hinge.[6] The term *hip hinge* refers to truncal motion in which the lumbar spine is fixed in a neutral lordosis and all motion occurs at the acetabular joint, not the spine.

An ideal squat begins by securing the toes and heels firmly on the floor. The lumbar spine should be fixed or "locked" into a neutral lordosis throughout the squatting motion. While descending, the buttocks should travel back and down; using a stool, gym ball, or chair as a target may be beneficial in learning this motion pattern. A wide stance is preferred, and the participant should be mindful not to allow the knees to travel forward.

Purposely engage the GM throughout the squatting motion both during decent and ascent; the use of an elastic exercise band around the thighs will help the patient to consciously engage the GM. The ascent phase of a squat reverses the motion groove of the descent phase. It should also be noted that the patient needs to stiffen the core during hip hinges and squatting

The Squat as a Functional Screen for Gluteal Activation

Inspecting a patient's ability to squat is a practical method for clinical screening of the lumbo-pelvic-femur chain. While the patient performs repetitive squatting motions, analyze the three main components of gluteal involvement: hip extension, flexion and external rotation.

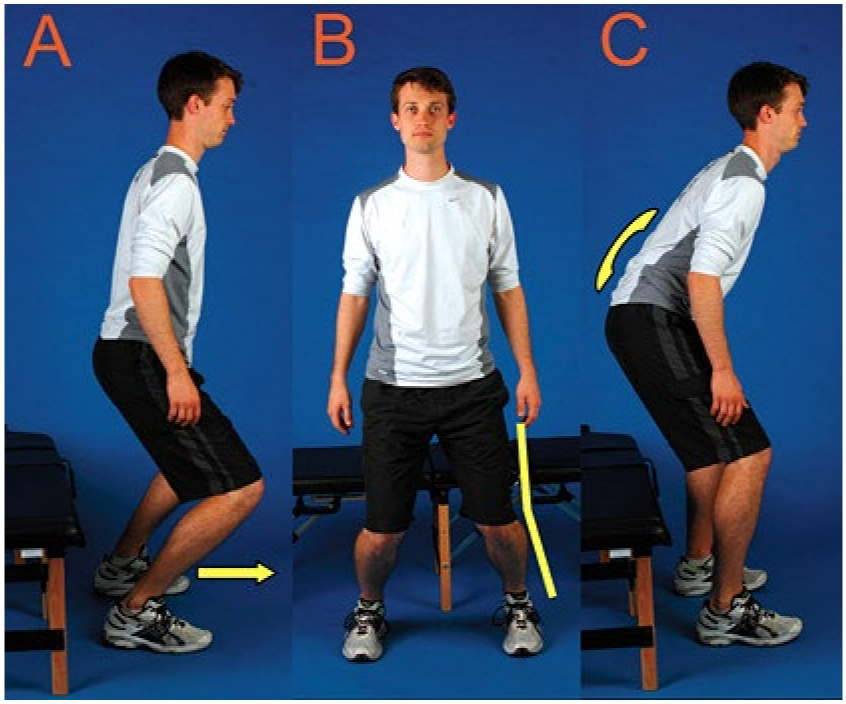

Figure 2: Squat Functional Screen - Failures. Anterior knee travel, valgus knee position, and loss of lumbar lordosis.

A key point in assessment is the initiation of hip movement before knee flexion or ankle dorsiflexion. The knee should remain in a varus position throughout the squatting motion. The lumbar lordosis should remain unchanged during the entire squat. (**Figure 1**) Early anterior knee translation (**Figure 2a**), a valgus knee angle (**Figure 2b**), and a flexed lumbar spine (**Figure 2c**) are failures for the squat functional screen.

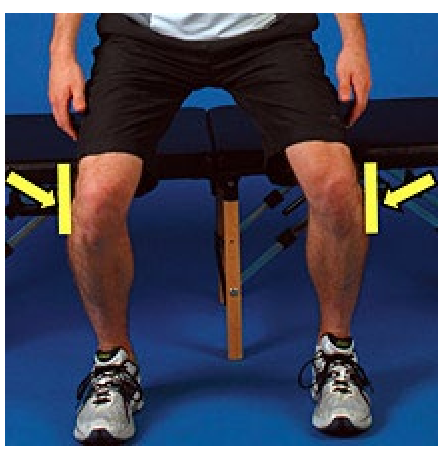

Figure 3: Squat Functional Screen - Palpation**.** The clinician provides challenge by applying medially directed pressure on the knees while the patient performs a squat. The examiner should palpate the GM for activation throughout the movement of both ascending and descending phases of the squat. In

addition to palpating the GM, activation of the gluteus maximus can be tested by applying medial pressure to the knees. If the GM is engaged the examiner will note springy, firm resistance. With proper GM function, it should be difficult for the examiner to push the squatter's knee into a valgus position. (**Figure 3**) With practice and patience, you will be able to identify motion defects and provide precise recommendations for improving motion patterns.

Athletes performing cross-fitness feats of strength, agility, and endurance with functional impairments can expect to have reduced levels of performance and increased occurrences of injury and infirmity. Gluteal activation and properly functioning hip mechanics are fundamental components of proper motion and maximized athletic performance. Cross-fitness devotees with impaired gluteal/hip function can expect diminished performances and increased risk of injury. An astute clinician should be able to observe a cross-fitness athlete's squat and discern gluteal function and activity, correcting those at risk before injury occurs.

References

1. McGill S. *Low Lack Disorders: Evidence-Based Prevention and Rehabilitation, 2nd Edition*. Champaign: Human Kinetics, 2007:110-112.
2. Wilson J, et al. A structured review of the role of gluteus maximus in rehabilitation. *New Zealand Journal of Physiotherapy*, 2005;33(3):95-100.
3. Bullock-Saxton JE, Janda V, Bullock MI. Reflex activation of gluteal muscles in walking. *Spine*, 1993;18(6):704-8.
4. Morris CE, Chaitow L, Janda V. Functional Examination for Low Back Syndromes. In: Morris C. *Low Back Syndromes: Integrated Clinical Management*. McGraw-Hill, 2006:347.
5. Boling MC, Padua DA, Creighton RA. Concentric and eccentric torque of the hip musculature in individuals with and without patellofemoral pain. *Journal of Athletic Training*, 2009;44(1):7-13.
6. Liebenson C. The hip hinge. *Journal of Bodywork and Movement Therapies*, 2003;7:151-152.

The Importance of the Thoracic Spine in Shoulder Mechanics

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By Chris Feil, DC and William E. Morgan, DC

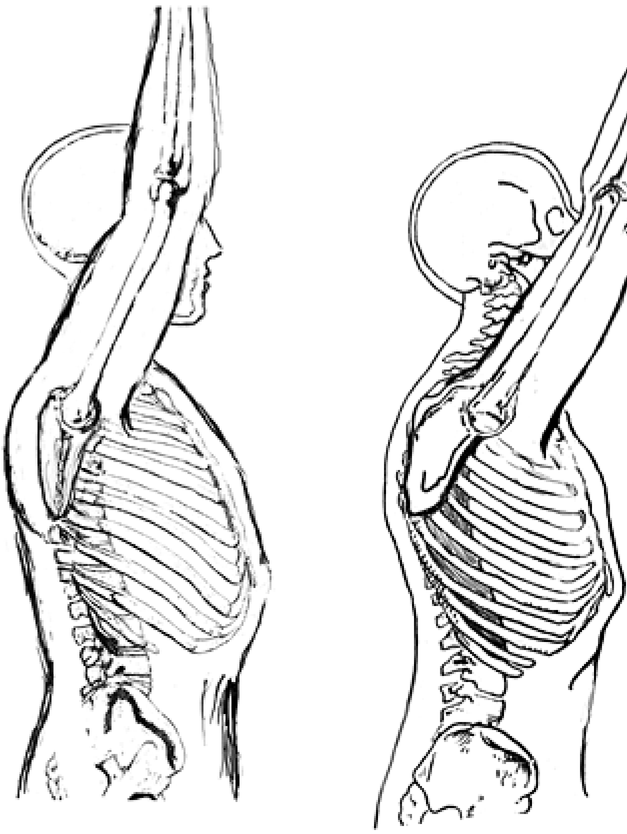
As discussed in previous articles in this series, cross-fitness programs tend to advocate exercises that require maximal shoulder end-range motions: pull-ups (often with a kip or a jerk motion at end range), handstand presses, press squats, push-presses, clean and presses, kettlebell overhead lifting, gymnastic ring work and other similar exercises.

To perform these motions without injury requires unfettered shoulder range of motion and optimum shoulder stability. While an argument may be made that these exercises help to create coordinated athletic patterns of strength, agility, and stamina, they still have a strong potential for causing shoulder injuries. Often not included in the explanation of the workout of the day in cross-fitness programs is the need for the participant to have flawless shoulder mechanics and strength.

Impingement of the rotator cuff muscle (supraspinatus) develops when the space between the rigid coracoacromial arch and the head of the humerus narrows. The muscles and tendons of the cuff that pass through this space begin to fray and eventually may tear because they are pinched between these hard surfaces. Why does this space narrow? Anatomically, it narrows due to bony spurs, degenerative changes, or soft-tissue thickening. Functionally, the space narrows due to dysfunctional synchronicity of the rotator cuff muscles, aberrant scapular-humeral rhythm, or faulty scapular positioning during overhead arm movements.

To maintain the subacromial space in an overhead arm movement, the scapula must retract and tilt posterior.[7] A shortened pectoralis minor will cause the scapula to tilt anterior, contributing to a functional shoulder impingement. A study conducted at Ohio State University found that subjects with tight and short pectoralis minor muscles displayed similar scapular kinematics as individuals with shoulder impingements.[1] Scapular retraction is affected by the mobility of the thoracic spine and rib cage upon which it glides.[9]

Thoracic Spine Mechanics and Shoulder Pain



Normal scapular and thoracic spine motion allows optimal mechanics for athletic shoulder motions (left). Increased thoracic kyphosis, reduced thoracic mobility, or scapular protraction from pectoralis minor tautness can contribute to shoulder impairment and injury (right). The concept of scapulo-humeral rhythm is well-documented,[4,7] and the rhythm is fundamental to maintaining the subacromial space. The long-accepted linear ratio of scapular rotation to arm motion in adduction is 1:2,[2] though the true interaction of the scapula and arm is not linear, but more curvilinear in nature.8 There is very little scapular rotation in the first 60 degrees of arm abduction, and then the scapula progressively begins to rotate as the arm travels to a full overhead position.[4]

Normal thoracic-humeral rhythm is important for injury prevention. Thoracic mobility becomes increasingly important in athletic overhead activities. The higher an athlete raises their arm, the more thoracic motion is needed from the thoracic spine to maintain the proper relative shoulder alignment. Individuals with a shoulder impingement have statistically less thoracic mobility and a more kyphotic thoracic spinal posture than individuals with healthy shoulders.[3,6-7] A few weeks of cross-fitness training with a rigid thoracic spine could lead to injury and impairment of the rotator cuff.

Does T4 Syndrome Exist?

T4 syndrome has been accepted as fact by many clinicians over the past decade, in spite of a lack of evidence to support its existence. The theory of T4 syndrome attributes many of the problems seen in shoulders to a loss in the normal extension that takes place at the T4 vertebra.[5] We should note that T4 syndrome has also been credited with causing diffuse arm, shoulder, and torso pain and sensory symptoms.

A review of the literature review did not find research substantiating association of the T4 syndrome to shoulder function. However, we did find a boatload of seminar notes elevating the "T4 syndrome" to a height not supported by the current body of research. T4 syndrome is based on clinical antidotal experience rather than scientific evidence. While there is no substantial evidence that T4 syndrome directly relates to shoulder impingement, there is some current research pointing to the lower thoracic spine as being a fundamental component of shoulder motion.[4]

If accurate, this research suggests that the majority of thoracic extension occurs in the lower thoracic spine during overhead arm movement in asymptomatic shoulders, especially with both arms in an elevated position, as is seen in an overhead squat or overhead press.

In the same study, upper thoracic extension was present in full overhead arm motion, but it was not deemed to be a significant variable in shoulder function.[4] However, what the study did find statistically significant in the upper thoracic spine was lateral bending and ipsilateral rotation during single-arm elevation. Theodoridis and Ruston also found this repeatable relationship of overhead arm movement causing an ipsilateral coupling pattern between lateral flexion and rotation, which was repeatable and comparable for both arm elevation planes in healthy subjects.[11]

Thoracic Joint Manipulation

It appears that simply assessing T4 extension in a cross-fitness athlete may miss significant dysfunctions in the thoracic spine that affect the thoracic-humeral rhythm. For example, optimal shoulder function in a single-arm kettelbell swing may be improved by use of manual therapy when specifically addressing lateral bend and rotation components of the upper thoracic spine and any loss of extension in the lower mid-thoracic spine.

Thoracic joint manipulation might be the simplest answer to reducing pain in an impinged shoulder. In a 2009 study by Strunce and colleagues, a thoracic spinal manipulative thrust was performed on a sample of 56 individuals with symptomatic shoulders from impingement. After two days, there was a significant decrease in pain levels in over 50 percent of individuals.[10]

Before giving a list of boring rotator-cuff strengthening exercises to a cross-fitness athlete who is performing fun, dynamic exercises in their daily workouts, remember that a key component to overhead arm motion is thoracic mobility. When the alignment of the shoulder and the subacromial space is compromised from the loss of thoracic spine mobility and/or muscle tightness, it doesn't matter what tension of rehab exercise band is used until the underlying cause of impingement is addressed. Evaluation and appropriate treatment of the spine should be considered when shoulder dysfunction is present.

The cross-fitness emphasis on pull-ups and overhead lifting may produce a glut of shoulder injuries from otherwise dormant thoracic and shoulder impairments. By recognizing the functional relationship between the thoracic spine and the shoulder joints, we can help athletes remain active and pain-free as they engage in their preferred activities.

References

1. Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. *Journal of Orthopedic Sports Physical Therapy*, 2005;4:227-238.

2. Codman EA. *The Shoulder; Rupture of the Supraspinatus Tendon and Other Lesions in or About the Subacromial Bursa*. Thomas Todd, Boston, 1934.
3. Crawford HJ, Jull GA. The influence of thoracic posture and movement on range of arm elevation. *Physiotherapy Theory and Practice*, 1993;9:143-148.
4. Crosbie J, Kilbreath SL, Hollmann L, York S. Scapulohumeral rhythm and associated spinal motion. *Clinical Biomechanics*, 2008;23:184-192.
5. DeFranca GG, Levine LJ. The T4 syndrome. *Journal of Manipulative and Physiological Therapeutics*, 1995;1:34-37.
6. Greenfield B, et al. Posture in patients with shoulder overuse injuries and healthy individuals. *Journal of Orthopedic Sports Physical Therapy*, 1995;5:287-295.
7. Kibler BW. The role of the scapula in athletic shoulder function. *The American Journal of Sports Medicine*, 1998;26:325-337.
8. McClure PW, Michener LA, Sennett BJ, Karduna AR. Direct 3-dimensional measurement of scapular kinematics during dynamic movements in vivo. *Journal of Shoulder and Elbow Surgery*, 2001;10:269-277.
9. Stewart S, Jull GA, Ng, JKF, Willems JM. An initial analysis of thoracic spine movement during unilateral arm elevation. *Journal of Manual & Manipulative Therapy*, 1995;3:15-20.
10. Strunce J, et al. The immediate effects of thoracic spine and rib manipulation on subjects with primary complaints of shoulder pain. *Journal of Manual & Manipulative Therapy*, 2009;17:230-236.
11. Theodoridis D, Ruston S. The effect of shoulder movements on thoracic spine 3D motion. *Clinical Biomechanics*, 2002;17:418-421.

The Dangers of Extreme Exertion

(This is an excerpt from a book soon to be published: *Hero Workouts*)

Rhabdomyolysis

Extreme physical exertion can result in severe illness, permanent impairment, organ failure, and death. Exceptional metabolic injuries can occur in the young and old, as well as in very fit individuals. While there are many potential causes of exertional injury (heart failure, stress fractures, heat stroke, acute dehydration, kidney failure, compartment syndrome, and stroke), this chapter will focus on a condition known as rhabdomyolysis or ”rhabdo” as it is often referred to for short.

Rhabdomyolysis is a condition characterized by muscle breakdown which releases the intercellular components of muscle cells into the blood stream (where they do not belong). One of those components, myoglobin, is particularly damaging to the kidneys and will result in dark urine. The kidneys are designed to filter small substances from the blood stream. However, the contents of these damaged muscle cells are relatively large and will clog the kidneys which can result in devastating illness and death. Liver damage has also been cited as a result of overexertion.

Sudden increases in physical exercise can result in the muscle breakdown that causes rhabdomyolysis. While swimming, running, calisthenics, football, soccer, and virtually any kind of fitness endeavor can cause rhabdomyolysis, high intensity workouts that combine weights, gymnastics, running, and calisthenics in timed events are particularly risky.

Athletes who may be fit and high performers in conventional fitness programs might find that their particular type of fitness does not translate to the type of fitness that is found in special operational workouts or in cross-fitness centers. Being a good swimmer, runner, and weightlifter can give athletes a false sense of security and tempt them to jump into an exercise program for which they are not prepared. No one, no matter how fit they believe themselves to be, should radically change their workout program. Gradual changes over time will allow the body to adapt to new stresses. Maintaining adequate hydration and resting sufficiently between workouts are also protective measures that will help prevent rhabdomyolysis.

Being fit has its own risk factors. Someone who is competitive and fit may be inclined to jump into a new workout program with vigor. To adapt to the demands of a new program or training methodology (like performing workouts for time or as many repetitions as possible) may take several weeks or months depending on your level of fitness. The danger with those who are fit, proud, and competitive is that they will ignore warnings and over-train. Additionally, those who have a history of high levels of fitness, but have let their fitness wane, may attempt to jump back into a fitness program at the same level of exertion as they had once attained.

The Signs and Symptoms of Rhabdomyolysis

- Muscle pain (which may be severe)
- Dark urine
- Confusion
- Fever
- Rapid pulse
- Nausea
- Vomiting
- Abdominal pain
- Swelling
- Weakness
- Loss of consciousness
- Kidney failure and the inability to urinate

Steps to Prevent Rhabdomyolysis

1. Get medical approval before beginning any exercise program. Be honest with your physician when explaining the type of program you intend to pursue.
2. Stay hydrated. Drink plenty of water.
3. Gradually add high intensity components to your workouts over weeks and months.
4. Rest between high intensity workouts. Mingle light workouts and days of total rest between days with rigorous workouts.
5. Do not perform high intensity workouts if you are taking statins, antipsychotics, or other drugs that have been linked to causing rhabdomyolysis.
6. Receive professional coaching from a certified health and fitness expert.

Take Action if Someone has Signs of Rhabdomyolysis

Anyone showing signs of rhabdomyolysis needs to hydrate and get to an emergency room as soon as possible.

Other Causes of Rhabdomyolysis

- The use and abuse of drugs and alcohol
- Crush injuries to muscles
- Excessive or prolonged muscle compression
- Seizures
- Infections (both viral and bacterial)
- Hyperthermia (high body temperature)
- Muscular dystrophy

- Electrical shock

Exertion injuries are real and dangerous. Sensible and gradual introduction of progressively higher levels of fitness are protective, but there are some people who should never perform high intensity exercise. Obtaining a physical examination and medical approval from a physician is mandatory before beginning any exercise program or substantially changing your exercise program.

Adequate Hydration	Adequate Hydration	Early Dehydration	Dehydration	Significant Dehydration	Severe Dehydration or Rhabdomyolysis Medical Care Required	Severe Dehydration or Rhabdomyolysis, Emergency Medical Care Required

Figure 1. *This image depicts the color of urine. Every athlete should be educated on observing the color of their own urine and be able to detect dehydration and a possible medical emergency.*

Note: Those taking statin drugs (medications intended to control high levels of cholesterol in the blood) are at a much higher risk for developing rhabdomyolysis.

Stress Fractures

Bones become stronger when loads are placed upon them, but the increase in load must be gradual and implemented over time. A sudden increase in load, be it from increased running, marching, loading by compressive weight, or other physical stresses can lead to stress fractures and bony edema (swelling and inflammation) within the marrow of the bone.

To reach elite levels of fitness is a process that is years in the making. Training (running and marching) mileage should be increased gradually over months and years. Cardiovascular fitness, exertional stamina, and muscular strength can increase relatively quickly while bone, joints, tendons, and ligaments are slower to strengthen and adapt to an increase in training loads.

Tendonitis

Tendons, like bones, respond best to a gradual increase in training load. Sudden increases in workload can cause inflammation and pain in the tendons.

Vertebral Endplate Fractures

The bones of your spine are susceptible to injury much like stress fractures. The endplates of the vertebra may develop microfractures and result in bony edema within the vertebra. These end plate fractures may not be visible on X-rays.

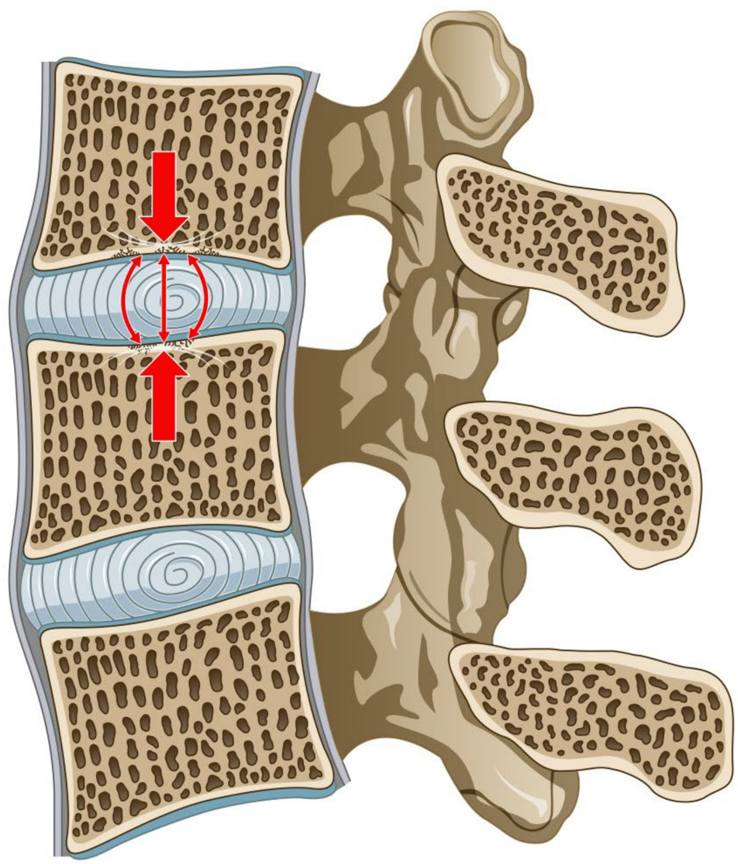


Figure 2. Microfractures of the vertebral endplates can occur as a consequence of a sudden increase in repetitive compressive forces upon the spine, a fall, or a sudden or excessive loading of the spine with weights.

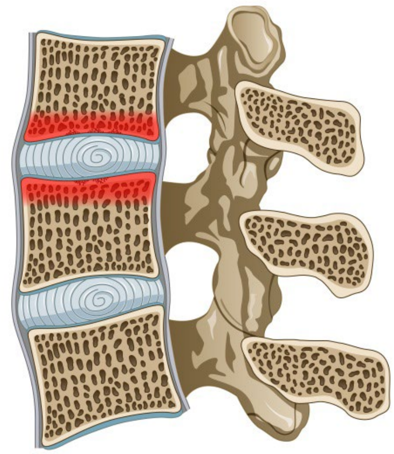


Figure 3. Endplate fractures and the resulting bony edema can lead to a deep bony ache which may persist for months after an injury.

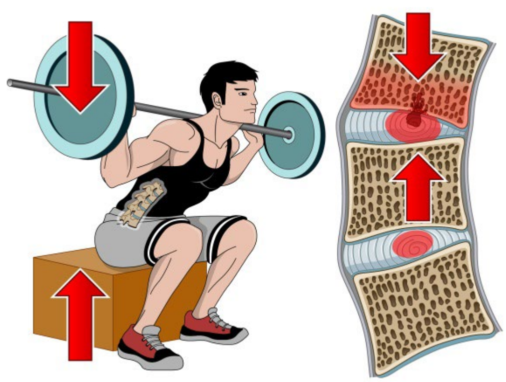


Figure 4. Excessive sudden loads on the spine, like an inappropriately executed box squat, can cause an overt injury to the vertebral endplate which can be painful and undetected on X-ray.

Dehydration

Dehydration occurs when the body lacks sufficient fluid to complete normal physiologic functions. Dehydration results from consuming insufficient water to replace the fluids excreted. Dehydration can occur with extreme or prolonged exertion especially when performed in a warm environment. Athletes should drink plenty of water, particularly when exercising in hot weather.

Heat Stroke

Heat stroke is an extreme heat injury which can lead to brain injury and death. It occurs when the body's core temperature is elevated. A clinical diagnosis of heat stroke is made when the core temperature (rectal thermometer) measures at least 105 degrees Fahrenheit. Heat stroke occurs when exercising in hot weather. One of the warning signs of heat stroke is the lack of sweating. The likelihood of having heat stroke is elevated in persons who are dehydrated.

The symptoms of heat stroke include:

- Headache
- Disorientation
- Dizziness
- Hot, dry, red skin
- Nausea and vomiting
- Weakness
- Rapid shallow breathing
- Unconsciousness

Heat stroke is a medical emergency which requires medical treatment and cooling of the core temperature.

Conclusion

While moderate exercise has been shown to have significant health benefits, extreme exercise has the potential to cause bodily harm. Athletes should gradually advance the tempo, duration, and intensity of exercise as they advance toward their performance goals. Overexertion injuries are real, and every athlete should be mindful of potential harm.

Abdominal Bracing

(This is an excerpt from a book soon to be published: *Hero Workouts*)

In an attempt to maximize the impact of spinal stabilization exercises, researchers have been studying various core activation strategies. Research has lit upon one particular mechanism for activating the core muscles with the effects of protecting the spine from injury and enhancing athletic performance. This mechanism is called bracing. Bracing of the core involves an isometric stiffening of the abdominal core muscles.

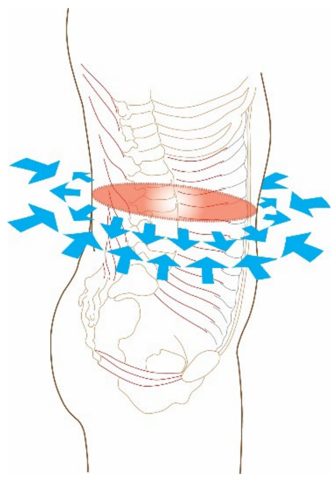


Figure 1. Bracing of the core involves an isometric stiffening of all the muscles of the core.

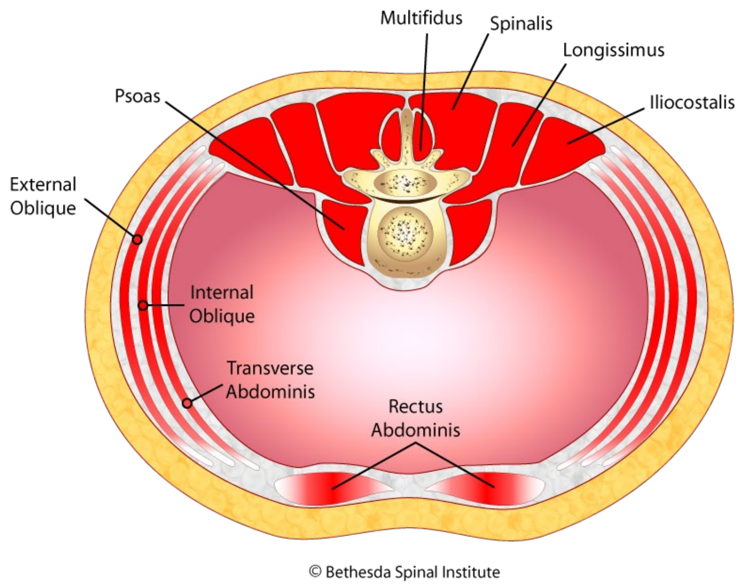


Figure 2. Bracing does not isolate muscles of the core, but rather engages all of the muscles in a global stiffening and bracing of the abdominal muscles.

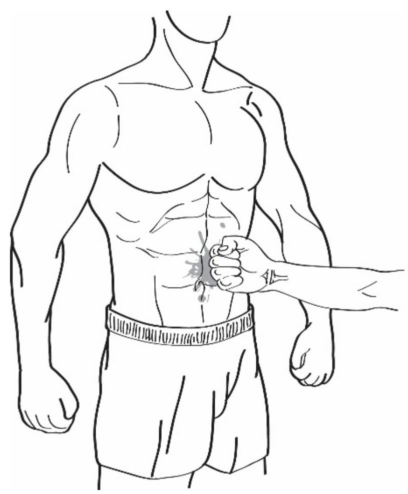


Figure 3. To replicate the bracing concept, stiffen your abdominal muscles as if you were about to be punched in the gut. Bracing in anticipation of receiving a punch is equivalent to bracing or stiffening.

What is Abdominal Bracing?

Abdominal bracing is tensing of all the abdominal musculature: all the layers of the abdominal muscles are tensed as if preparing to be punched in the abdomen. This creates a crisscrossing mesh of stabilizing vectors steadying the spine in all directions. This is what spinal researcher, Dr. Stuart McGill, refers to as *superstiffness.*

Abdominal stiffness allows us to transfer power, inhibit excessive spinal motion, and protect the spine from injury. It also has the added stabilizing effect of increasing the intra-abdominal pressure which in turn further enhances the stability of the spine.

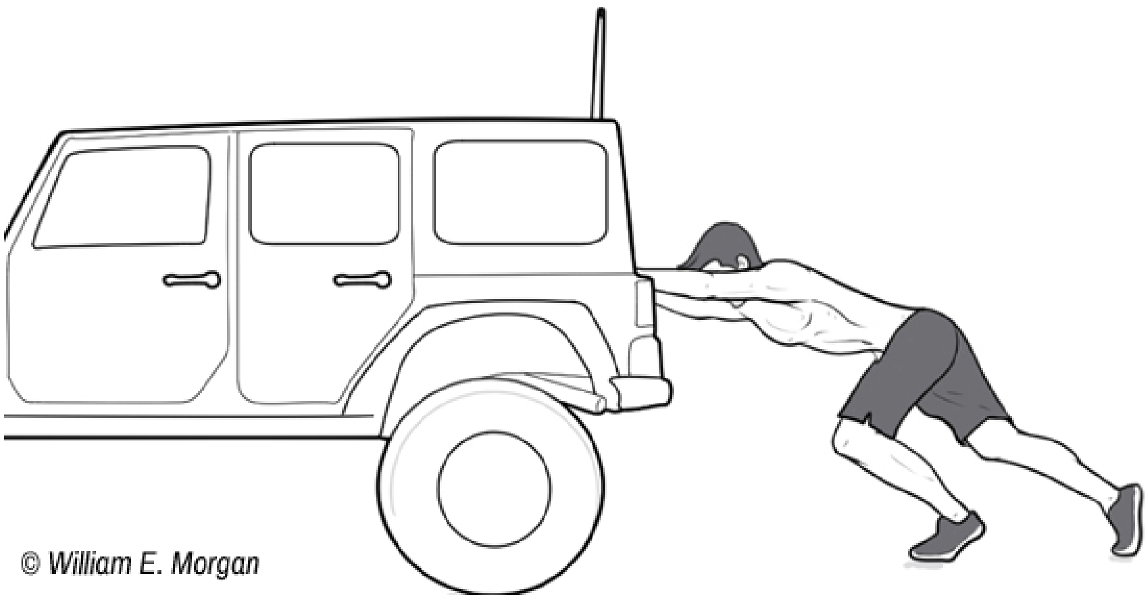


Figure 4. During extreme exertion such as heavy lifting or pushing, we instinctively stiffen the core in preparation for the exertion.

It is Intuitive

When you prepare for a heavy lift or to push a vehicle, what do you instinctively do in preparation for the effort? You instinctively brace your abdominal muscles.

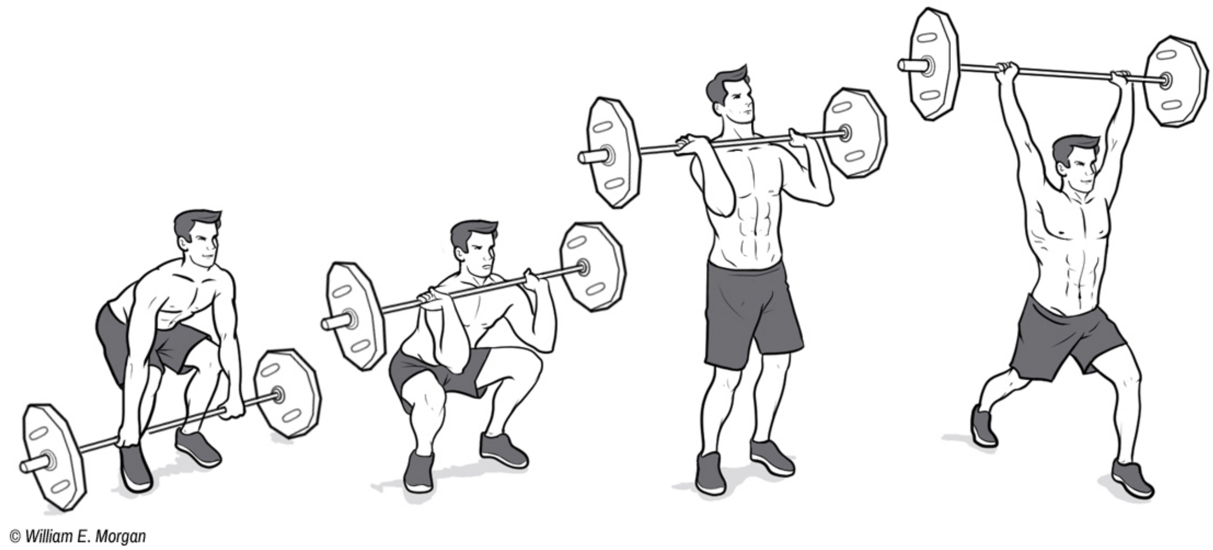


Figure 5. When performing complex athletic movement patterns such as the clean and jerk, there is a concert of muscle activation, muscle inhibition, and spinal stiffening which must occur in a coordinated sequence. Practicing these types of motion patterns should reinforce reflexive stiffening and core bracing without conscious thought.

Athletic Performance Training

When performing an athletic lift like the deadlift, the Olympic clean and jerk, or the squat, there is an instantaneous stiffening and bracing at precisely the right time during the lift which occurs without conscious thought. Coaches and trainers should encourage athletes to use proper form and engage in abdominal bracing.

In athletics the timing of abdominal bracing is important. An athlete should be trained to maximize the natural, momentary reflexive stiffening of the core during an athletic motion. If an athlete tried to constantly stiffen and brace the core, it would impede athletic performance. Imagine the functional impairment of a golfer trying to swing a golf club while maintaining a constant stiffening of the core. It would impair the resulting swing. The golfer should have a relaxed core until momentary reflexive stiffening maximizes power and protection.

When training pain-free athletes, the goal is to enhance performance and prevent injury. We want to enhance the reflexive stiffness of their core. This can be accomplished through several functional exercises and by having athletes practice their form during actual athletic activity.

Functional athletic weight lifting exercises such as the clean and jerk, kettlebell swings, medicine ball throwing and catching, battle ropes, sled pulling and pushing, and some pulley exercises can have a training effect which enhances athleticism and injury protection. These exercises are described in the chapter titled *The Exercises*.

Conclusion

Abdominal or core bracing increases spinal stiffness and activates the protective muscles of the core. When training to enhance athletic performance, utilize a program which equips the athlete to subconsciously react to perturbation and power projection with momentary core muscular stiffening and bracing followed by immediate slackening and relaxation.

References

1. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain: a motor control evaluation of transverse abdominis. *Spine* 21(1996): 2640-2650.

2. Hodges PW, Richardson CA. Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. *Archives of physical medicine and rehabilitation* 80(1999): 1005-1012.

3. Vera-Garcia J, Elvira J, Brown S, McGill S. Effects of abdominal stabilization maneuvers on the control of spine motion and stability against sudden trunk perturbations. *Journal of Electromyography and Kinesiology* 17(2007): 556-567.

4. Cholewicki J, Juluru K, McGill, S.M. *Intra-abdominal pressure mechanism for stabilizing the lumbar spine. J Biomech* 32(1999): 13-17.

5. Cholewicki J, Juluru K, Radebold A, Panjabi MM, McGill S.M. *Lumbar spine stability can be augmented with an abdominal and/or increased intra-abdominal pressure. Eur Spine J* 8(1999): 388-395.

6. Cresswell, AG, Thorstensson A. Changes in intra-abdominal pressure, trunk muscle activation, and force during isokinetic lifting and lowering. *Eur J Appl Physiol* 68(1994): 315-321.

7. Grenier SG, McGill SM. Quantification of lumbar stability by using two different abdominal activation strategies. *Arch Phys Med Rehabil* 88(2007): 54-62.

The Problem with Sit-ups (and other exercises)

(This is an excerpt from a book soon to be published: *Hero Workouts*)

Most of what we have believed about how to train the abdominal muscles is wrong. We used to believe that abdominal muscles were designed to flex the trunk and that sit-ups prevented lower back pain. While the rectus abdominis muscles (the muscles which comprise the six pack appearance of defined abdominal muscles) can flex the spine slightly, the network of abdominal muscles is better equipped to resist excessive spinal motion and to transfer power.

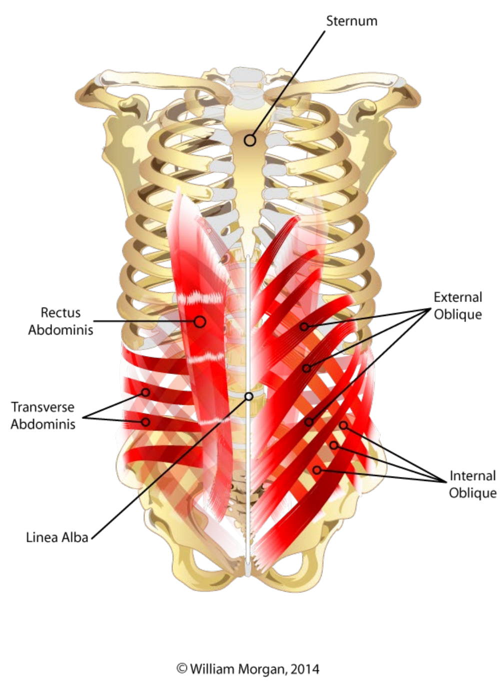


Figure 1. The network of abdominal and core muscles provide a wide variety of vectors which allow for stabilization of the spine and transfer of power from the lower extremities through the torso to the upper extremities.

The spine is not a hinge joint like the knee or elbow. It is a flexible column. Yet for at least the past century, mainstream physical culture has targeted the muscles which stabilize the spine with exercises that flex and extend it as if the spine was a hinge joint. Excessive flexion and extension of the spine, especially when under load, can cause disc damage resulting in herniation, bulging, and/or degenerative changes.

The muscles which support the spine are best trained using exercises that develop reactionary functional spinal stiffness. They are not designed for great changes in length like the biceps or triceps muscles. Instead, they are more like springs which provide a marginally flexible absorption of external forces and allow for transfer of power from the hips to the upper extremities. Can you think of anytime in athletics, work, or normal activities in which you would need to replicate the motion or function that is trained while performing a crunch or sit-up? Probably not.

Figure 2. In natural movement patterns the abdominal muscles do not repeatedly flex. They stiffen to provide a fixed platform for transferring power from the legs through the torso to the arms. This is the function of the abdominal core. These muscles should be trained to maximize that function.

Between each of the vertebrae (spinal bones) is a cartilaginous disc. The disc has a gel center which remains in the center of the disc while in the neutral position with a mild lordosis (arch). Excessive or repeated spinal flexion, as occurs when performing sit-ups, causes a disruption within the disc. Over time this disruption progressively worsens. Eventually the disc migrates back and a disc bulge, herniation, or other derangement occurs. Also, since repeated flexion of the torso does not replicate or translate benefit to normal patterns of functional movement, it may be enforcing dysfunction.

Sit-ups and crunches should never be used to treat lower back pain. They actually re-create the mechanism of injury for most back pain sufferers through repeated and prolonged flexion.

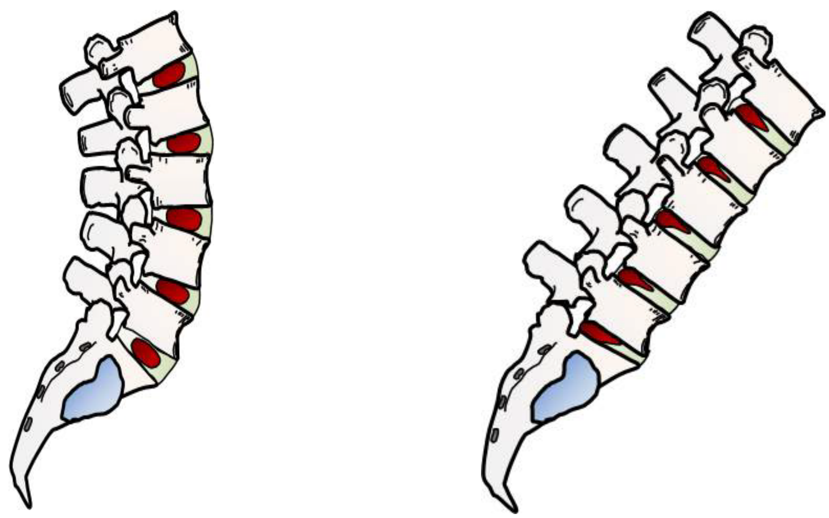


Figure 3. Between the vertebrae are cartilaginous discs. The disc has a gel center which remains in the center of the disc while in the neutral position with a mild lordosis (arch). Excessive or repeated spinal flexion, as occurs when performing sit-ups, causes a disruption within the disc. In time, this can lead to a disc bulge, herniation, or other derangement.

Figure 4. Sit-ups and crunches repeatedly flex the spine and have a high potential for lumbar disc injury.

Figure 5. Incorporating a twist into a sit-up or crunch combines two deleterious motions with minimal if any training benefit.

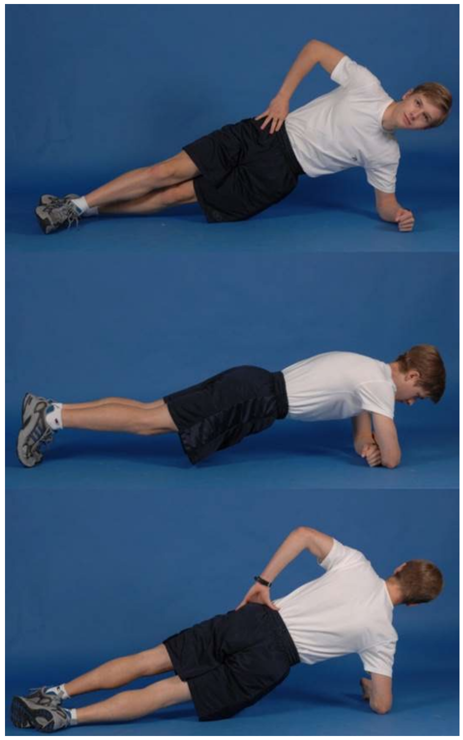


Figure 6. In the early stages of training, simple stiffening exercises are preferred. These are superior to exercises that produce excessive spinal flexion, extension, or twisting. See chapter six for additional information on preferred exercises for strengthening the core.

Figure 7. Curling the spine forward to stretch the hamstrings can overstretch the spinal ligaments and facilitate or create disc injuries. This common exercise is injurious and should be avoided.

Rest, Recovery, and Life Balance

(This is an excerpt from the book: *Hero Workouts*)

Lack of physical training is not the limiting factor in enhancing athletic performance. Recovery is the limiting factor. It does not matter how hard you train if you do not maximize your physical recovery through intelligent optimization of rest periods. More is not always better. Sometimes more is just more. Lack of adequate recovery leads to injury, dysfunction, and illness.

As you look over the workouts found in this book, you will note that some workouts are more rigorous than others, and some are not very hard at all. This is intentional; you should not perform to maximal exhaustion every day. There should be hard days, easy days, and rest days.

Additionally, certain body parts are prone to injury when exercises are paired incorrectly. For example you would not want to mix overhead presses, pull-ups, and swimming freestyle and butterfly sprints in one workout or even on consecutive days. This combination would increase the likelihood of shoulder injury.

Ideally there should be one rest day for every three days of working out. The rest day could be a day with some diaphragmatic breathing exercises and biofeedback training (using an automated vital signs machine to learn to maximize oxygen uptake, slow pulse and respiration rates, and lower your blood pressure). Biofeedback and diaphragmatic breathing will help in athletics, diving, and shooting.

Sleep

Anyone who has ever been in an SOF unit has learned to function without sleep. Most operators believe they can function at top form with less sleep than the general population and that they do not need more than four or five hours of sleep per night. This is not true. Regardless of training, everyone performs better with eight or more hours of sleep per night.

There is no task that is not hindered by lack of sleep or improved by getting more sleep. Do not believe the lie that some people need only four to five hours of sleep per night. Studies have shown that sleep deprivation can reduce cognitive function as much as drunkenness.

Day	Example 1	Example 2	Example 3	Example 4
Sunday	Rest	Rest	Long run	Rest
Monday	High Intensity Strength and Run	Run, Pull-ups, Push-ups, Squats, Run	High Intensity Strength	Strength and Run
Tuesday	Fin Swim	Moderate Intensity Strength Work	2000 meter Compass Swim	Pool Workout
Wednesday	Strength Circuit	Fin Swim	Rest or Breath Hold Drills	High Intensity Strength
Thursday	Run	High Intensity Strength and Run	High Intensity Strength and Run	Long Run
Friday	Swim	Diaphragmatic Breathing/ Relaxation Training	Run-Swim-Run	High Intensity Strength and Run
Saturday	Strength Circuit	Run	High Intensity Strength	Rest
Sunday	Rest	Rest	Rest	Rest

Figure 1. Sample chart depicting workout days and rest days. Example 4 shows the workout schedule on a five day work week.

Cortisol and Leptin

Cortisol is a stress hormone which is released when we have too little sleep, too much stress, or too much exertion. In fact the body begins to produce cortisol after 40 minutes of continual exercise. Excessive cortisol production is responsible for the wasting of muscles and the distribution of fat in the belly.

Leptin is the substance which signals satiety (tells us when we are full). Leptin production is reduced when you lack adequate (seven or more hours) sleep. There are several high quality studies which have linked obesity to lack of sleep.

Life Balance

Recovery is more than sleep or rest between sets or events, or even days off. Recovery involves the restoration which takes place when there is absolute balance in your life, when you have true respite as well as spiritual and mental rest. We need days off and sometimes weeks off. We need time to rekindle relationships and family ties. There needs to be balance and purpose in a warrior's lifestyle. Love, friendship, and fellowship are part of the recovery process from training and operations.

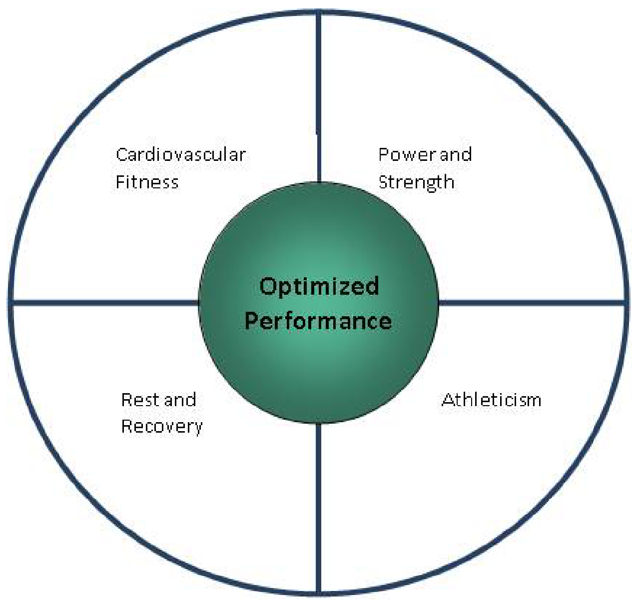


Figure 2. Continually adjust your workouts, rest, and priorities in the pursuit of the elusive concept of optimal performance.

Manipulation Activates Muscles of the Core

Motor control is an interactive process that allows the body to initiate activity to react to perturbations and other outside forces in a coordinated manner.

Normal global reactive motor control is complicated when you consider the vast amount of interactive and competing neuronal transmissions that are involved. However, in the simple example of evoking a patellar reflex, we can see that a stimulus, in this case a reflex hammer, places a rapid stretch on the muscle spindle fibers of the quadriceps. This sudden rapid stretch results in an afferent nerve transmission to the spinal cord and brain. There is a resulting efferent message that, traveling through an intermediate interneuron, inhibits contractions of the hamstring muscle, while another efferent transmission evokes a rapid contraction of the quadriceps.

This simple reflex arch is replicated in more complex patterns throughout the body.

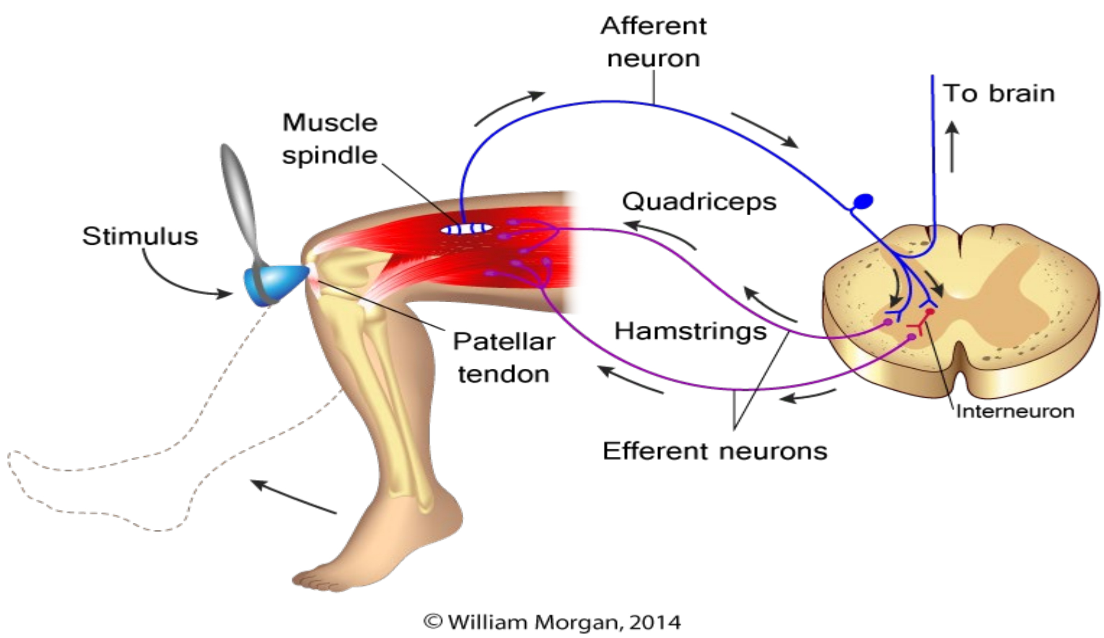


Figure 1. The myotatic (stretch) reflex of the patellar tendon.

Applying this reflexive motor control model to the deep muscles of the core, it appears that there is a reflexive response between the small muscles of the spine (Intertransversarii, rotatores, and interspinales),1,2 ,3 and the spinal ligaments(3, 4) with the multifidus muscles. This reflexive control provides for a sensitive and reactive protective contractile response by the multifidus muscles.

Certainly there has been a proliferation of research on the effects of the multifidus muscles and other core stabilizers (like the transverse abdominis) on spinal health since the publication of several landmark studies by a group of physiotherapists (Richardson, Hodges, Jull, and Hides) from Australia in the late 1990s/early 2000s. These innovators have changed the way we look at reactive spinal stabilization. Yet in spite of this wave of interest, we are forced to proceed with incomplete and imperfect knowledge in this developing field of discovery.

Not all of the information from this wave of research is generalizable. For example, first time lower back pain patients recruited at an emergency room will respond differently than patients with chronic refractory lower back pain.[6] Some of the information has been refuted and contested.[7,8] Also, while the multifidus is important, it is not all important. There is no one muscle that dominates core motor control.[9]

What is evident is that the multifidus is a key component in the deep stabilization of the spine and is particularly susceptible to inhibition and atrophy following back injury. It is also evident from the research that the multifidus does not naturally recover from this post-injury inhibition and subsequent atrophy. Researchers are striving to find the right combinations of exercises to reverse this downward spiral.

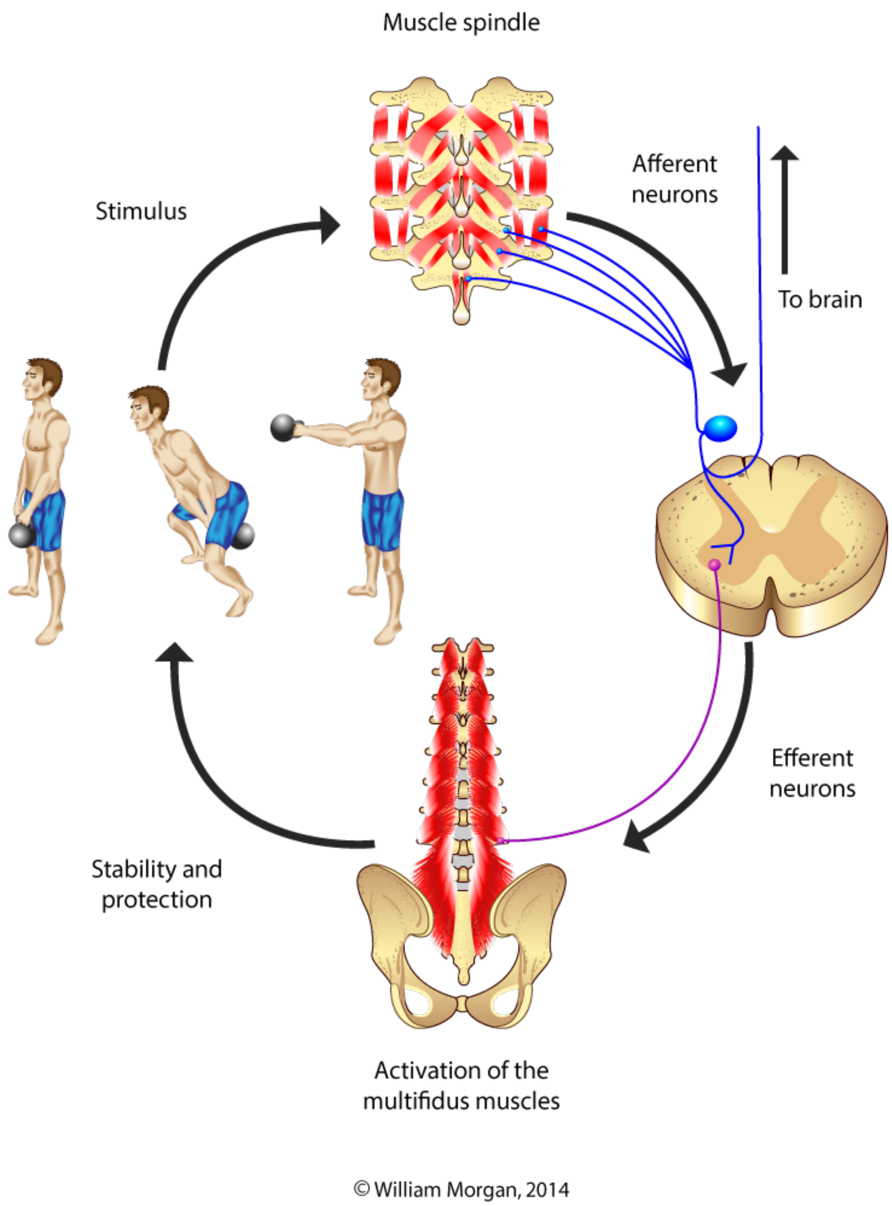


Figure 2. The normal protective response of the multifidus muscles: When potentially deleterious motions occur, the muscle spindle fibers in the small muscles of the spine are stimulated and send afferent impulses to the cord. Reflexive efferent impulses from the cord then cause the multifidus muscles to contract. This creates stability and protection for that motion.

Manipulation Activation of Core Stabilization

A few recent studies have documented that the protective mechanisms of some of core muscles, particularly the multifidus and the transverse abdominis,[10,11, 12,13,14] are enhanced by high-velocity low-amplitude manipulations. While gaps remain in the science, it appears that the adjustment (HVLA manipulation) activates the multifidus by way of stimulating the muscle spindle fibers of the small muscles of the spine. Pickar has demonstrated that manipulation stimulates the proprioceptive mechanism by exciting both muscle spindle fibers and golgi tendon organs. [15,16] Another study showed the effect the speed of the manipulation has on the muscle spindle response, the faster the manipulative impulse the greater the muscle spindle response. [17]

Fritz found that the multifidus muscles retained increased recruitment one week following treatment. This indicates that the response was not simply a myotatic (stretch) reflex, but could be something more analogous to hitting the reset button on a computer.[13]

Chiropractic manipulation can enhance core stabilization, and particular exercises will also improve core stabilization. However, the synergistic effect of combining manipulation and exercise is preferred to either intervention alone. Core stabilization is a complex multifactorial system of sensory–motor control. It involves passive, active, and reactive components. As our understanding of the science of these mechanisms evolves, we will need to continually adapt our treatment programs and referral patterns to maximize our patients' outcomes.

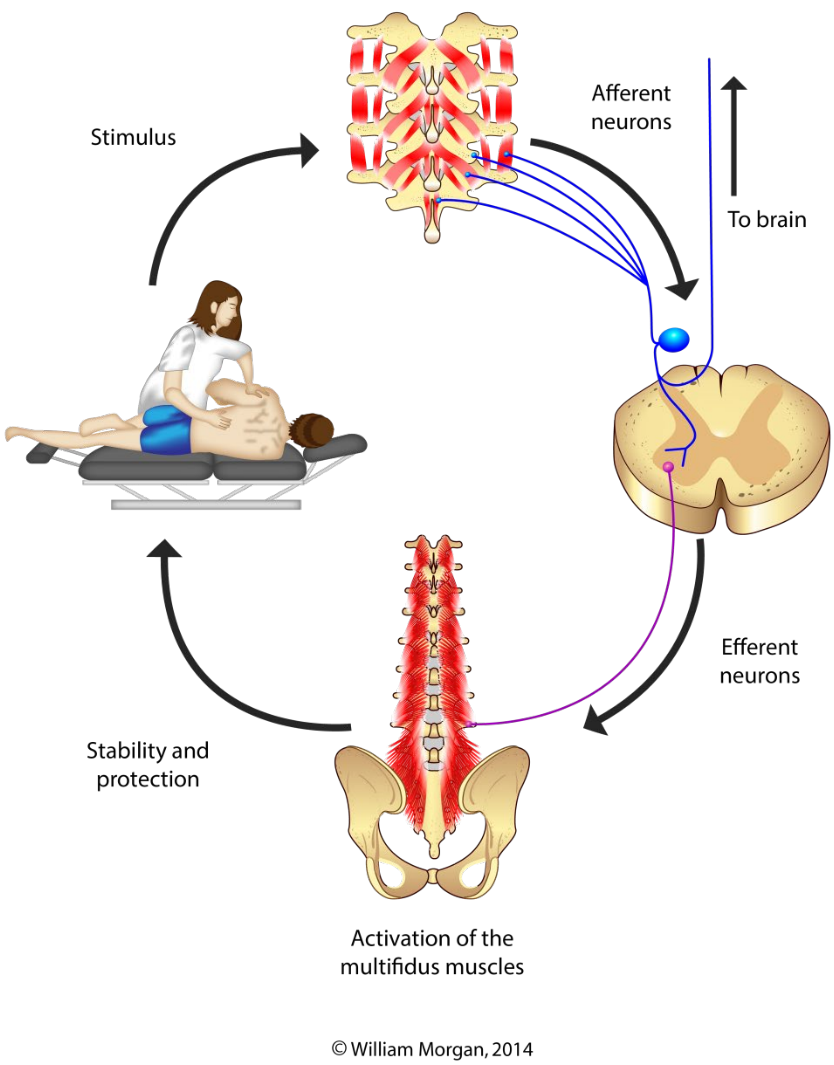


Figure 3. Improved activation of the lumbar multifidus muscles has been observed following spinal manipulation.

References

1 Bodduk MD,PhD. Clinical Anatomy of the Lumbar Spine and Sacrum. NY Churchill Livingstone 1997. 104-5.

2 Stuart McGill, Low Back Disorders: Second Edition © 2007 Stuart M. McGill

3 Carolyn Richardson, Paul Hodges, Julie Hides. Therapeutic Exercise for Lumbo Pelvic Stabilization – A Motor Control Approach for the Treatment and Prevention of Low Back Pain: 2nd Edition (c) Elsevier Limited, 2004

4 Solomonow M. Sensory-motor control of ligaments and associated neuromuscular disorders. J Electromyogr Kinesiol, 2006;16:549-67.

5 Le B, Davidson B, Solomonow D, et al. Neuromuscular control of lumbar instability following static work of various loads. Muscle Nerve, 2009;39:71-82.

6 Hides JL, Richardson CA, Jull GA. Multifidus recovery is not automatic after resolution of acute, first-episode low back pain. Spine, 2006; 21(23): 2763-9.

7 Standaert CM, Herring SM. Expert opinion and controversies in musculoskeletal and sports medicine: core stabilization as a treatment for low back pain. Arch Phys Med Rehabil, 2007;88:1734-6.

8Vera-Garcia FJ, Elvira JL, Brown SH, McGill SM. Effects of abdominal stabilization maneuvers on the control of spine motion and stability against sudden trunk perturbations. J Electromyogr Kinesiol, 2007;17:556-67.

9 Kavcic N, Grenier S, McGill SM. Determining the stabilizing role of individual torso muscles during rehabilitation exercises. Spine, 2004; 29(11): 1254-65

10 Gill NW, Teyan DS, Lee IE. Improved contraction of the transversus abdominis immediately following spinal manipulation: a case study using real-time ultrasound imaging. Manual Therapy, 2007; 12: 280-5.

11 Brenner A, et al. Improved activation of lumbar multifidus following spinal manipulation: a case report applying rehabilitative ultrasound imaging. JOSPT, 2007; 7:613-7.

12 Koppenhaver SL, et al. Association between changes in abdominal and lumbar muscle thickness and clinical improvement after spinal manipulation. JOSPT, 2011; 41 (6): 389-99.

13 Fritz JM, et al. Preliminary investigation of the mechanisms underlying the effects of manipulation; exploration of a multivariate model including spinal stiffness, multifidus recruitment, and clinical findings. Spine, 2011;36 (21): 1772-81.

14 Marshall PP, Murphy BD. The effect of sacroiliac joint manipulation on feed-forward activation times of the deep abdominal musculature. JMPT, 2006; 29: 196-202.

15 Pickar JG, Wheeler JD. Response of muscle proprioceptors to spinal manipulative-like loads in the anesthetized cat. JMPT, 2001;24 (1): 2-11.

16 Pickar JG, Kang YM. Paraspinal muscle spindle responses to the duration of a spinal manipulation under force control. JMPT, 2006; 29: 22-31.

17 Sung PS, Kang YM, Pickar JG. Effect of spinal manipulation duration of a spinal manipulation on low threshold mechanoreceptors in the lumbar paraspinal muscles: a preliminary report. Spine, 2005; 30 (1): 115-22.

Chiropractic Red Flag: Ehlers-Danlos Syndrome

Ehlers-Danlos Syndrome (EDS) is not one syndrome but a group more than 10 different congenital disorders characterized by a defect in the production of collagen. EDS can be present as a mild condition that presents with hyperelastic joints, or it can present as a life threatening form that can result in major blood vessel or organ rupture. Since EDS affects the production of collagen, it can cause increased elasticity and fragility of skin, ligaments, blood vessels, the intestines, muscles, and organs. As chiropractors, we should be particularly concerned with the combined characteristics of hyperelasticity of joints and increased fragility of blood vessels. The increased propensity for vessel damage and increased motion would increase the danger of causing vertebral artery dissection if a high-velocity low amplitude adjustment was performed on the cervical spine.

In addition to the increased risk for vascular injury, there is also the risk for dislocation of joints and other joint disorders. Bracing and stabilization exercises are common treatment for patients with EDS. There have been a couple case reports demonstrating the safe chiropractic management of patients with EDS through the use of chiropractic adjusting instruments, non-force techniques, postural advice, stabilization, and postural corrective exercises.

EDS is a relatively rare condition, but I tend to get two or three new cases per year (confirmed by subsequent referral and evaluation by our rheumatology department). It may be that the arthralgia of EDS sends these patients to chiropractors at a higher rate than would be seen by a family practitioner. For this reason we should be mindful of the diagnosis criteria and management of patients with EDS.

Clinical Presentation

There are a variety of types and levels of severity for EDS, but some of the characteristic findings include:

Excessive joint motion
Chronic arthralgia

Overly elastic, fragile, or velvety skin
Fragile blood vessels and organs
Veins clearly visible under the skin
Scoliosis
Fragile eyes that are easily damaged
Prolapse of the uterus or rectum
Hernias
Dental crowding and high palate

The Beighton Score

The Beighton score is based on a series of orthopedic tests that are used to quantify hypermobility and joint laxity found in EDS. A high Beighton score (6 or greater) is not pathognomonic for EHS, but it would warrant a referral to a rheumatologist. It is important for EDS to be properly diagnosed and managed medically (by a rheumatologist or geneticist) since there is a potential for life-threatening complications (organ or aorta ruptures top my list of potential concerns for severe cases).

Conclusions

Ehlers-Danlos Syndrome patients do present to chiropractic offices for treatment. Chiropractors should be able to identify patients with the likelihood of EDS and make appropriate referrals to medical specialties. Chiropractors may also participate in the integrated and collaborative care of EDS patients, though they should forgo vigorous osseous and soft tissue techniques, and instead use low force techniques avoiding manual treatments that include cervical rotation. Bracing, ergonomic instruction, and stabilization exercises may be particularly beneficial to patients with EDS. EDS is not cured, it is managed.

References:

Smits-Engelsman B, Klerks M, Kirby A. Beighton score: a valid measure for generalized hypermobility in children. J Pediatr. 2011 Jan;158(1):119-23, 123.e1-4. doi: 10.1016/j.jpeds.2010.07.021. Epub 2010 Sep 17.

Beighton PH Horan F. Orthopedic aspects of the Ehlers-Danlos syndrome. J Bone Joint Surg [Br]. 1969; 51: 444-453.

Grahame R., Bird H. A., Child A. et al. (2000). The revised (Brighton 1998) criteria for the diagnosis of benign joint hypermobility syndrome (BJHS). Journal of Rheumatology, 27, pp. 1777-1779.

Colloca CJ, Polkington BS. Chiropractic management of Ehlers-Danlos syndrome: A report of two cases. J Manip and Physiol Ther 2003 Sept;26(7):448-459.

Morley JJ, Perrault T. Chiropractic Management of Ehlers-Danlos Syndrome: A Case Report

J Amer Chiropr Assoc 2010 Mar;47(2):6-15.

Bone Morphology and Modic Classifications

Vertebral body edema is a common finding on MR imagery. Though degenerative changes like bony edema may seem like unimportant background noise to the busy clinician, recent studies have found that vertebral marrow edema is clinically significant and can be a progressive condition.

Michael T. Modic, MD, identified and published his findings on vertebral bony marrow changes in the journal *Radiology* in 1988. [1, 2] Since that time these findings and his grading criteria have borne his name. *Modic* changes represent MRI observations of vertebral marrow and endplate changes. These changes have been linked to trauma, disc disruption, and degeneration. More studies are currently underway to identify the clinical significance of this finding and to fully understand its progression.

The vertebral body has a dense outer barrier of cortical bone which is particularly dense at the vertebral endplates. Within this tough outer shell lies the subcortical marrow cavity. This cancellous bone is less dense and is porous. It is normal for this porous bone to contain fatty marrow. The T1 and T2 weighted MR images will reflect the presence of normal fatty marrow with a supportive bony matrix. When edema is present in the marrow, it is characterized by an influx of water content: T1-weighted images show loss of signal (hypointense signal in the marrow), while T2-weighted images will demonstrate an increased (hyperintense) signal.

Degenerative disc disease (DDD) without Modic changes is a relatively insidious and not particularly painful condition, whereas DDD with Modic changes is much more frequently associated with pain. [3,4, 5, 6, 7] Type 1 Modic changes show bony edema and inflammation and are strongly associated with back pain. Emerging evidence indicates there is a progressive nature to Modic changes. The bony edema of type I Modic changes may progress to type 2, and type 2 may progress to type 3. [8, 9, 10]

Modic Types

The Modic classification system is a method for categorizing vertebral body and endplate findings on MRI. Here are the three types:

Type 1. Type 1 Modic changes are characterized by high water content that is indicative of inflammation and edema. They are manifested as hypointense (dark) on T1 weighted MRI and hyperintense (bright) on T2 weighted images.

Type 2. Modic type 2 changes identify yellow fatty infiltration into the vertebral body. On T1 images, the fatty infiltration of type 2 Modic changes will appear hyperintense, and on T2 weighted images, they will appear hyperintense or isointense.

Type 3. Modic type 3 changes are less common than types 1 and 2 with less scientific investigation. Modic type 3 is identified by decreased signal or hypointense on both T1 and T2 weighted MR images. These findings can typically be correlated with sclerosis on plain film x-ray.

Conclusion

Modic changes can have strong clinical significance. Type 1 Modic changes have been strongly associated with [deep bony] pain and inflammation where type 2 and type 3 Modic Changes are less likely to be associated with refractory pain and tend to be more stable.

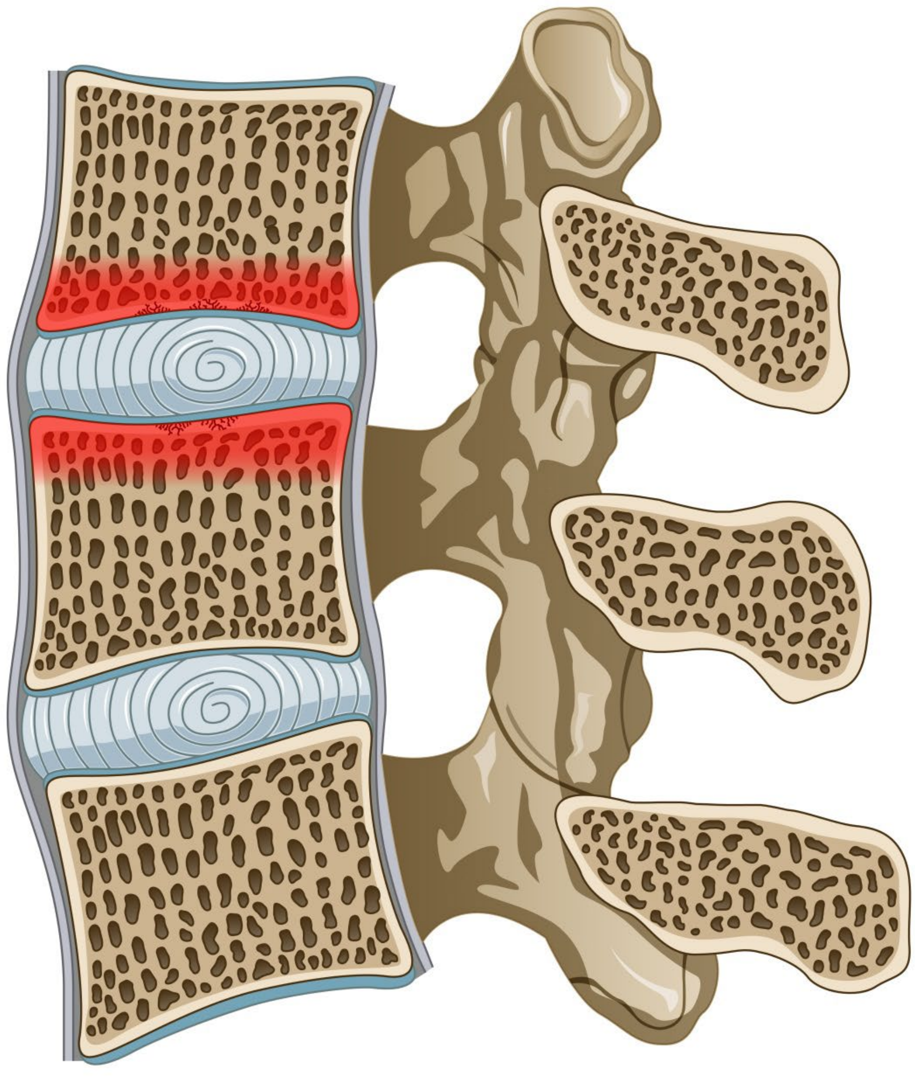


Image 1. Bony edema (red) extending into the spongy subcortical bone.

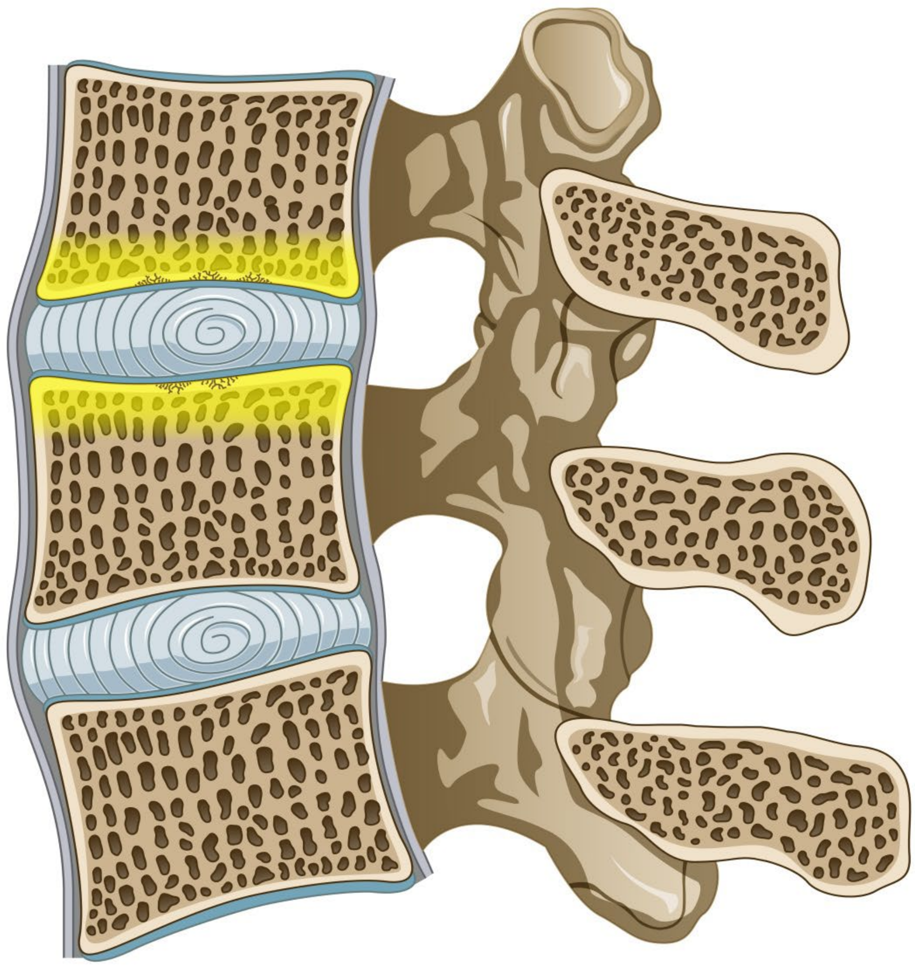


Image 2. Yellow fatty infiltration of the subcortical bone is characteristic of Modic 2 changes.

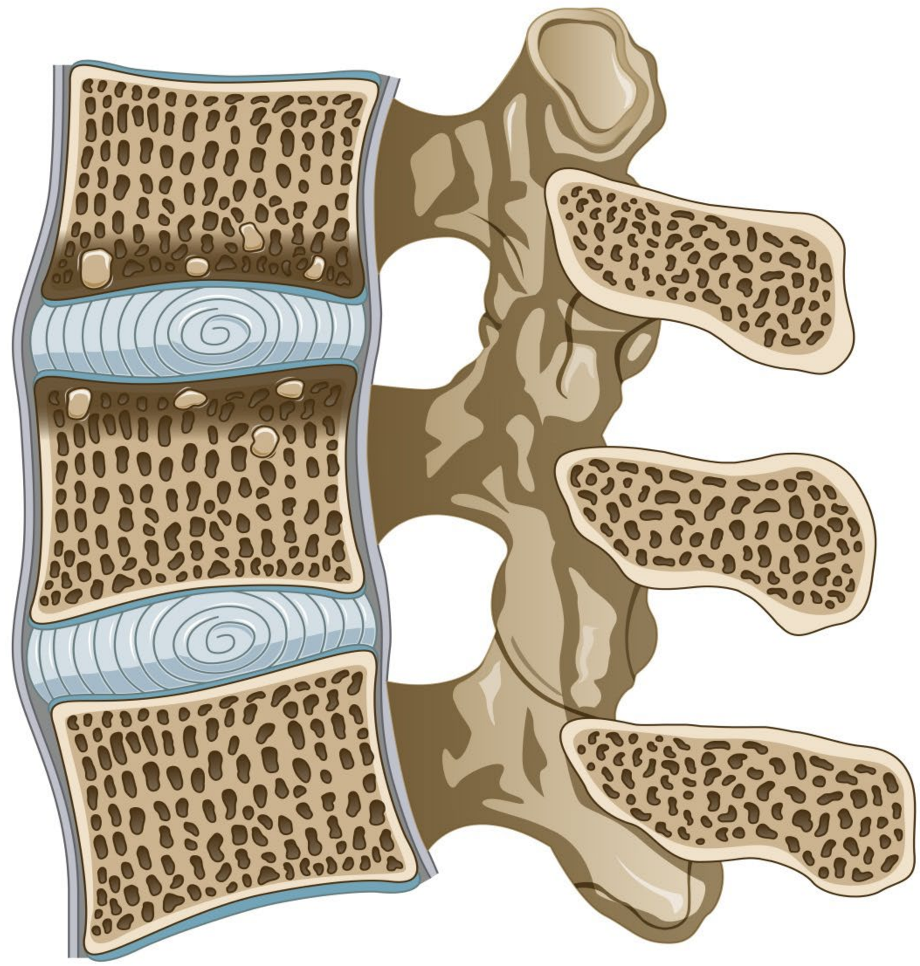


Image 3. Sclerotic changes of the subcortical bone and thickening of the vertebral endplates. Type 2 and type 3 changes are normally associated with progressive DDD.

Maigne's Syndrome

William E. Morgan

It is natural to associate the site of pain as the source of pain. If the pain is over the sacroiliac joint, it is a sacroiliac problem. If there is lateral thigh pain, it is probably a tensor fascia lata (TFL) syndrome. While pain often originates at the site of pain, other times pain is referred from another site: it is where it isn't. This is the case with thoracolumbar junction syndrome. This malady can refer pain to the inguinal area, lateral thigh, and posterior pelvis (sacroiliac or gluteal region).

I cannot recall the number of the patients treated for TFL syndrome with foam rolling and myofascial release therapy of the lateral thigh who were finally restored to normal after an adjustment to the thoracolumbar junction. Or, additionally, how many patients had been told for years they had a sacroiliac problem and had their SI adjusted ad nauseam, but received only limited relief. However, when the thoracolumbar junction was adjusted, their pain issues resolved.

The intent of this series is to bring attention to other possible sources of pain than the most obvious. There have been many others who have written on this topic, but it deserves being resurrected every few years to keep us mindful. What I write here, and much of what has been written regarding these conditions, is based on our knowledge of anatomy and clinical observations. The astute doctor will view this and other writings on the subject through the lens of skeptical scrutiny while allowing for these clinical observations to one day be substantiated. I should note that conditions such as cluneal nerve entrapment, piriformis syndrome, and Maigne's syndrome are primarily based on clinical observations with little firm evidence to substantiate their existence.

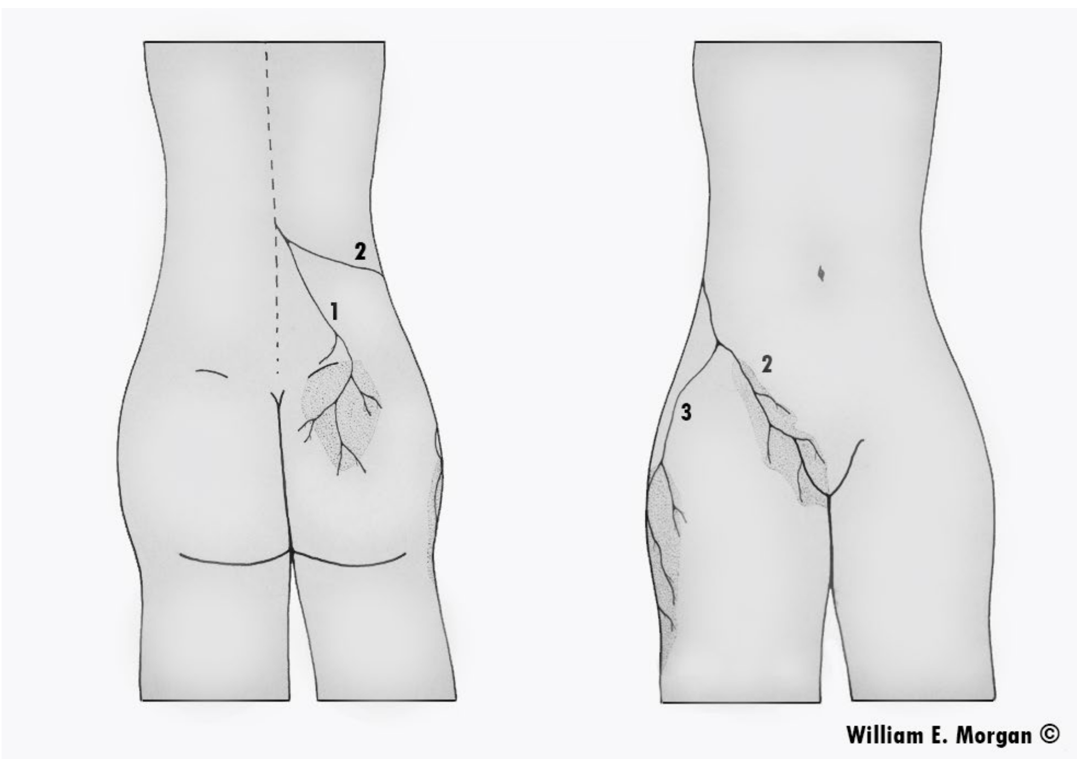


Figure 1. The thoracolumbar junction syndrome is clearly defined by a triad pattern of pain involving the posterior pelvis, lateral thigh, and inguinal region. This image identifies the distribution of pain; the posterior pelvis (1), the inguinal region (2), and the lateral thigh (3).

Maigne's Syndrome: Thoracolumbar Junction Syndrome

Musculoskeletal providers frequently see patients with inguinal pain, sacroiliac and buttocks pain, and lateral hip pain, and it is common to focus on the region of pain rather than other possible sources of it. Pain over the sacroiliac may be interpreted as originating in the sacroiliac joint, pain in the lateral thigh as *Iliotibial* band syndrome, and inguinal pain as psoas dysfunction. Doctors and therapists focusing on the region of pain, manipulate the painful sacroiliac, provide foam rollers for the "Iliotibial band" pain, and perform myofascial release on the psoas muscles.

The French physician, Robert Maigne, proposed in his writings in the 1970 -80s that a thoracolumbar facet syndrome could be responsible for causing referred pain to the regions innervated by those segment's posterior rami and the peripheral nerves which originate in that region. Maigne also proposed other techniques, such as skin rolling, to determine the tissue quality and other clinically oriented criteria which could be used to diagnose thoracolumbar syndrome. Dr. Maigne identified the syndrome which now bears his name with these observations:

- Unilateral lower back pain, usually in the sacroiliac region
- Inguinal or testicular pain
- Abdominal pain
- Gynecological symptoms or pain
- Pubic pain

Nerves Originating from the Thoracolumbar Region

The nerves which innervate the skin over the sacroiliac and buttocks (the posterior ramus of the thoracolumbar segments/cluneal nerves), the inguinal region (the posterior ramus of the thoracolumbar segments), and the lateral thigh (the posterior ramus of the thoracolumbar segments/lateral cutaneous femoral nerve) originate from the thoracolumbar junction.

It should be noted that the pain distribution may not follow standard dermatomal or peripheral nerve maps and that a sclerotomal pattern of pain (which will be a deeper pain) may be observed. Dermatome maps are general guidelines, but the actual dermatomes will vary from person to person.

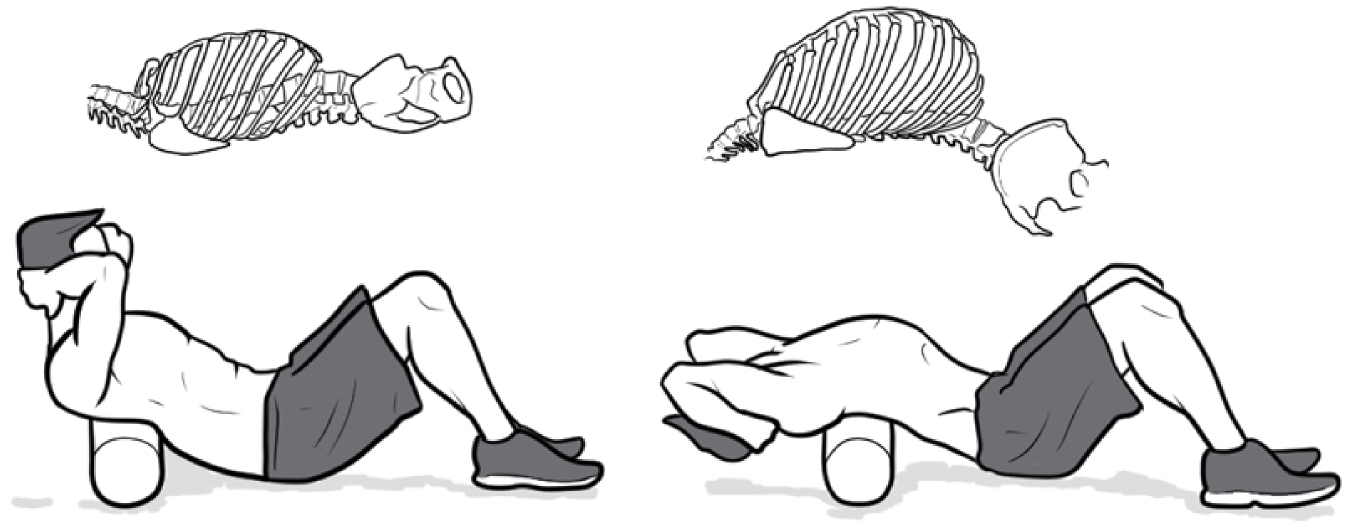


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Figure 2. In addition to adjusting the thoracolumbar spine, the doctor may also prescribe a foam roller for home use. Clasp your hands behind your head with the foam roll underneath the upper portion of the thoracic spine. Extend backward over the roll while keeping the neck in a neutral posture. Repeat three or four times. Next roll the foam down the spine a few inches, and then repeat. Slowly work the foam roller down to the thoracolumbar junction.

Treatment

Maigne encouraged the use of spinal manipulation to treat this syndrome. Adjusting the lower thoracic and upper lumbar vertebrae (T10-L2) is the primary treatment. I prefer standing anterior to posterior adjustments. In addition to spinal adjustments, the patient can also self-treat at home with the use of a foam roller (figure 2).

Peripheral Nerve Entrapment

While the thoracolumbar spinal segments may be a source of pain in the inguinal region, buttocks, and lateral thigh regions as described by Maigne, there are other sources of symptoms. In subsequent articles I will address sources of nerve entrapment of the cluneal nerves, and lateral cutaneous femoral nerve, as well as conservative treatment options.

References to Doctor Maigne’s Writings:

Maigne R. - Sémiologie des dérangements intervertèbraux mineurs. Ann. Med. Phys. 1972. 15, 277-289.

Maigne R. - Dérangements intervertèbraux mineurs et syndrome cellulo-téno-myalgique. Conceptions nouvelles des mécaniques des douleurs vertébrales communes. Rev. Méditer. Sci. Méd., 1978 5, 337-348.

Maigne R. - Origine dorso-lombaire de certaines lombalgies basses. Rôle des articulations interapophysaires et des branches postérieures des nerfs rachidiens. Rev. Rhum. 1974, 41, 12, 781-789.

Maigne R. - Le syndrome de la charnière dorso-lombaire. Lombalgies basses, douleurs pseudo-viscérales, pseudo-douleurs de hanche, pseudo-tendinite des adducteurs. Sem. Hôp. Paris 1981, 57, 11-12, 545-554.

Maigne R. - Low back pain of thoracolumbar origin. Arch. Phys. Med. Rehabil. 1980, 61, 389-395.

Maigne J.Y., Lazareth J.P., Guérin-Surville H., Maigne R. - The lateral cutaneous branches of the dorsal rami of the thoraco lumbar junction. An anatomical study on 37 dissections. Surg. Radiol. Anat. 1986, 8, 251-256.

Maigne R., Le Corre F., Judet H. - Premiers résultats d'un traitement chirurgical de la lombalgie basse rebelle d'origine dorso-lombaire. Rev. Rhum. 1979, 46, 177-18.

Lumbo-Pelvic Pain (part two): Cluneal Nerve Entrapment

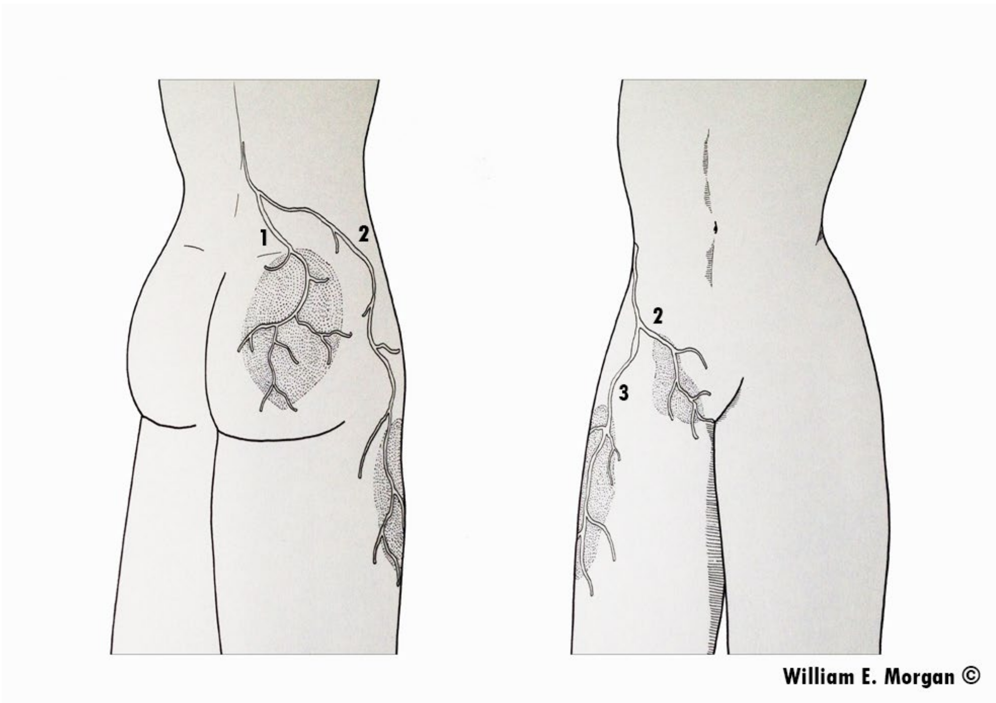

Figure 1. In the first article of this series I discussed Maigne's syndrome (AKA thoracolumbar junction syndrome) as a potential source of lumbo-pelvic pain. This syndrome is identified by a triad pattern of pain involving the posterior pelvis, lateral thigh, and inguinal region. This image identifies the distribution of pain; (1) the posterior pelvis, (2) the inguinal region, and (3) the lateral thigh arising from dysfunction in the T10-L2 vertebral segments.

In the first article in this series we discussed the concept (initially described by the French physician Robert Maigne) of thoracolumbar facetal irritation creating symptoms in the posterior pelvis, the lateral thigh, and the inguinal region (figure 1). Maigne's work explained that pelvic pain may originate higher in the trunk and arise from the lateral branches of the dorsal ramus. Maigne proposed that manipulation of the T10-L2 vertebral segments may reduce the symptoms associated with thoracolumbar junction syndrome. He uncovered this notion through research, clinical observation, knowledge of anatomy, and human dissection. While Maigne identified common pain distribution patterns, I should note that innervation from the lateral branches of the dorsal ramus may vary from person to person.

Superior Cluneal Nerve Entrapment

This article will focus on a peripheral nerve entrapment which may occur "downstream" from the thoraco-lumbar junction: superior cluneal nerve entrapment. Strong and Davila were the first to describe this condition in 1957. While the superior cluneal nerve neruopathy has been identified as a source of lower back and posterior pelvic pain, albeit rare, there has been little research on the effectiveness of treating this condition. The superior cluneal nerve originates from the posterior rami of L1-2-3, then descends inferior to cross over the crest of the ilium in three branches. The medial branch travels through an osteofibrous tunnel which has been cited as a site of entrapment similar to carpal tunnel syndrome. The osteo component of this tunnel is the rim iliac crest, and the fibrous component is composed of the tough thoracolumbar fascia.

Clinical Presentation of Superior Cluneal Nerve Entrapment

Superior cluneal nerve entrapment will present with pain over the posterior ilium and upper buttocks region. You may also feel a thickening of tissue along the rim of the posterior iliac crest, and there may be tenderness in this region. By tapping on the tender spot or thickened tissue, you may evoke a shock-like sensation. If this tapping produces an electrical shock-like sensation, it is considered a positive Tinel's sign. This is strongly indicative of cluneal nerve involvement.

Treatment

Making the diagnosis of a superior cluneal nerve syndrome is easier than treating this disorder. Few inroads have been made studying the treatment of this malady, so we are left with mainly antidotal recommendations for treating pain attributed to the superior cluneal nerve entrapment. Medical practitioners may perform pain injection procedures or more rarely perform a surgical release of the entrapment.

Manual practitioners can utilize manipulation of the segments of innervation for this region (T11-L2), instrument assisted myofascial mobilization (such as Graston), pin and stretch techniques, and soft tissue mobilization techniques. While there is little evidence to validate this treatment as being effective in treatment of this condition, there is no evidence to indicate that it is not effective. Hence a trial treatment of manual methods is still prudent.

I treat superior cluneal nerve syndrome with adjustments and soft tissue mobilization using a motorized prone distraction table to elongate the fascia as I perform either a pin and stretch type "release" or use a myofascial mobilization instrument. While I feel that this technique is effective, it is based solely on antidotal experience. I would be the first to say research is needed to substantiate its effectiveness. While all healthcare professions use unsubstantiated treatment methods, we need to avoid making unsubstantiated *claims* about those treatments.

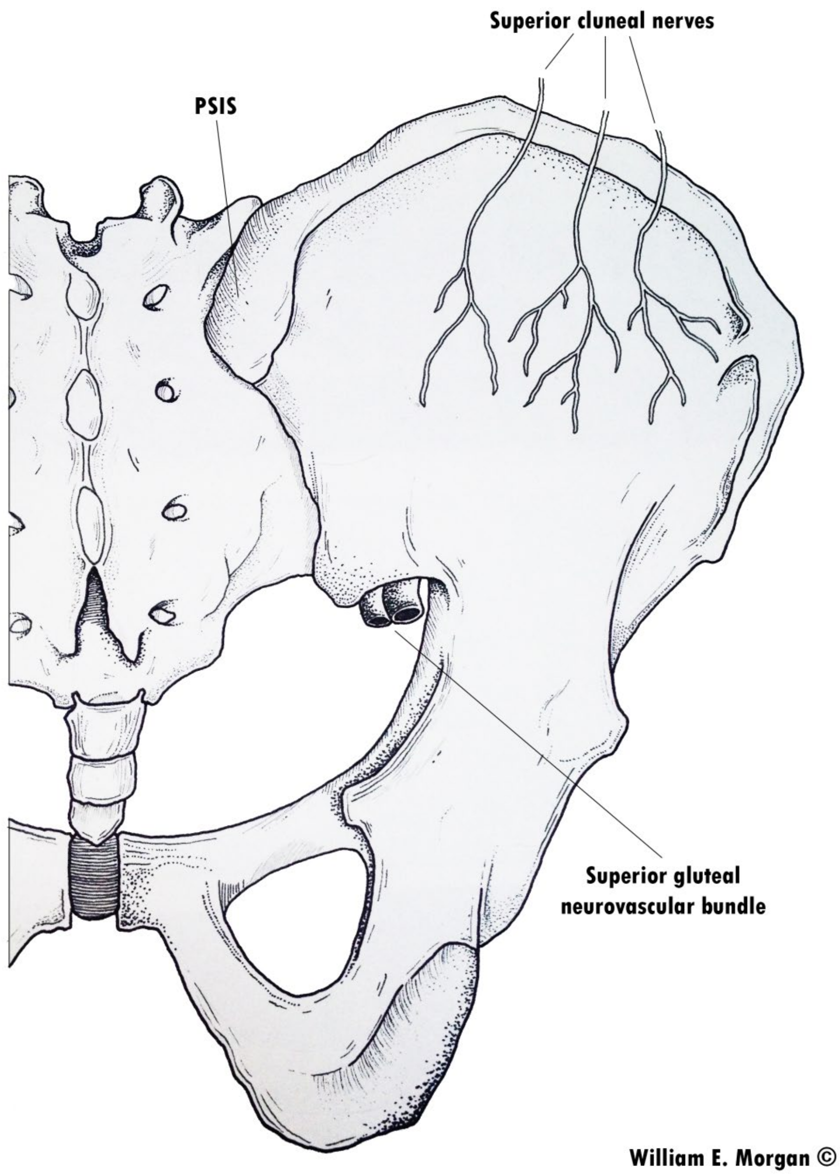

Figure 2. The superior cluneal nerves cross over the rim of the iliac crest in three branches. While all branches may succumb to entrapment, the medial branch travels through an osteofibrous tunnel which makes it particularly susceptible to entrapment.

References

Tubbs RS, Levin MR, Loukas M, Potts EA, Cohen-Gadol AA: Anatomy and landmarks for the superior and middle cluneal nerves: application to posterior iliac crest harvest and entrapment syndromes. J Neurosurg Spine13:356–359, 2010.

Strong EK, Davila JC: The cluneal nerve syndrome; a distinct type of low back pain. Ind Med Surg 26:417–429, 1957.

Lu J, Ebraheim NA, Huntoon M, et al. Anatomic considerations of superior cluneal nerve at posterior iliac crest region. Clin Orth & Rel Res 1998;347:224-228.

Drury BJ. Clinical evaluation of back and leg pain due to irritation of the superior cluneal nerve. J Bone Joint Surg 1967;49A(1):199.

Maigne JY, Maigne R. Trigger point of the posterior iliac crest: painful iliolumbar ligament insertion or cutaneous dorsal ramus pain? An anatomic study. Arch Phys Med Rehabil 1991;72:734-737.

Maigne R. – Sémiologie des dérangements intervertèbraux mineurs. Ann. Med. Phys. 1972. 15, 277-289.

Kuniya H, et al. Prospective study of superior cluneal nerve disorder as a potential cause of low back pain and leg symptoms. Journal of Orthopaedic Surgery and Research (2014) 9:139.

Skinny Jeans Syndrome

Lumbo-Pelvic Pain (Part Three)

Meralgia paresthetica (MP) is a sensory mononeuropathy which can produce pain or paresthesia of the anterior-lateral thigh. Normally it is the result of a focal entrapment of the lateral femoral cutaneous nerve (LFCN) as it travels under the inguinal ligament, but it can also be caused by external compression. This peripheral entrapment is relatively common and has been confused with nerve root lesions.

Clinical Anatomy

The LFCN, a nerve of the lumbar plexus, originates from the second and third lumbar nerves. It passes through the psoas muscle, and then traverses anterior to the iliacus muscle as it travels laterally across the pelvis. I t finally exits the pelvis near the anterior superior iliac spine (ASIS) under the inguinal ligament. The most common site of compression or entrapment is the point where the LFCN exits the pelvis under the inguinal ligament.

Since this sensory nerve innervates the skin of the anterior-lateral thigh, entrapment usually creates sensory disturbances. Studies have shown that patients with an anatomic variant which causes the LFCN to traverse closer to the ASIS are more prone to this condition.[1,2] This variant causes the LFCN to exit the pelvis through a tighter space.

External Causes

While anatomical variations may predispose certain patients to develop meralgia paresthetica, external pressure on the LCFN can also cause this disorder. Military body armor, police belts, workman belts, seat belts, or any external pressure compressing the LCFN, such as leaning over the hood of a car can lead to meralgia paresthetica.[3]

Additional causes of MP which have been cited include surgery,[4] and weight gain (even by pregnancy).[5] A study conducted at the Mayo Clinic found that diabetics were 7 times more likely to have MP.[6]

Surprisingly, modern fashion has been the culprit in causing a recent surge in the occurrence of meralgia parethestica. Skinny jeans have been cited as the cause of an increase in the number of young people suffering from this condition. Combining skinny jeans and high heels (which anteriorly tilt the pelvis and increases the likelihood of LCFN compression) increases the likelihood of developing MP, even earning its own colloquial diagnosis: *Skinny Jeans Syndrome*.

Symptoms of Meralgia Paresthectica

- Burning pain of the skin (versus deep pain), which feels like a sunburn, of the anterior-lateral thigh

- Paresthesia of the anterior lateral thigh
- Numbness
- Magnification of symptoms by wearing body armor, loadbearing belts, tight belts, or "skinny jeans"
- Worse with pregnancy or obesity

Diagnosis

The diagnosis of meralgia paresthetica is almost always a clinical diagnosis, versus a diagnosis based on objective observable technology. Diagnostics such as X-ray, CT, MRI, and diagnostic ultrasound can only rule out other conditions, but they cannot confirm the diagnosis of this malady. The diagnosis of MP can be made through history, presentation, examination, and clinical deduction. Particularly helpful in making the diagnosis is the pain distribution pattern, a clearly defined cause (like the physical pressure of body armor), and a positive Tinel's sign of the LCFN or tenderness of the nerve where it emerges from under the inguinal ligament.

Not all anterolateral thigh paresthesia is caused by LCFN entrapment. Disc herniation, spinal stenosis, and other sources of nerve root lesions of the upper lumbar (L2-L3) spine may also cause these symptoms.[7] Nerve root lesions may exhibit motor, reflex, and MRI findings, whereas MP only has sensory findings.

The orthopedic test, *femoral nerve stretch test,* may be positive in both nerve root lesions and in LCFN entrapments, so this test is not beneficial in differentiating between the two conditions.

Treatment

The simplest treatment for any condition is to take away the cause. If the patient is wearing tight clothes, belts, loadbearing belts, then those should be removed. If the patient is obese, then weight loss would be the primary treatment. While there is a lack of strong evidence for any one treatment to be particularly effective, there are plenty of conservative treatments which can be started on a trial basis, and if effective, continued. Other conservative treatments could include myofascial mobilization of the inguinal ligament, neuro-mobilization techniques, stretching, pin-and-stretch techniques, passive modalities such as cold laser, and, of course, chiropractic adjustments.

Medical treatment may include drugs intended to treat nerve pain (like gabapentin), nerve blocks, neurotomy, lidocaine, and corticosteroid injections.

Three Cases

Here are how three cases of meralgia paresthetica have presented in my practice.

The first case was post-surgery. The patient woke up after surgery with burning pain in the lateral thigh. After ruling out nerve root involvement, we concluded that pressure from position or pressure (from possibly be leaned on) while the patient was anesthetized was the most likely cause. The patient's symptoms were very superficial and could be replicated by finding the irritated LCFN through palpation as it emerged from under the inguinal ligament and tapping on it, a positive Tinel's sign. This patient failed to respond to conservative care.

Case two: A male patient in his sixties reported with acute onset of lateral leg pain. He had recently gained weight, but continued to wear the same size trousers, which were now worn below his belly fat. The patient's belt was worn more tightly and lower than previously. A positive Tinel's test was noted along the lateral inguinal ligament on the affected side. The patient was encouraged to wear more loose fitting trousers, to use suspenders instead of a belt, and to lose weight. His symptoms resolved within three weeks.

Case three: A soldier presented who had worn body armor that put pressure on the anterior lateral pelvis when he rode "shotgun" in a vehicle with his right leg raised. The raised right leg allowed his elbow to rest on his thigh to enhance his ability to hold his rifle "at the ready" for long periods. The pressure of his body armor compressed the LCFN and led to MP. He responded to chiropractic adjustments and pin-and-stretch techniques, along with instrument assisted myofascial manipulation.

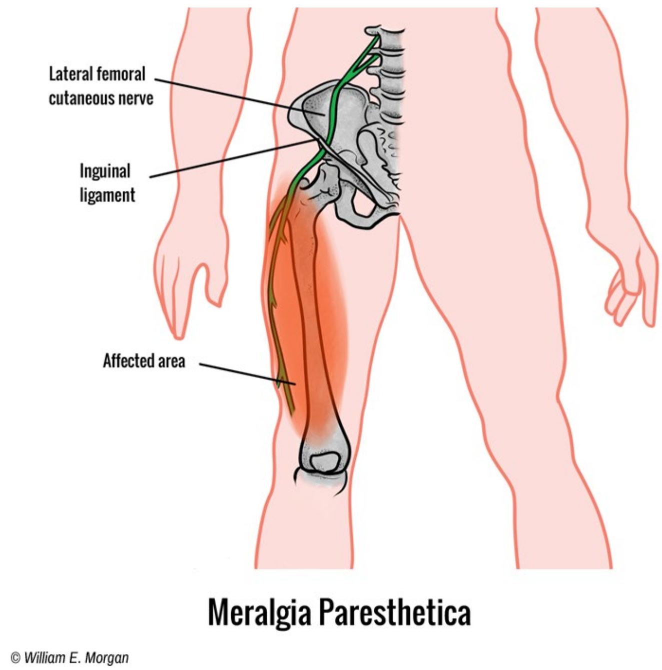

Figure 1. The lateral cutaneous femoral nerve exits the pelvis near the ASIS and under the inguinal ligament, where it is most frequently entrapped. The LCFN innervates the skin of the anterolateral thigh (shaded region).

Figure 2. Body armor, police belts, and loadbearing carpenter belts can all place pressure on the lateral cutaneous femoral nerve resulting in meralgia paresthetica: pain, paresthesia, numbness, or tingling of the anterolateral thigh.

Conclusion

Meralgia paresthetica is a relatively common sensory mononeuropathy that in some cases may be a source of refractory pain, or it may resolve with something as simple as losing weight and wearing loose fitting clothing. It may be mistaken for an L2-L3 nerve root lesion or other neuropathies. Every musculoskeletal provider should be familiar with this condition and be able to diagnose it.

[1] Moritz T, Prosch H, Berzaczy D, Happak W, Lieba-Samal D, Bernathova M, Auff E, Bodner G. Common anatomical variation in patients with idiopathic meralgia paresthetica: a high resolution ultrasound case-control study. Pain Physician. 2013 May-Jun;16(3):E287-93.
[1] de Ridder VA, de Lange S, Popta JV. Anatomical variations of the lateral femoral cutaneous nerve and the consequences for surgery. J Orthop Trauma. 1999 Mar-Apr;13(3):207-11.
[1] Fargo MV, Konitzer LN. Meralgia paresthetica due to body armor wear in U.S. soldiers serving in Iraq: a case report and review of the literature. Mil Med. 2007 Jun;172(6):663-5.
[1] Grossman MG1, Ducey SA, Nadler SS, Levy AS. Meralgia paresthetica: diagnosis and treatment. J Am Acad Orthop Surg. 2001 Sep-Oct;9(5):336-44.
[1] Mondelli M1, Rossi S, Romano C. Body mass index in meralgia paresthetica: a case-control study. Acta Neurol Scand. 2007 Aug;116(2):118-23.
[1] Parisi TJ1, Mandrekar J, Dyck PJ, Klein CJ. Meralgia paresthetica: relation to obesity, advanced age, and diabetes mellitus.Neurology. 2011 Oct 18;77(16):1538-42.
[1] Trummer M, Flaschka G, Unger F, Eustacchio S. Lumbar disc herniation mimicking meralgia paresthetica: case report. Surg Neurol. 2000 Jul;54(1):80-1.

The Clinical Significance of the Sacrotuberous Ligament

Lumbopelvic Pain (Part Four)

To be a master clinician you must become proficient in clinical anatomy, striving to unlock the mysteries of anatomy, optimum human function, and sources of dysfunction. Over the years I have learned that there are certain anatomical crossroads which lend themselves to patterns of dysfunction and injury. Certainly most of us are familiar with some of these anatomic junctions where dysfunctions are common: the carpal tunnel, the piriformis, the thoracic outlet, the iliotibial band, the inguinal ligament, the sacroiliac joint, the plantar fascia , and of course, the spine. Here I will present another clinically significant anatomical juncture, *the sacrotuberous ligament, the pudendal nerve, and the sacrospinous ligament.*

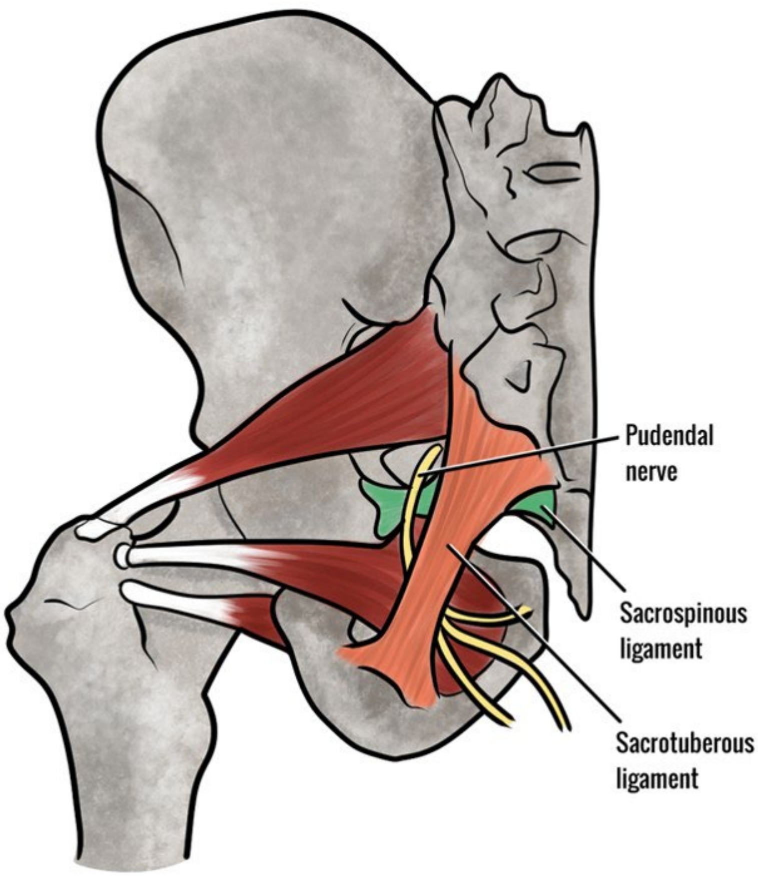

Figure 1. The pudendal nerve travels between the sacrotuberous ligament and the sacrospinous ligament.

I was first introduced to the clinical significance of the sacrotuberous ligament and the sacrospinous ligament by my instructor Patrick Montgomery at Palmer-West. Dr. Montgomery was a favorite instructor for most of the students at Palmer. This was due to his very practical clinical knowledge in chiropractic technique. He taught Logan Basic technique at Palmer-west.

Hugh Logan heavily emphasized the treatment of this ligament for patients with spine conditions, not simply for low back pain. He believed a very light and precisely vectored contact on the sacrotuberous ligament would normalize the sacral position and through that, affect the entire spinal column; in fact he believed that other subluxations of the spine to be self-correcting if only the primary sacral subluxation were corrected. While I acknowledge the intent of Dr. Logan's technique for correcting subluxations, this article will concentrate on using his technique to treat pudendal neuralgia.

The Anatomical Significance of the Sacrotuberous Ligament

The sacrotuberous ligament arises from the posterior sacrum, and the upper coccyx, with its fibers blending into the complex network of the posterior ligaments of the sacrum connecting this ligament to the posterior superior iliac spine. It extends to the ischial tuberosity. The sacrotuberous ligament contributes to the strength of the pelvis, inhibits nutation, and provides an attachment point for muscles (gluteus maximus and the long head of the biceps femoris). Some fibers of the long head of the biceps femoris attach to the sacrotuberous ligament (sometimes absent in anatomical variants),[1] and the inferior fibers of the gluteus maximus attach to it as well. Some authors have credited the biceps femoris with providing an active component to sacroiliac stabilization. While far from providing conclusive evidence, some clinical studies have linked normal hamstring function to the enhancement of sacroiliac stability.[2] Additionally, sacroiliac dysfunction has been associated with gluteus maximus weakness. [3,4] The sacrotuberous ligament is clearly a significant component in joining the myofascial trains of the lower extremities to the upper body.

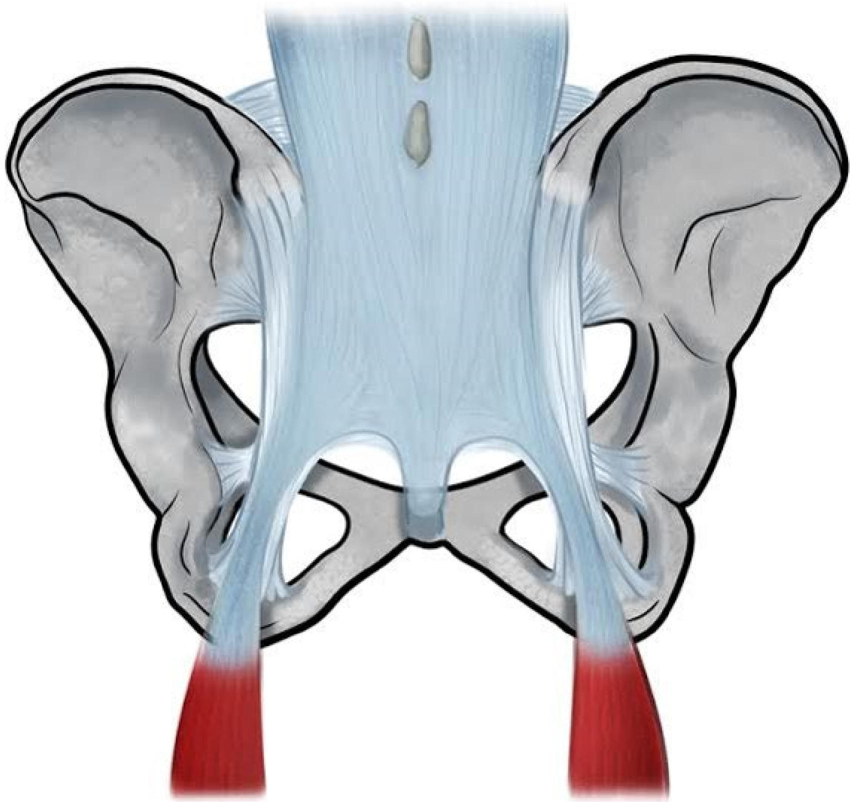

Figure 2. The long head of the biceps femoris blends into the fibers of the sacrotuberous ligament. This provides an active component to the mechanics of pelvic stability and motion. Flexion of the femur or increased tone of the biceps femoris can put tension on the sacroiliac joint.

Another ligament in this region, the *sacrospinous* ligament, is deep to the sacrotuberous ligament. It arises from the lateral sacrum and coccyx and attaches to the spine of the ischium (figure 1). Of clinical significance is that the pudendal nerve travels between these two ligaments and can become entrapped.

Pudendal Nerve Entrapment

Pudendal nerve entrapment between the sacrotuberous and sacrospinous ligaments can result in pudendal nerve neuralgia. Pudendal nerve entrapment can result in recurrent pain or numbness of the genitals, rectal pain, reduced awareness of an impending bowl movement, disturbance of normal urination (including overactive bladder), altered sensation during ejaculation, and urinary or bowel incontinence.

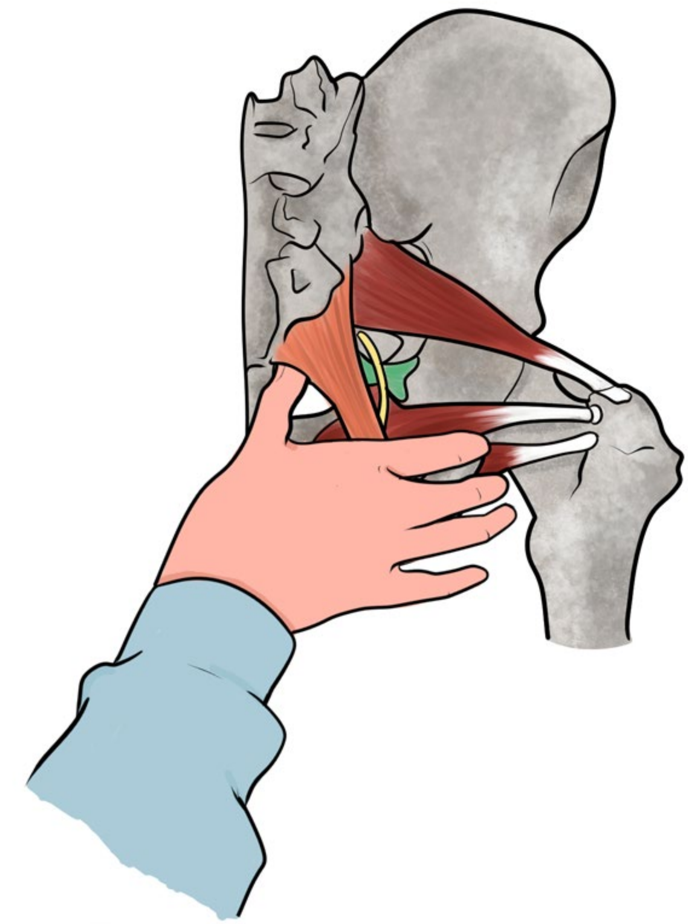

Figure 3. By contacting the anterior portion of the sacrotuberous ligament and applying pressure anterior to posterior and obliquely superior, the ligament can be lifted from the pudendal nerve.

Pudendal nerve entrapment can be profoundly life altering, but due to the intimate nature of the symptomatology, many people suffer in silence. Medical treatment for pudendal neuralgia includes pain injections, surgical decompression, and drugs. Chiropractic options include adjustments, pelvic floor myofascial treatment, modalities (such as cold lasers), and my preferred method, the Logan Basic Technique.

Manual Treatment of the Sacrotuberous Ligament

While I cannot adequately describe all of the specifics, principles, and techniques which comprise Logan Basic Technique in this article, I will share the basic concept of the contact and my adaption of this technique. For a more detailed instruction, I recommend a technique class on the subject.

The patient is positioned in a prone position, flexed slightly at the waist, and at the knees, with any outer restrictive clothing removed. The doctor is contralateral to the side being treated. The doctor palpates to locate the coccyx and then palpates out lateral from the coccyx to find a web-like structure which will feel similar to the web between your fingers. This web is the sacrotuberous ligament. The doctor will then hook the tip of the thumb under the anterior portion of the ligament and distract posteriorly, slightly oblique, and superior. The pressure is light but constant. The direction of pressure can be altered gradually and slightly. While maintaining the contact, the basic technique would have you palpate the paraspinal muscles for feedback to determine when to change the contact or discontinue. I usually perform the contact for 45-60 seconds.

While I would be the first person to admit that the success of this technique is based almost exclusively on clinical outcomes and that there should be more research to validate its success in treating pudendal neuralgia, I would also be the first to tout the numbers of referrals from medical providers at our hospital for treatment of this malady with this technique.

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[1] Vleeming, A., R. Stoeckart, et al. (1989). “The sacrotuberous ligament: a conceptual approach to its dynamic role in stabilizing the sacroiliac joint.” Clinical Biomechanics 4(4): 200-203.
[2] Cibulka MT, Rose SJ, Delitto A, Sinacore DR. Hamstring muscle strain treated by mobilizing the sacroiliac joint. Phys Ther 1986;66:1220–3.
[3] van Wingerden JP, Vleeming A, Buyruk HM, Raissadat K. Stabilization of the sacroiliac joint in vivo: verification of muscular contribution to force closure of the pelvis. Eur Spine J 2004;13:199–205.
[4] van Wingerden JP, Vleeming A, Kleinrensink GJ, Stoeckart R. The role of the hamstrings in pelvic and spinal function. Vleeming A, Mooney V, Snijders CJ, Dorman TA, Stoeckart R, editors. editors. Movement, stability and low back pain: the essential role of the pelvis 1997. New York: Churchill Livingstone; 207–10.
[5] Marios Loukas,Robert G Louis Jr, Barry Hallner, Ankmalika A Gupta and Dorothy White. (2006) “Anatomical and surgical considerations of the sacrotuberous ligament and its relevance in pudendal nerve entrapment syndrome” Surg Radiol Anat 28(2): 163-169.
[6] Cooperstein R, Lisi A, Burd A. Chiropractic management of pubic symphysis shear dysfunction in a patient with overactive bladder. J Chiropr Med. 2014 Jun; 13(2): 81–89.

Functional Symmetry Through Asymmetrical Training

Most chiropractors strive for symmetry. Whether looking at radiographs, performing range of motion analysis, postural analysis, strength training, or EMG analysis, we like symmetry. Ironically most activities of life, sport, work, and survival are asymmetrical. Consider these asymmetrical activities of life: carrying groceries or a tool box, swinging a hammer, shoveling, sweeping, eating, using the mouse for your computer, carrying a small child, or gardening. These activities are performed with a dominant side performing most of the work. Functional asymmetry abounds. Asymmetry is even more obvious in athletics: tennis and all racquet sports, golf, baseball, boxing, martial arts, basketball, football, and lacrosse. These activities require propulsion, primarily from one lower extremity, with the core stabilizing to transmit power. Think of a football lineman driving forward. One leg drives him forward, then the other. Meanwhile his core and upper extremities rapidly shift to adapt

to the various resistances and obstacles he encounters.

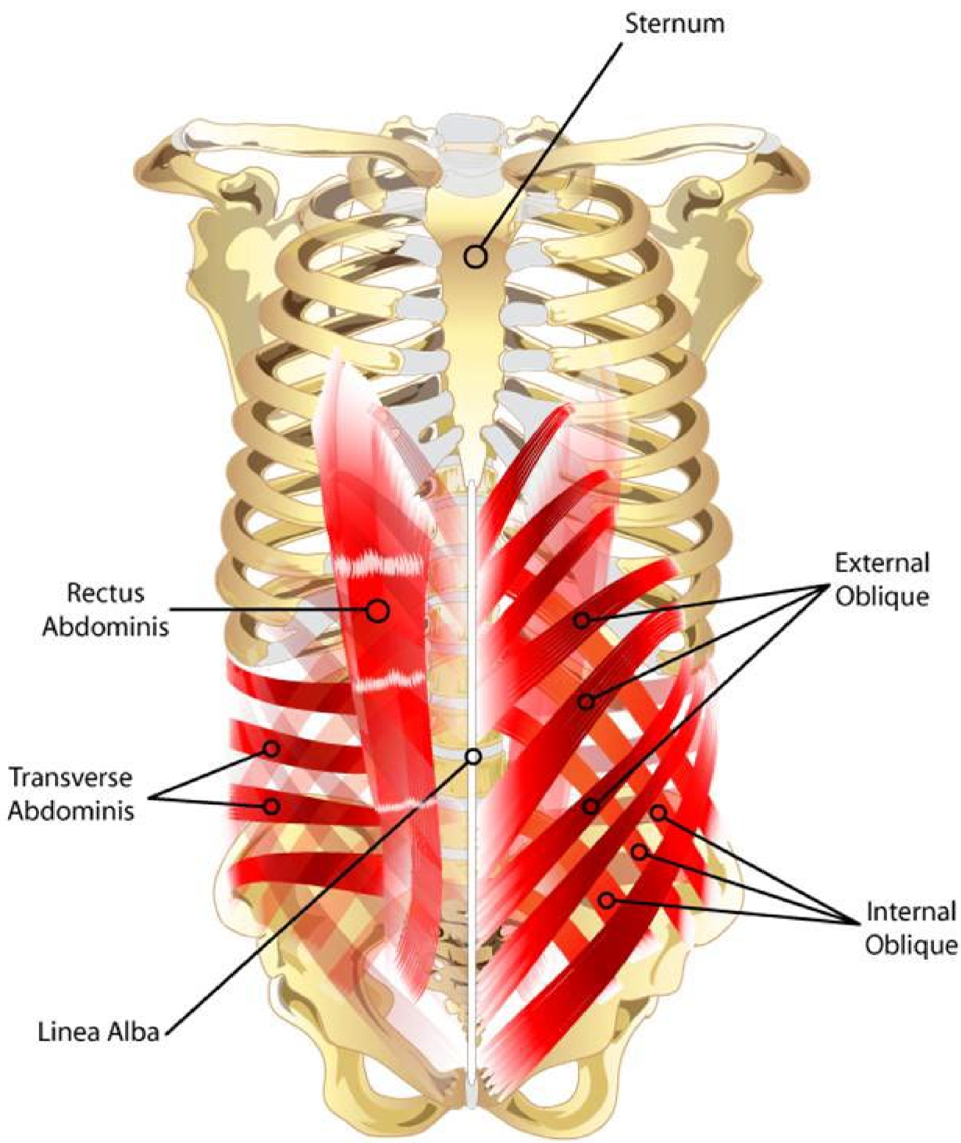

Image 1: The muscles of the core are interconnected and designed to work together in reaction to asymmetrical loads and challenges. They should not be trained in isolation, but with functional exercise programs.

Even seemingly symmetrical activities like swimming, bicycling, walking, and running are a synchronized, coordinated concert of alternating one-sided exertions. These activities require an alternating one-sided contraction of the muscles of stabilization and the muscles of propulsion.

We function in asymmetry. So why to do we train almost exclusively in symmetrical workouts? Most gyms and rehabilitation facilities still utilize balanced, symmetrical resistance loading. Think of the exercises which are most often utilized at gyms: bench press, squatting, barbell curls, pulls downs, leg presses, leg curls, and certainly most weight lifting machines. These symmetrical exercises train our muscles in a way they are not utilized in daily function. To maximize function and performance, we should train and rehabilitate our patients with asymmetrical loads and balance.

Image 2: Farmer walk with an asymmetric load.

Most people separate their physical training routines into strength training, core training, aerobic exercise, and flexibility as if each of these categories is mutually exclusive. Consider an exercise like the lunge walk with overhead weight (image 3). It enhances hip motion, works global body strength and the core, and if done correctly, will certainly work the cardiovascular system. This type of training has benefits that transfer into normal activities and sports much better than symmetrical exercises and the use of weight lifting machines.

The spine is a flexible column, not a hinge joint; so we should not train the muscles supporting the spine like we would a hinge joint. We should not perform sit-ups, crunches, or other truncal flexion exercises. We should train the core muscles to work in harmony with the extremities. The core is designed to inhibit spinal motion and transfer power. So training it by placing it under an asymmetrical load will train the core as it was designed. Symmetry of strength, flexibility, and stamina is achieved through training each side with the same exercise and weight.

Image 3: Lunge walking with an overhead barbell. While not appropriate for everyone, this exercise combines flexibility, balance, and engagement of most of the muscles of the body.

There are many exercises which can be incorporated into an asymmetrical exercise or rehab program. Some of these exercises are too advanced for patients with high levels of dysfunction. These may be more appropriate for enhancing sports performance and injury prevention than for patients in the early stages of healing. The use of dumbbells, kettle bells, sand bags, pulleys, ropes, sleds, elastic bands, medicine balls, and sand balls are great tools for asymmetrical functional training. Next is a sampling of exercises which challenge the core with asymmetrical stresses.

- Single leg, single arm deadlifting
- Lunge walking
- Lunge walking with a weight (barbell, kettle bell, or dumbbell) in one hand or overhead in one hand.
- Standing one arm pulley exercises
- Farmer walking (image 2)
- One arm overhead presses
- Turkish get up
- Sled pushing
- One-armed clean and presses
- Squatting with a weight in one hand

Training to enhance performance and to rehabilitate patients following injury should emphasize functional motion patterns that provide a benefit which transfers to real life activities. Certainly not every patient should be put on an advanced program of asymmetrical loading. But if you are not training for function, you are training for dysfunction.

Image 4: Weighted sled pushing.

Image 5: Sandbag lunge walking.

Image 6: Pulleys and elastic tubing can be used to create asymmetrical loads while exercising.

Chiropractic Management of Lower Extremity Disorders: The Hallux Joint and Athletic Power (Part 1)

This article is reproduced from the original publication in *Dynamic Chiropractic*.

By William E. Morgan, DC

The importance of normal motion of the great toe (hallux) cannot be overstated. The motion of the great toe into dorsiflexion is extremely important to normal, pain-free gait and to transferring power in running and athletics. The great toe is unique among the phalanges, metatarsals and tarsals for its contribution to optimized foot stiffness in the propulsion portion of gait.

The Importance of First MPI Dorsiflexion

The first metatarsophalangeal joint (MPJ) has a distinctive significance beyond its size, and this joint's ability to dorsiflex is important in the ability to propel us forward with efficiency and speed. Paradoxically, significant motion (dorsiflexion of 65 degrees or more) of the great toe is required for optimized stiffness of the midfoot during the propulsion phase (toe-off) of the gait cycle. (**Figure 1**) Dorsiflexion of the hallux is paramount in maximizing the "windlass" effect for leveraging stiffness and strength in the foot.

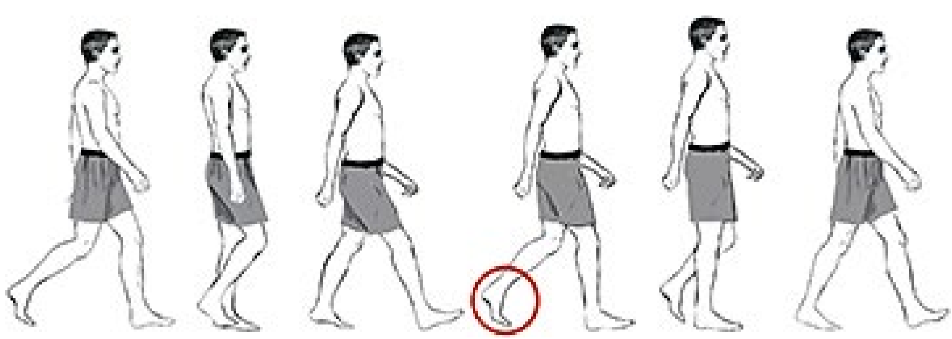

Figure 1: The gait cycle. The fourth figure from the left shows the left foot during the propulsion phase of gait. It is important that the hallux (great toe) is able to adequately dorsiflex during the propulsion phase of the gait cycle to increase foot stiffness and maximize power transfer. A windlass is a simple machine used to lift heavy loads. Through the use of pulleys, ropes and cranks, a windlass magnifies the load-lifting capacity of the operator. The foot has a mechanism that operates much like a windlass pulley system, and this mechanism magnifies the strength of the foot in propulsion during gait.

The Windlass Mechanism

In the foot, the windlass effect results from the combined forces of the extrinsic muscles (gastrocnemius, soleus and tibialis posterior), intrinsic foot muscles, and the tension enhancement created by dorsiflexion of the great toe. This effect is further enhanced by the sesamoid bones functioning as pulleys.

This windless effect increases arch height, plantar fascia tautness and foot stiffness. This allows for an efficient transfer of power and propulsion during the toe-off phase of the gait cycle. Without optimal foot stiffness during the propulsion phase, the midfoot is slackened and less efficient in transferring force. (**Figure 2**)

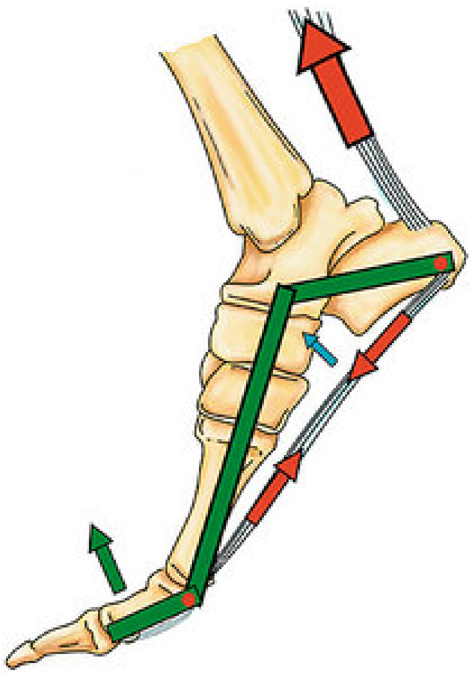

Figure 2: The windlass effect magnifies the power of the foot, particularly with dorsiflexion of the first toe, which adds tension and raises the arch. If the hallux is unable to fully dorsiflex, the foot will not be as stiff during the propulsion phase of gait; this results in pushing off of a slackened (versus rigid) foot. Pushing off of a slackened foot will result in loss of propulsive efficiency and power. This reduces efficiency of gait.

This power drain will need to be made up for high in the kinetic chain, which can lead to injuries higher in the chain, such as the knee, hip, sacroiliac or lumbar spine.

Dizzy Dean's Toe Injury

The importance of the hallux in the global kinetic chain of body is epitomized in the career-ending story of the baseball pitching great, Dizzy Dean, who pitched the 1937 all-star game with a broken toe. His pitching biomechanics were so dramatically altered by the toe injury that by the end of the game, his pitching shoulder was irreparably damaged, forcing him into early retirement. A broken toe resulted in a ruined pitching shoulder.

A dysfunctional hallux can set the stage for injuries throughout the kinetic chain from the foot to the knee, hip, lower back, and even to the shoulder. I am still surprised by the common responses of patients after I've adjusted a fixated hallux: "Doc, I am squatting so much better since you adjusted my toe" or "My knee pain is better." I even have patients with persistent shoulder complaints recover after I've adjusted the foot and ankle.

Hallux Disorders

Turf toe is a first metatarsophalangeal injury commonly attributed to playing on artificial turf. It occurs when the ligaments and cartilage of the great toe are damaged. The term is closely associated with football and the forceful driving off of the great toe and jamming of the great toe during play. However, this injury can also affect athletes in other sports, including baseball players, soccer players, wrestlers, gymnasts and dancers.

One common mechanism of injury in American football may occur when a player's toe is extended and fixed on the ground, and another player lands on the back of their calf. Turf toe can progress and lead to chronic pain, stiffness and progressive degeneration.

Hallux limitus is the diagnosis of a stiffened great toe (big toe). As the name implies, it is characterized by reduced motion of the great toe at the first metatarsophalangeal joint. Hallux limitus may also be characterized by pain and may progress to the more debilitating arthritic condition known as hallux rigidus (a painful, rigid degeneration of the metatarsophalangeal joint).

The hallux limitus may be pain free and not recognized until symptoms occur and it has progressed toward becoming a hallux rigidus. The normal motion of the MPJ is very important in ambulation. This motion also affects the foot, ankle, knee, hip and even the lumbar spine.

Hallux limitus can be detected by testing range of motion of the toe, particularly dorsiflexion of the MPJ; and by motion palpation of the joint through the various planes of motion: anterior to posterior shear, medial to lateral shear, rotation, and long axis distraction. The normal passive range of motion of the MPJ in dorsiflexion is between 50 degrees and 100 degrees. For optimal forward propulsion, the great toe needs at least 65 percent of dorsiflexion. Note that some authors recommend range of motion be tested by observing the patient's gait versus static range-of-motion testing (static testing in open or closed chain).

Hallux rigidus is a painful, rigid degeneration of the metatarsophalangeal joint that tends to worsen with time, which can result in erosion of hyaline cartilage and subsequent debilitating pain. Hallux rigidus may progress to having an exostosis, creating a bony barrier on the dorsum of the joint. This creates a hard barrier to dorsiflexion of the great toe. It is important to identify and treat hallux limitus before it progresses to hallux rigidus.

Differential Diagnosis

Other conditions of the hallux include those which have varied response to manual treatment. I list them more as differential diagnoses, rather than a list of conditions that will respond to adjustments. These conditions include hallux valgus (bunions), hallux varus, gouty arthritis, rheumatoid arthritis, hammer toes, and claw toes. I do not want to generalize the management recommendations of this article to those conditions.

Causes of Hallux Limitus and Hallux Rigidus

While hallux limitus and hallux rigidus have often been attributed to idiopathic origins, there are also some identifiable causes of these conditions:

- Congenital variations in anatomy or genetic predisposition
- Occupational stresses (occupations that require kneeling and pressure on the hallux, such as carpet layers or plumbers)
- Improper footwear: high heels or improperly fitting shoes
- Repetitive stress: ballet dancers, runners, and athletes in general
- Overt injury
- Prolonged immobilization (casting or surgical boots)

The most common causes of hallux limitus are inherited anatomical variations, such an elongated first metatarsal bone or a shortened second metatarsal. Injury, such as stubbing the toe, jams the articular surfaces together, and if severe enough, can lead to chronic joint stiffness, hallux limitus and possibly hallux rigidus.

Resources

- Root ML, Orien WP, Weed JH. Normal and Abnormal Function of the Foot. In: *Clinical Biomechanics, Volume II*. Clinical Biomechanics Corp. Los Angeles, 1977.
- Buell T, Green D, Risser J. Measurement of the first metatarsophalangeal joint range of motion. *J Am Pod Med Assoc*, 1988;78:439.
- Bojsen-Moller F, Lamoreux L. Significance of free dorsiflexion of the toes in walking. *Acta Orthop Scand*, 1979;50:471.
- Hetherington VJ, Johnson RE, Albritton JS. Necessary dorsiflexion of the first metatarsophalangeal joint during gait. *J Foot Surg*, 1990;29:218.
- Nawoczenski DA, Baumhauer JF, Umberger BR. Relationship between clinical measurements and motion of the first metatarsophangeal joint during gait. *J Bone Joint Surg,* 1999*;*81(3):370-6.

Part 2 of this article covers chiropractic management of hallux disorders.

Managing Hallux Hypomobility Disorders (Part 2)

This article is reproduced from the original publication in *Dynamic Chiropractic*.

By William E. Morgan, DC and Clare P. Morgan, DC

In part one of this series we discussed the unique properties and significance of the first toe in the propulsive phase of gait. In particular, we discussed the importance of the first metatarsophalangeal joint (MPJ). The MPJ uses the windlass effect to raise the arch and stiffen the foot during dorsiflexion of the hallux. (**Figure 1**) This stiffness increases the efficiency of the propulsion portion of the gait cycle. To be efficient in creating stiffness, the hallux should be able to dorsiflex at least 65 degrees. The normal passive range of motion of the MPJ is 50-100 degrees.

We also discussed some maladies that impede hallux dorsiflexion. These conditions include hallux limitus, hallux rigidus, and turf toe. Hallux limitus is when the passive dorsiflexion of the first MPJ is 60 degrees or less, and hallux rigidus is when first MPJ dorsiflexion is 30 degrees or less. Conservative management of hallux hypomobility will involve one of two treatment paths.

Three Paths of Allopathic Care, Two Paths of Conservative Treatment

There are two basic conservative options for treating hallux hypomobility: (1) support the MPJ with an orthotic; (2) increase the motion of the MPJ with adjustments and exercise. Both of these treatment options have merit under the proper circumstances and are detrimental under the wrong circumstances. Many patients whose hallux conditions have not progressed too far respond to combining these conservative treatments.

In severe cases of hallux rigidus, the pain and degeneration are so advanced that adjustments and motion-enhancing stretches would be provocative and should be avoided. In these cases, an orthotic or a rocker-bottom shoe can provide pain relief and an artificial stiffness of the foot. While natural movement patterns are always preferred to artificial, there are times that artificial supports will minimize the effects of severe degeneration and should be considered.

There are many types of orthotics that may be used and an incredible divergence of opinion exists on which type of orthotic is preferred. One that is popular with our hospital's orthotic department is a carbon-fiber orthotic, which limits motion of the MPJ while providing stiffness to the medial arch of the foot. This stiffness enhances propulsion, but may place biomechanical burdens upon other joints of the lower extremity, pelvis and spine.

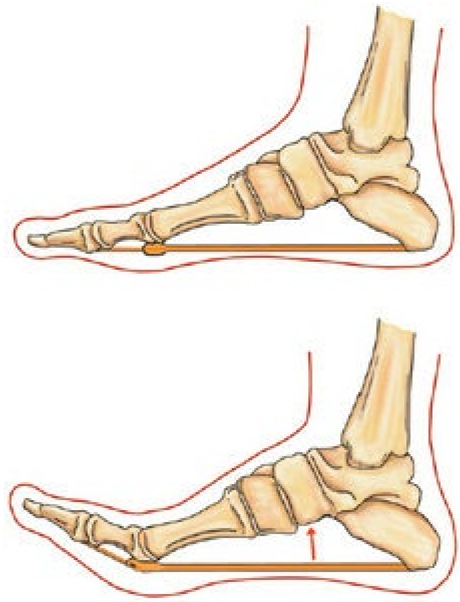

Figure 1: Dorsiflexion of the hallux (bottom image) raises and stiffens the arch of the foot. This motion enhances gait efficiency and propulsive power. Ensuring 65 degrees or more of hallux dorsiflexion will maximize athletic performance. The three treatment options available for allopathic care are essentially drugs, injections or surgery. These all have a place in care, but only after more conservative care has failed, and the patient's pain and dysfunction are refractory.

Determining the Course of Care: Adjustment, Support or Both?

This is a relatively easy question to answer. Patients who feel better with adjustments should start with adjustments; patients whose condition is aggravated by increased motion should be treated with an orthotic. Patients who tolerate motion well, but do not progress, may try a combination of manual care and orthotics. Patients with the following criteria may be better suited for support, rather than adjustments:

- Ankylosis of the MPJ
- Advanced degenerative joint disease
- Exostosis, which limits dorsiflexion of the MPJ
- Sustained pain with normal activities, passive joint motion, joint glides, and adjustments
- A reduction in pain with support from stiff soles, rocker-bottom shoes, athletic taping or a stiff orthotic

Essentially, those who feel better with support should get support; those who feel better with adjustments should get adjustments. Those who fail conservative care may try, in ascending order: oral medication, joint injections and surgical intervention.

Examination Prior to Performing Manual Treatment

In addition to a standardized examination of the patient that would include history, vital signs, systemic review and examination, and an orthopedic and neurologic examination, there should be a dedicated evaluation of the foot. The foot examination should address vascular health: pedal pulses, capillary refill time and visual appearance.

Motion palpation of the hallux is performed by grasping and stabilizing the first metatarsal with one hand and grasping the proximal first phalynx with the other hand. Test the accessory motion of this joint in A-P glide, medial-to-lateral glide, eversion-inversion, and long-axis distraction. Observe for reduced joint motion, fusion, pain, instability or deformation. If uncertain about whether the accessory joint motion is normal or not, motion palpate the other hallux MPJ for comparison.

Absent findings of rheumatological, neurological, endocrinological or vascular diseases, deformation such as hallux valgus, and orthopedic damage such as fractures or soft-tissue damage, manual treatment can be attempted.

Adjusting the Hallux

There are several ways to adjust the hallux. The least traumatic way to increase motion in a hypomobile hallux joint is with low-velocity mobilizations or joint glides. The doctor faces the medial portion of the foot to be treated and with the proximal hand grasps and stabilizes the first metatarsal, and with the distal hand grasps the first proximal phalynx. Then the phalynx is put through these joint glides: anterior-posterior, medial-to-lateral, eversion-inversion, and long-axis distraction. The glides should be smooth and controlled mobilizations of the joint.

Figure 2: Adjusting the hallux with a "pistol grip." If joint glides are well-tolerated, the doctor may progress to an impulse. Motion palpate the various aspects of hallux MPJ accessory motion. If a fixation is perceived, give a high-velocity, low-amplitude impulse through the fixation.

Adjusting the hallux with a "pistol grip." The doctor grasps the MPJ of the hallux between the index and middle finger of the lateral hand. The medial hand supports the grasping hand and can provide a gentle medial-to-lateral pressure. (**Figure 2**) The doctor distracts the joint to tension and then provides a quick, long-axis distracting impulse.

There are many ways to treat the hallux, and we are only introducing a few in this article. These techniques are best observed in our video instruction.

Soft-Tissue Mobilization and Self-Mobilization

Figure 3: Instrument-assisted release / mobilization of the plantar fascia. In addition to articular restrictions, myofascial restrictions of the flexor tendons, plantar fascia, and joint capsule may restrict motion of the hallux.

We recommend using instrument-assisted myofascial mobilization and release techniques, such as Graston technique, for treating adhesions in the plantar fascia (Figure 3) and freeing the capsular ligaments of the hallux. Pin-and-stretch techniques applied to the plantar fascia and the muscles of the calf can also improve hallux motion.

Patients also should be taught to self-manage conditions like hallux limitus and hallux rigidus. Teaching them various ways to self-mobilize or stretch their hallux will aid in long-term relief and correction. The first self-treatment technique that we impart to patients is simply stretching the hallux into dorsiflexion. There are several ways to do this, but we do not have the space in this article to address them all.

[**Editor's Note:** *Several other demonstration videos, including a video on stretching the hallux, accompany the app version of this article in Dynamic Chiropractic.*]

Final Points / Considerations

While this article has discussed only one of the 33 joints found in the foot, we do not intend for the reader to treat this one joint in isolation. When we treat the hallux, we also evaluate every joint in the foot and the entire kinetic chain. We frequently will treat several other components of joint dysfunction in one patient.

Not every hypomobile joint should be adjusted. There are certain contraindications that should be respected: malignancy, bone disease, fractures, joint replacements or fusions, inflammatory joint disease (gout, RA) and joint ankylosis. Patients with these contraindications should not be adjusted.

Finally, the information in this article is not generalizable to other conditions of the hallux. For example, advanced hallux valgus, severe hallux rigidus, gouty arthritis, rheumatoid arthritis, and other inflammatory conditions should not be treated with high-velocity adjustments. Chiropractic adjustments may be provocative to these conditions, and prescribing an orthotic or obtaining protective footwear may be a good first step in conservative management.

Resources

- Cotterill J. Stiffness of the great toe in adolescents. *Br Med J*, 1887;1(1378):1158.
- Bergman T, Peterson D. *Chiropractic Technique Principles and Procedures, 3rd Edition*. Mosby; New York, 2010.
- Mennell JM. *Joint Pain*. Little Brown and Company, 1964.
- Root ML, Orien WP, Weed JH. *Normal and Abnormal Function of the Foot - Clinical Biomechanics, Volume II*. Clinical Biomechanics Corp. Los Angeles, 1977.
- Buell T, Green D, Risser J. Measurement of the first metatarsophalangeal joint range of motion. *J Am Pod Med Assoc*, 1988;78:439.
- Bojsen-Moller F, Lamoreux L. Significance of free dorsiflexion of the toes in walking. *Acta Orthop Scand*, 1979;50:471.
- Hetherington VJ, Johnson RE, Albritton JS. Necessary dorsiflexion of the first metatarsophalangeal joint during gait. *J Foot Surg*, 1990;29:218.
- Nawoczenski DA, Baumhauer JF, Umberger BR. Relationship between clinical measurements and motion of the first metatarsophangeal joint during gait. *J Bone Joint Surg*, 1999;81(3):370-6.
- Manral DB. Hallux rigidus: A case report of successful chiropractic management and review of the literature. *J Chiropr Med*, 2004 Winter;3(1): 6-11.

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Appreciating Knee Function: The Amazing Four-Bar Mechanism

This article is reproduced from the original publication in *Dynamic Chiropractic*.

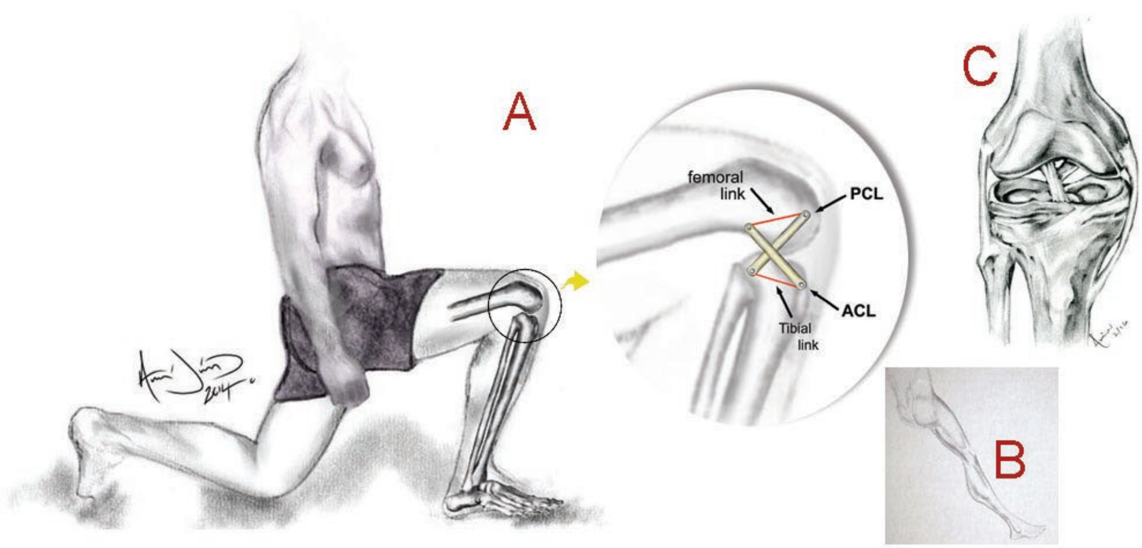
By William E. Morgan, DC and Amin Javid, DC

On first blush, the knee joint may appear to be a relatively simple, stable joint that hinges through a single pivot point with several key anatomic points of strength. Yet if one takes a detailed look at the anatomy and function of the knee, its complexities quickly become evident.

The knee joint is not simple; it is a complex compound joint that deserves a deep appreciation from musculoskeletal clinicians.

The knee is the largest synovial articulation and has the largest synovial reservoir in the human body. It is not a hinged joint, but is considered a complex compound joint due to the irregular joint surfaces, the menisci, the presence of intra-articular ligaments (anterior cruciate and posterior cruciate), and the compounded articulations of the tibia with the femur and the patella with the femoral condyles.

More than a dozen muscles cross the knee joint. Additionally, several other joints and muscles contribute to the motion, function and stability of the knee.



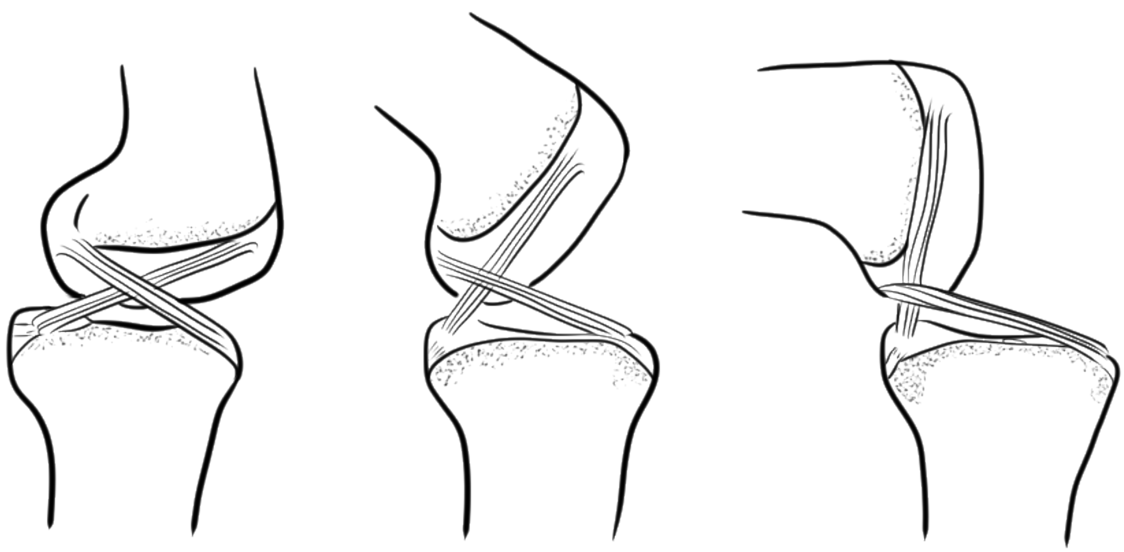
The Four-Bar Mechanism

To many clinicians, it may appear that the function of the anterior cruciate and posterior cruciate ligaments (ALL and PLL) is to limit anterior and posterior shear of the knee, as well as prevent rotation of the tibia in relation to the femur. This is what we were taught in orthopedics as we learned to perform the drawer and Lachman's tests of the knee.

In reality, the function of these ligaments is more than merely their contribution to knee stability. These ligaments are vital in transferring power from the muscles of the hip and pelvis (particularly the gluteus maximus and medius) to the leg. This transfer of power is done through the *four-bar mechanism* created by the degree of tension of these ligaments, and the stiffness of the tibia and femur.[1-4]

A four-bar mechanism is a simple closed-chain linkage composed of four bars (also referred to as links) and joined by four pivoting connections.[5] This mechanism provides efficiency of motion, strength and stability.

Examples of four-bar mechanisms in engineering include vise-grips, lever-armed water pumps, car jacks, oil well pumps, folding chair mechanisms, and umbrellas. This mechanism is so efficient that many of the more modern prosthetic knees (for above-the-knee amputations) are now made with four-bar linkages. Researchers are trying to emulate this naturally occurring mechanism in knee-replacement prostheses.



The four-bar mechanism of the knee is a relatively simple apparatus that transfers power while maximizing leverage and minimizing energy loss. It is part of a broader *biotensegrity system*, which combines contractile and non-contractile tissues to efficiently transfer power and motion through the musculoskeletal system with minimal energy expenditure.

The four links transfer power and motion from relatively distant sources of power through a driver. In the knee, the femur, which is the longest lever in the body, acts as the driver as it transfers power from the gluteal muscles through its stiffness and strength to create tension on the ALL and PLL. This tension moves the femur relative to the plane(s) of the tibial plateau.

(It should be noted that the four-bar mechanism of the knee does not exactly mirror man-made mechanical models of four-bar machines. The ACL and PCL are relatively stiff only while under load, and even when under load, they maintain some elasticity.)

Certainly the ALL and PLL do not work autonomously in transferring power. The lower extremity is a complex aggregate of structures that includes ligaments, muscles, joint capsules and fascia. There is a concert of activity between these structures during knee motion.

Four Bar Mechanism Video Link: https://www.youtube.com/watch?v=wWvB3lNYXB0

While each of these components is important, the gluteal muscles have a prominent role in both power transfer and protection of the knee.[6-10] This knee-gluteal muscle relationship is particularly interesting since the gluteal muscles do not directly attach to or even reside near the knee.

Closed-Chain Motions vs. Open-Chain Motions

Closed-chain motions of the lower extremities are motions such as lunges or squatting motions during which the feet are in contact with the ground or another immobile surface. Open-chain motions of the lower extremity are motions or exercises that allow the foot to move freely, such as leg extensions or leg curls.

The four-bar mechanism of the knee is particularly valuable at transferring power and motion from the muscle of the hip and pelvis while in closed-chain, yet may be less effective in open-chain. Rehabilitation and performance enhancement training should emphasize closed-chain exercises like squatting motions, kettlebell swings, lunges, and lunge walks; and de-emphasize open-chain exercises such as the leg extension.

The Problem With Leg Extensions

In athletics and activities of daily living, muscles do not work in isolation. Because of this, it is unwise to train muscles in isolation. The leg extension machine isolates the quadriceps in an open chain and places the ACL under considerable and constant load while the exercise is being performed.[11-13] Leg extensions also place considerable shear force through the knee joint.[11]

Twenty years ago, leg extension machines were found in most rehabilitation facilities, although now they have all but vanished. Functional-minded gyms and cross-fitness facilities typically do not have these machines or other muscle isolation machines that became popular in the bodybuilding culture of the 1960s and 1970s.

Training the legs using an open-chain apparatus like the leg extension machine has little correlation to athletic performance or activities of daily living. In fact, "kicking" may be the main open-chain athletic motion the leg extension exercise simulates in any semblance.

Certainly leg extensions should be avoided by patients with ACL injuries and/or post-knee-surgery patients. We as physicians should also steer our other patients away from this potentially harmful exercise. The trend in knee rehabilitation and athletic training is away from the use of open-chain machines like the leg extension machine.

Clinical Applications

While we will endeavor to further develop clinical applications in upcoming installments of this series, here are some applications that can be applied from knowing that the knee joint is a very effective mechanism at transferring forces from the hip and pelvis:

- In older patients or patients who have difficulty in performing sit-to-stand motions, you should train the patients to activate and use their gluteal muscles to stand from a sitting position. (We will address the details of this in a future installment in this series.)
- Train the muscles of the lower extremity in closed-chain motions like lunges, squatting motions and gluteal bridging; and de-emphasize open-chain exercises such as the leg extension and the leg curl.
- Remember that strong, activated gluteal muscles protect the knee from injury and enhance athleticism.

The mechanism that accounts for gluteal protection of the knee will be addressed in the next installment of this ongoing series on chiropractic management of lower extremity disorders.

Editor's note: Review the first two articles in this series on lower extremity disorders in the Jan. 15 and March 1 issues.

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The Gluteal-Knee Connection: Part Two

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By William E. Morgan, DC and Amin Javid, DC

Artwork by Amin Javid

The Gluteal-Knee Connection: Part Two

The underlying causes of knee pain and dysfunction are rarely isolated to the knee. The knee is a relatively stable joint with limited intrinsic ability to adapt to aberrant motion. Usually when there is a problem with the knee, it originates in the foot/ankle complex or in the hip region. The foot and the hip have the ability to adapt and accommodate to changes in gait, terrain, and directional forces much better than the knee. In our last article we shared how the gluteal muscles contribute to hip extension and the transference of motion and power to the leg through the knee in a sagittal (flexion/extension motion) plane. In this installment we will discuss how the gluteus maximus (GM) muscle also affects the transverse (internal and external rotational) planes of motion of the lower extremities. Though we are emphasizing the gluteal muscles and knee in this portion of this series, it is the authors' intent to convey the overall interconnectedness of the body. The lower extremity is an aggregate of many structures that work together to produce locomotion.

Anatomy and Function of the Gluteus Maximus

The gluteus maximus muscle originates medially from the posterior ilium along the gluteal line and the posterior third of the iliac crest, the sacrum, the sacrotuberous ligament and the coccyx **(figure 1)**. One quarter of it inserts into the gluteal tuberosity of the femur, and the remaining three quarters into the iliotibial band (which inserts into the anterior portion of the lateral condyle of the tibia at Gerdy's tubercle).

The action/function of the GM is to extend and externally rotate the hip. The GM also assists in maintaining the knee in extension due to its connection to the anterior portion of the tibia via the iliotibial band.

Weak Gluteus Maximus Muscles and Genu Valgus

Since the primary function of the GM is to externally rotate and extend the knee, a weak or inhibited GM can result in internal rotation of the femur, placing the knee into genu valgus **(figure 2)**. This [genu valgus] position greatly increases the likelihood of an anterior cruciate ligament (ACL) injury.

When athletes fatigue, their gait degrades. If you watch an endurance runner at the beginning of a long race, their gait usually will look better than at the end of the race. This concept can also be applied to other sports and activities. As the muscles fatigue, both the gait and general athletic performance degrades.[i] [ii] [iii] [iv] In regard to the GM, as the athlete fatigues, the knee is more likely to internally rotate. This shift creates the appearance of genu valgus and increases the likelihood of injury, particularly ACL injury. Fatigued athletes are more likely to injure their knees than fresh athletes.[v]

Elements that contribute to the degradation of athletic form resulting from fatigue are multiple. Not only does local muscle fatigue contribute to increased risk of injury, but also metabolic fatigue, aerobic fatigue, and fatigue of the central and peripheral nervous systems.[vi] Fatigue has been cited in contributing to or causing a lag in neuromuscular activation,[vii] reduced coordination,[viii] diminished balance,[ix] and impeded muscle force.[x] [xi] Studies have also shown increased electromyography (EMG) activity of the quadriceps and hamstrings as the GM fatigues.[xii] As a result, optimal performance patterns are substituted with sub-optimal motion patterns that are more likely to contribute to injury.

Conditioning for strength and endurance is important to athletes, but so is managing rest and play time. Weekend-long tournaments in which athletes play one game after another will yield high rates of ACL injuries as fatigue takes its toll. Coaches must rotate players in and out of games to ensure that athletic fatigue does not contribute to injury.

The Female Athlete

Women are much more prone to knee injuries than men. In fact depending on the research, women athletes are two to nine times more likely to have an ACL rupture than their male counterparts.[xiii] The real question is why, and what we do about it. There has been much written about this subject, and there are several theories, but no one reason has been able to fully explain this phenomenon. Some of the possible causes include the wider Q angle (between the pelvis and the femur) found in women due to the fact that they have a wider pelvis **(figure 3).** Other factors unique to women are increased laxity of ligaments, slower reflex time, weaker hamstrings (in relationship to the quadriceps), hormonal effects of estrogen on the strength of the ACL, smaller ACL and intercondylar notch, and poor landing technique when leaping. One factor that can be easily identified and managed is GM weakness.

Determining if a Patient has *Weakness* and/or *Inhibition* of the Gluteus Maximus

Identifying gluteal weakness requires developing a keen eye for internal knee rotation and the appearance of a valgus migration during functional motion. Manual muscle testing may be used to grade more overt weakness, but gait analysis and observation of the patient moving through more functional motor patterns are better methods for identifying more subtle gluteal weakness patterns.

Observing a patient perform single-leg squats can reveal the subtle signs of a weak GM **(figure 4).** The weight bearing leg should remain stable and straight as the patient descends. If the knee migrates medially into a valgus position, this is an indication of GM weakness. A variation of this test is to observe the patient descending stairs, again observing for medial migration of the knee.

A more rigorous evaluation intended for athletes may include squat jumping (repeated jumping and landing into a deep squat). If the knees approximate, it is indicative of weak GM. Some doctors will even analyze the patient while performing single-leg hops or box jumping. The use of video recording with performance analyses software can aid the doctor in analyzing these motion patterns. If the athlete lands or jumps with valgus migration of the knees, the athlete should be coached in motion patterns that avoid genu valgus and internal hip rotation. They should also be instructed in a specific program of GM strengthening.

The advent of coaching, sports performance and analysis software, and mobile device applications has made it easy to record video of functional motions such as running, descending stairs, jumping, and squatting. Using the frame-by-frame play-back to look for medial migration of the knee allows a clear view into a patient's motion patterns. Many of these video applications come with line drawing analysis tools. This technology allows for video to be taken on the sports field or other locations and sent to doctors for analysis.

Management

Determining the management of a patient with GM weakness is dependent upon how far along the patient is in their rehabilitation. An athlete with no overt injury wishing to increase athletic power will start at a higher level of training than a patient recovering from injury. Nonetheless, when considering an athlete, we need to prepare for the higher rate of knee injury that accompanies fatigue and weakness by conditioning the GM for endurance and strength.

For athletes who are intent on improving performance versus rehabilitating from a state of infirmity, we like to include weighted squats with elastic band tubing around the distal thigh, just above the knee. This provides a gentle stimulus and tactile cue that helps them to activate their GM during this motion. Other exercises that may enhance GM activation include hip thrusters from a supine bridge, lunges, kettle bell swings and squats, and box jumping.

A less intense method of exercise would use exercise tubing around the legs, just above the knees, and exercising in a partial squat with the GM activated by abduction and mild external rotation. Additionally "monster" walks, side walking, partial squats, and hip thrusts will stimulate and strengthen the GM. Patients unable to tolerate these exercises may begin with side-lying "clams" and progress through the track.

In addition to conditioning the GM with the intent to increase strength and endurance, aberrant motion patterns should be corrected with technical motion training. This would involve training patients how to properly squat, how to activate the GM while descending stairs, and how to perform other activities of daily living. For athletes, this would include coaching in running, jumping, and agility components of their particular sport. A strong GM plays a protective role in the knee and will increase power in both athletes and the general population.

[i] McLean SG, Felin RE, Suedekum N, Calabrese G, Passerallo A, Joy S. Impact of fatigue on gender-based high-risk landing strategies. Med Sci Sports Exerc. 2007;39:502–514. [PubMed]

[ii] Gabbett TJ. Incidence of injury in amateur rugby league sevens. Br J Sports Med. 2002;36:23–26. [PMC free article] [PubMed]

[iii] Rahnama N, Reilly T, Lees A. Injury risk associated with playing actions during competitive soccer. Br J Sports Med. 2002;36:354–359. [PMC free article] [PubMed]

[iv] Murtaugh K. Injury patterns among female field hockey players. Med Sci Sports Exerc. 2001;33:201–207. [PubMed]

[v] Ortiz A, Olson SL, et al. Fatigue Effects on Knee Joint Stability During Two Jump Tasks in Women. J Strength Cond Res. Apr 2010; 24(4): 1019–1027.

[vi] Kent-Braun JA. Central and peripheral contributions to muscle fatigue in humans during sustained maximal effort. Eur J Appl Physiol Occup Physiol. 1999;80:57–63. [PubMed]

[vii] Chappell JD, Herman DC, Knight BS, Kirkendall DT, Garrett WE, Yu B. Effect of fatigue on knee kinetics and kinematics in stop-jump tasks. Am J Sports Med. 2005;33:1022–1029. [PubMed]

[viii]Coventry E, O'Connor KM, Hart BA, Earl JE, Ebersole KT. The effect of lower extremity fatigue on shock attenuation during single-leg landing. Clin Biomech (Bristol, Avon) 2006;21:1090–1097. [PubMed]

[ix] Greig M, Wlker-Johnson C. The influence of soccer-specific fatigue on functional stability. Physical Therapy in Sport. 2007;8:185–190.

[x] Rodacki AL, Fowler NE, Bennett SJ. Vertical jump coordination: Fatigue effects. Med Sci Sports Exerc. 2002;34:105–116. [PubMed]

[xi] Ronglan L, Raastad T, Borgesen A. Neuromuscular fatigue and recovery in elite female handball players. Scand J Med Sci Sports. 2005;16:267–273. [PubMed]

[xii] Orishimo KF, Kremenic IJ. Effect of fatigue on single-leg hop landing biomechanics. J Appl Biomech. 2006;22:245–254. [PubMed]

[xiii] Prodromos CC, Han Y, Rogowski J, Joyce B, Shi K. A meta-analysis of the incidence of anterior cruciate ligament tears as a function of gender, sport, and a knee injury-reduction regimen. Arthroscopy. 2007;23(12):1320–1325. [PubMed]

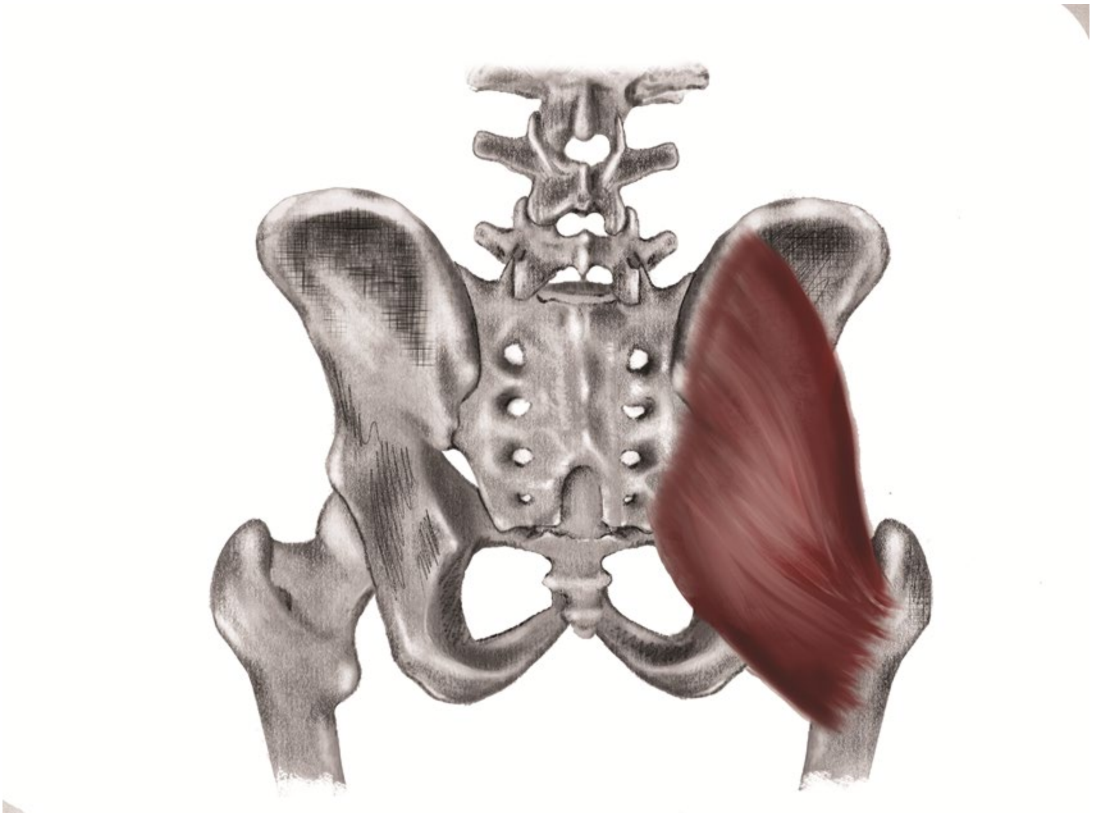


Figure 1. Schematic of the gluteus maximus. The medial to lateral and obliquely superior to inferior orientation of the gluteus maximus results in this muscle extending and externally rotate the hip.

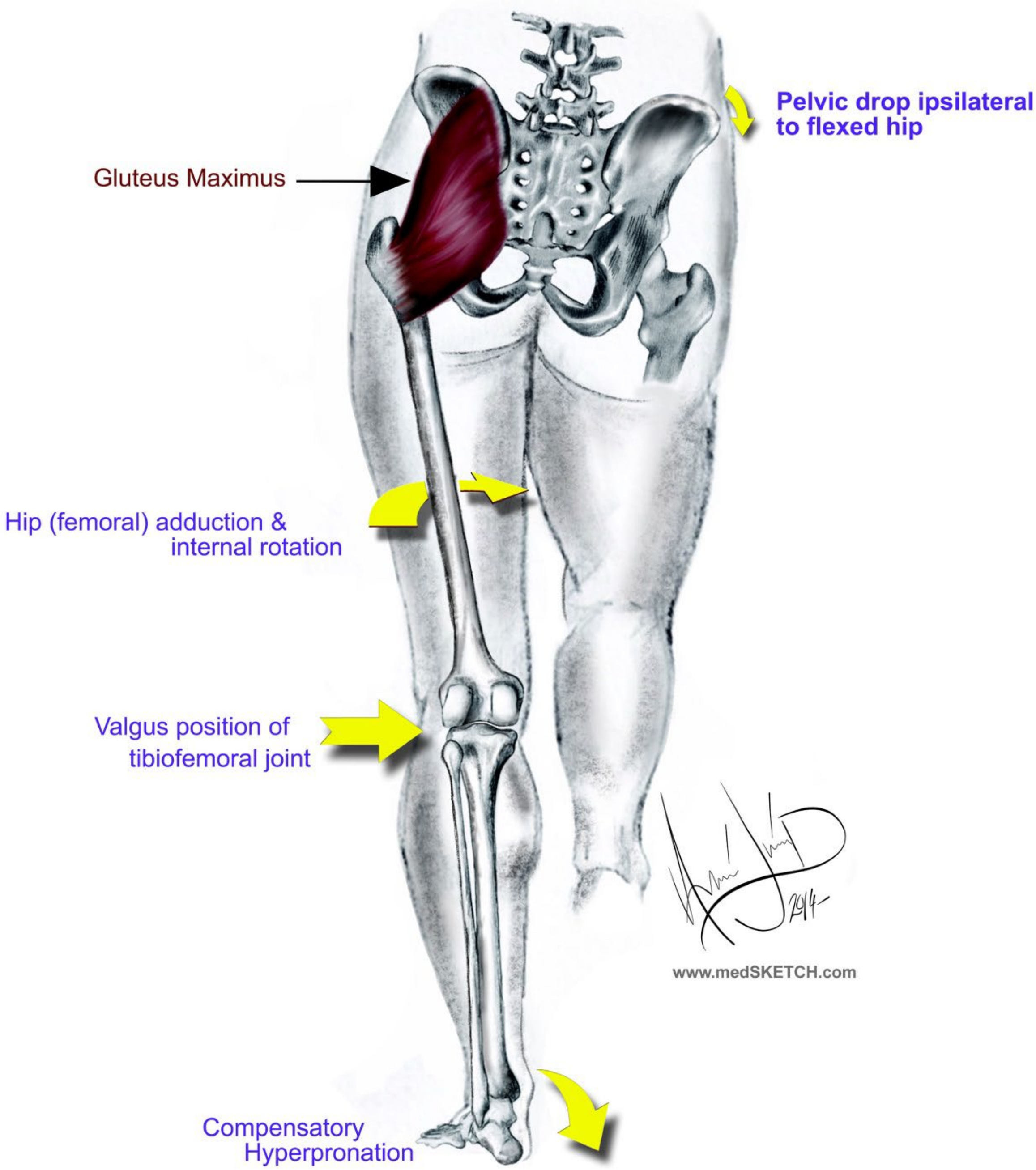


Figure 2. Gluteus maximus weakness creates a cascade of events that increases the likelihood of injury. GM weakness causes a contralateral pelvic lowering, ipsilateral internal rotation of the femur which results in a valgus position of the knee and compensatory hyperpronation.

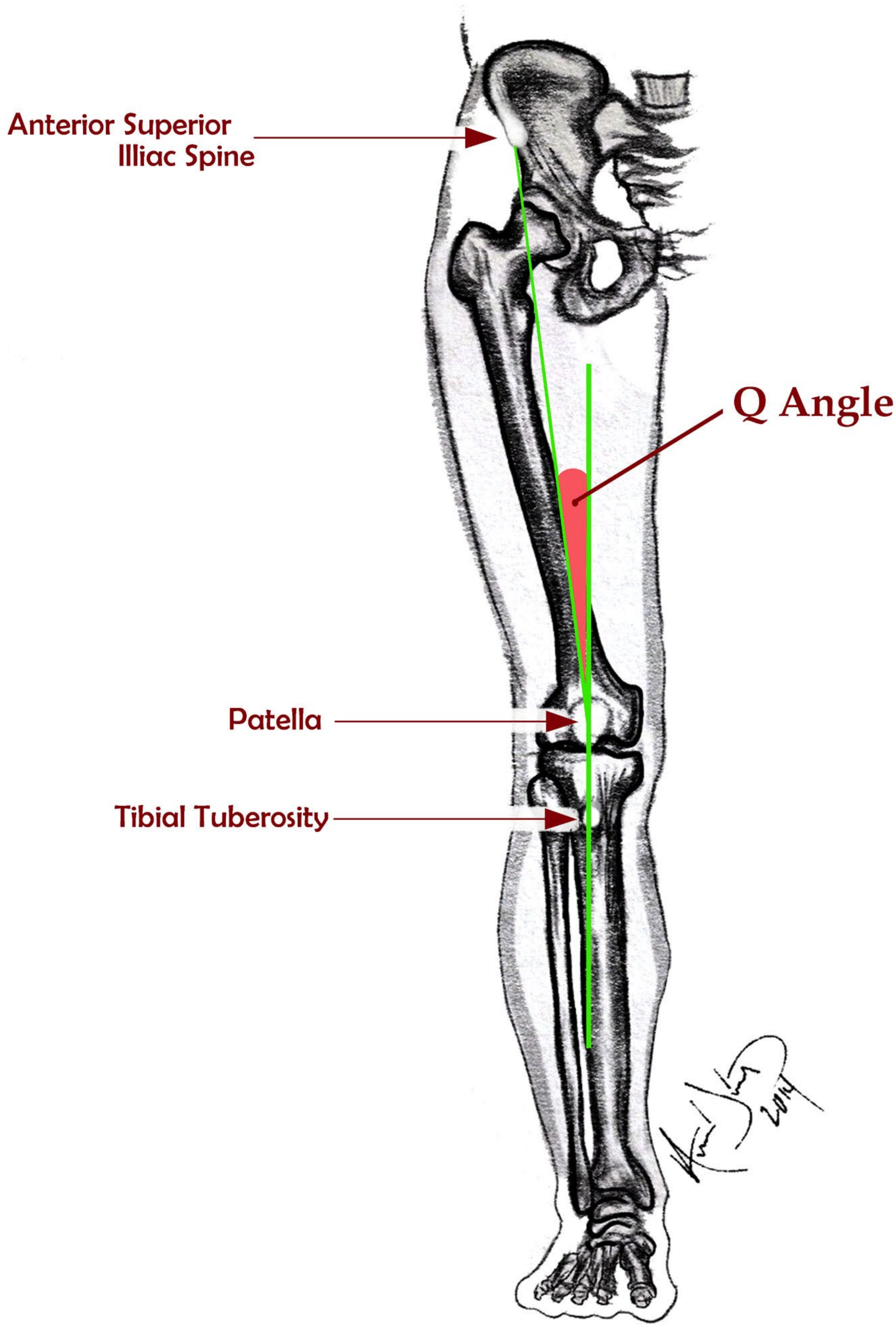
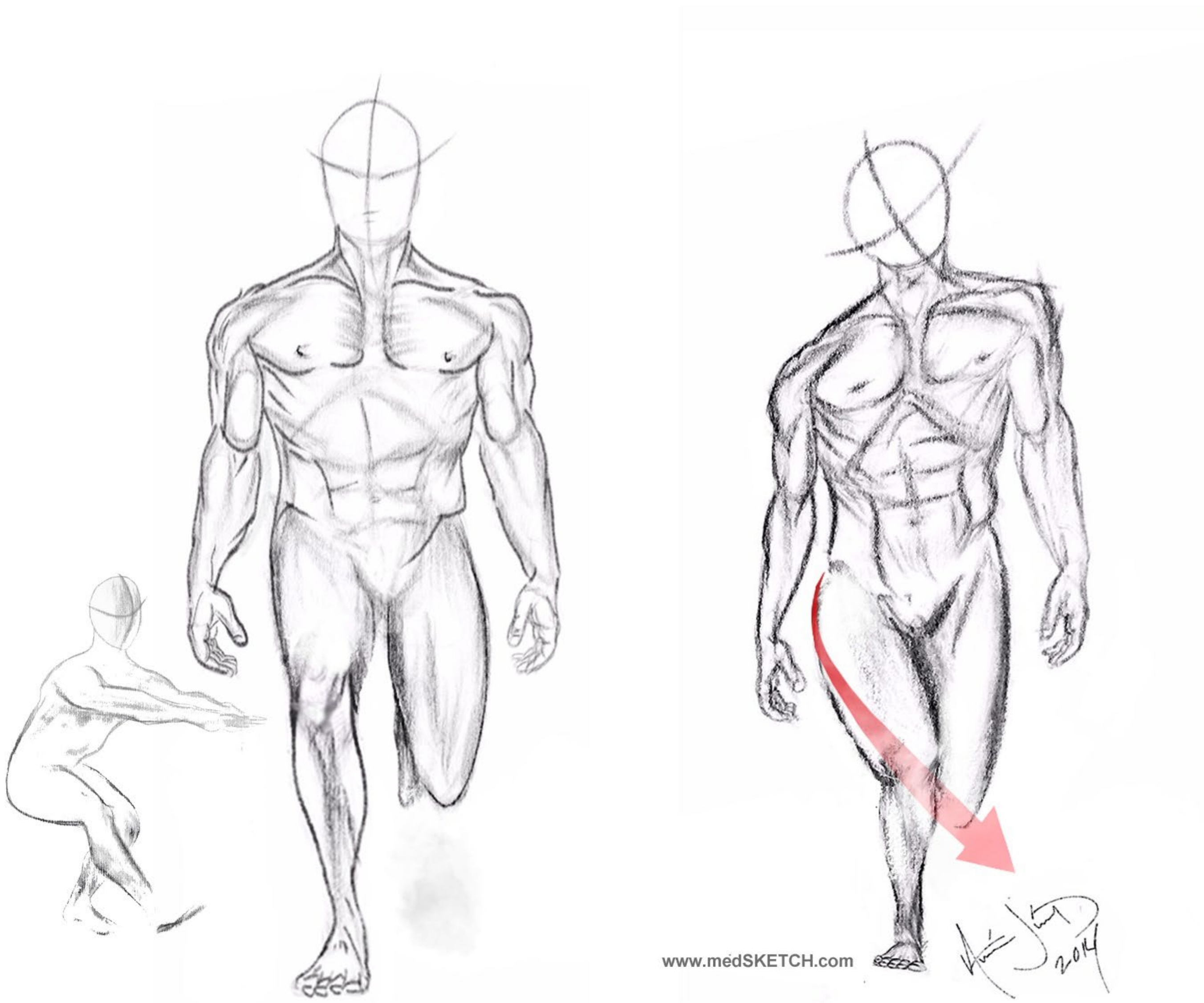


Figure 3. The Q angle (quadriceps angle) is the angle formed by the intersection of two lines: the line from the middle of the patella to the anterior superior iliac spine (ASIS) and a line from the



tibial tubercle through the middle of the tubercle.

Figure 4. Testing for gluteus maximus weakness. Clinical testing of the GM can be done by having the patient perform a one leg squat or hop or by watching the patient descend stairs. The knee should track down straight in alignment with the tibia and femur (left image). If the knee migrates medially (right image), it indicates a motion pattern fault and likely a weak gluteus maximus.

Clinical Insight: Knee Manipulation

Complex joints like the knee should not be manipulated with high-velocity low-amplitude (thrusting) manipulations injudiciously. Just because we *can* manipulate, does not mean that we *should* manipulate. Clinically, I (Morgan) have found that when a patient tells me that it feels like his knee needs to pop and asks for an adjustment, that there is often joint effusion within the knee and it is likely to have an internal derangement like a medial meniscus tear. This is a time to avoid thrusting manipulations of a joint. Much of the time knee dysfunction arises from the hips and pelvis or the foot and ankle. We are much more likely to address the foot, ankle, hip, and lumbo-pelvis regions than the knee when treating knee impairments. Likewise we are likely to include active care that addresses the gluteal muscles and closed chained exercises rather than isolating the knee with open chain exercises like the leg extension. Frequently we look to activate and strengthen the gluteal muscles to reduce unhealthy motion patterns and stresses from the knee.

Waking Up the Gluteus Maximus

This article is reproduced from the original publication in *Dynamic Chiropractic*.

By William E. Morgan, DC and Amin Javid, DC

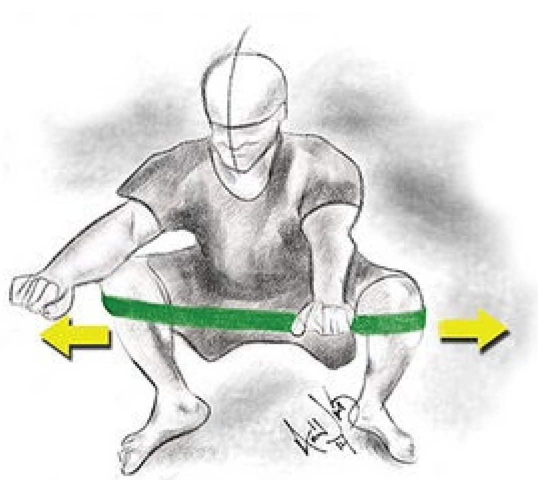
In previous articles in this series, we expounded on the importance of the gluteus maximus (GM) in athletic performance and protecting the knee from injury. We also know there is a link between iliotibial band syndrome and GM weakness.

The famous spinal researcher, Stuart McGill, has coined the phrase "gluteal amnesia" to describe GM inhibition. Gluteal amnesia or inhibition may be a result of hip pain.[1]

McGill found that lower-back-pain patients tend to have gluteal inhibition, which results in dominance of the hamstring muscle for hip extension.[2] This hamstring dominance increases the force load on the anterior capsule of the hip and the labrum.[3] Weak or inhibited gluteal muscles increase the likelihood of injury and impede athletic performance. Hip or back injury can cause gluteal inhibition, as can the sedentary lifestyles of modern living.

Activating the Gluteus Maximus With Exercise

Most of the exercises we present here are performed weight-bearing in a closed kinetic chain. For some patients with a greater degree of infirmity, we may use exercises like the *clam* (**see description later in article**), but we prefer not to isolate muscles from their functional motion patterns.



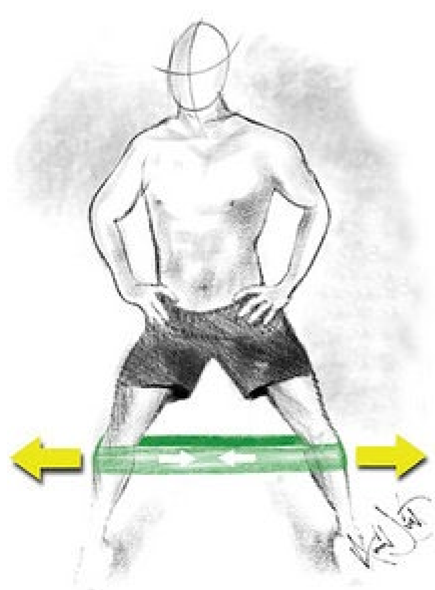
Squat with Exercise Band

1. Squatting

We all squat hundreds of times per day; every time we raise from a chair, car seat or commode, we are performing a squat. One of the factors that restricts geriatric patients from independent living is the inability to rise from a seated position. While our patients may progress to weighted squats, we need to ensure that they develop good form with body-weight squats prior to adding resistance.

Technique:

- Stand with feet wider than shoulder-width apart and toes pointed outward. This has been called an *athletic stance*. The feet should grip the ground with an external rotation force (although they should not move).
- Stiffen the core muscles by bracing your abdominals, neither pulling them in nor pushing them out.
- While maintaining a lumbar lordosis, descend with the buttocks moving down and backward. The motion should occur through the hip in a hip hinge. The shins should remain perpendicular or nearly perpendicular to the floor.
- Descend until the femurs are parallel to the floor or until you can no longer maintain your lumbar lordosis. (Not everyone will be able to perform deep squats.)
- The torso can move forward as long as the lumbar lordosis is intact. The arms may be extended forward to act as a balancing cantilever while performing body-weight squats.



Monster Walks

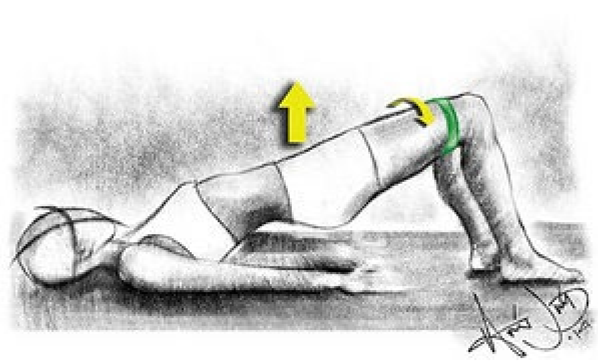
Monster Walks Progression:

Once the body-weight squat has been mastered, resistance may be added. Instead of beginning with a barbell, begin with the resistance of exercise tubing. Place the tubing at or above the knee and perform a squat while maintaining pressure against the resistance of the band. Once this is mastered, weighted squats with exercise bands may be added.

2. Monster or Sumo Walks

Place an exercise band around the knees, ankles or forefoot.[4] Next, separate the legs until the band is taut and the legs are at least 14 inches apart. While maintaining constant tension on the band, descend into a quarter-squat. Walk forward to perform monster walks or sideways to perform sumo walks. Do not let the exercise band lose tension while performing either exercise.

Hip Thrusters with Exercise Band

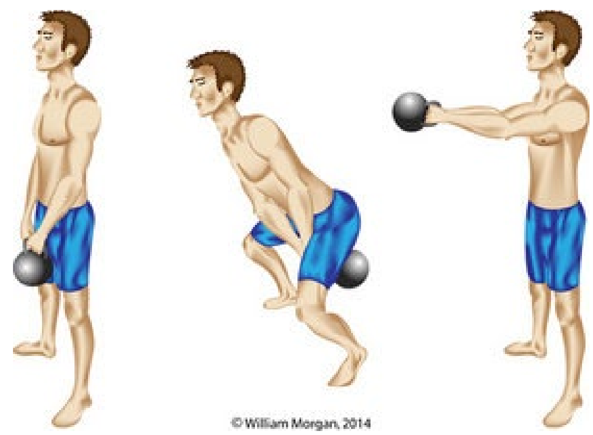


3. Hip Thrusters with Exercise Bands

This exercise is performed from the supine position with the legs bent. Place an elastic exercise band just above or below the knees. Spread the thighs until tension is felt and the GM is engaged; then rise up to a bridged position. A weighted bar may be placed across the pelvis to increase resistance.

4. Kettlebell Swings

Kettlebell swings are a great dynamic exercise for activating the gluteal muscles, but may be difficult to master without personal coaching. Grip the kettlebell with two hands, palms down. The lumbar arch should be maintained, with the chest out and shoulders back, the core stiffened, and the head facing forward.



Kettlebell Swings

Kettlebell Swings Begin by spreading the legs (standing in an athletic stance) with the toes pointing outward approximately 30 degrees. This is not a squatting motion (do not bend to 90 degrees) or a shoulder isolation exercise; it is a hip-hinging exercise.

Begin by sitting back. The kettlebell swings back between the legs as it reaches end range and the hips "pop," propelling the kettlebell forward. Remember, this is not a shoulder exercise. Use the momentum of the hip motion to propel the kettlebell forward.

Do not attempt to lift or pull the kettlebell upward with your arms or shoulders. Practice will be required to get the rhythm of this athletic motion pattern. This is a relatively advanced exercise.

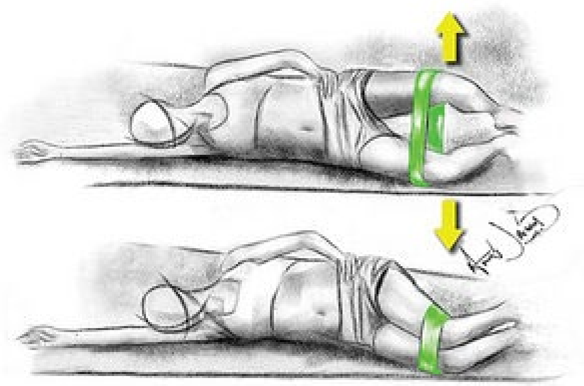
5. Lunges

Lunges should be performed with the same principles used for squatting. Maintain the lumbar lordosis, keep the tibia parallel to the ground, and stiffen the core.

While watching yourself in the mirror, step forward with one leg. Keep upright with your shoulders back and your chest out. Descend until your femur is parallel to the ground. Your front foot should remain flat on the ground, while the posterior foot may bend so that only the ball of the foot is in contact with the ground.

Make sure your knee remains in alignment with the hip and shin. Do not allow the knee to migrate medially. Return to standing, upright position and repeat on the other side.

Clams



6. Clams

Clams are not our preferred gluteal exercise due to their isolation of the external rotators of the hip. However, there are patients who are unable to perform the compound exercises we have previously proposed. In such cases, clams are performed with a resistance band placed just above the knees with the patient in side-lying position. The knees are bent and feet are together. The patient then opens the knees like a clam opening its shell to approximately 50 degrees. Perform repetitions on each side.

This portion of our series introduces the clinician to various ways to activate the gluteal muscles. It is incumbent upon the clinician to implement a program of gluteal invigoration. Some patients will be able to start with more advanced exercises like weighted band squats or kettlebell swings; while others will never be able to perform these exercises and may need to start with clam exercises.

We recommend you teach most patients the basics of squatting and begin with monster or sumo walks to activate the GM. We also recommend you highlight the lifestyle components of gluteal inhibition, such as excessive sitting and inactivity.

Editor's note: This article is the latest in an ongoing series by Drs. Morgan and Javid on chiropractic management of lower extremity conditions.

References

1. Freeman S, Mascia A, McGill S. Arthrogenic neuromusculature inhibition: a foundational investigation of existence in the hip joint. *Clin Biomech*, 2013 Feb;28(2):171-7.
2. McGill S. *Low Back Disorders: Evidence-Based Prevention and Rehabilitation, Second Edition*. Champaign, IL. Human Kinetics: 2007.
3. Lewis CL, Sahrmann SA, Moran DW, Anterior hip joint force increases with hip extension, decreased gluteal force, or decreased iliopsoas force. *J Biomech*, 2007;40(16):3725-3731.

4. Cambridge ED, Sidorkewicz N, Ikeda DM, McGill SM. Progressive hip rehabilitation: the effects of resistance band placement on gluteal activation during two common exercises. *Clin Biomech,* 2012 Aug;27(7):719-24.

Additional Resources

- Farrar RE, Mayhew JL, Koch A. Oxygen cost of kettlebell swings. *J Strength Conditioning Res,* 2010 Apr;24(4):1034-6.
- Jay K, Frisch D, Hansen K, et al. Kettlebell training for musculoskeletal and cardiovascular health: a randomized controlled trial. *Scand J Work, Environ & Health*, 2011 May;37(3):196-203.
- Brumit J, Gilpin H, Brunette M, et al. Incorporating kettlebells into a lower extremity sports rehabilitation program. *North Amer J Sports Phys Ther*, 2010 December;5(4):257–265.

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Functional Screening Using the Squat

The squat is a simple, fast, and functional tool to evaluate patient symmetry and function. As simple

and easy as it is to implement, it can yield considerable amounts of valuable clinically relevant information. A properly executed squat uses an aggregate of several joints (including ankles, knees, hips, and spine) and muscles (too numerous to mention here). While a normal squat will validate a normal functional movement pattern, an abnormal squat may lead to additional evaluations to tease out the dysfunction. Muscle weakness or tightness, instability, and reduced joint motion can all be teased out with this valuable diagnostic tool.

Why should doctors include the squat in their patient assessment? One reason is that the squat is a normal motion pattern that is part of the activities of daily living. Indeed, one of the factors which results in infirmity and the need to move into assisted living is the inability to squat. We squat hundreds of times per day: getting in and out of a car, sitting in chair, accessing items from the floor or shelves, exercising, and using the commode.

There are several methods for evaluating the squat, each with sound arguments for it. Every advocate for evaluating squatting motions has a favorite variation: back squat, front squat, single leg squat, an overhead squat, single leg box squats, or some other variant. But for simplicity, we will start with the fundamental air squat.

Prior to performing a squat, we should ensure that the patient can safely perform a squat by ruling out any orthopedic injury, age related exclusion, or other contraindication for squatting. While a squat may be an important tool for evaluating a teenage soccer player, it isn't for a geriatric patient using a walker.

Patient instructions for this evaluation:

1. Stand with your heels shoulder width apart and the toes pointed forward or slightly out (not more than 10^{o} external rotation).
2. Squat down until your thighs are at least parallel with the ground.
3. Perform three repetitions while I observe from the front, then three repetitions while I observe from the side, and then three more while I stand behind you.

I should note that I allow the patient to extend their arms forward as a counter lever, but do not require it.

A normal squat will have these characteristics:

1. Symmetry: the patient will not swerve to one side.
2. The heels and the toes will remain on the ground, and the feet will not rotate.
3. The knees will not travel forward of the toes.

4. The lumbar lordosis will be maintained throughout the squat.
5. The head will remain up and neutral to slightly extended, but not flexed or hyperextended.
6. Normal ankle dorsiflexion will be observed.
7. Hip and knee motion should be fluid, pain-free, and demonstrated movement throughout the ranges required to perform a squat.
8. The knees should descend in alignment with the tibias and not travel medially into a valgus position.

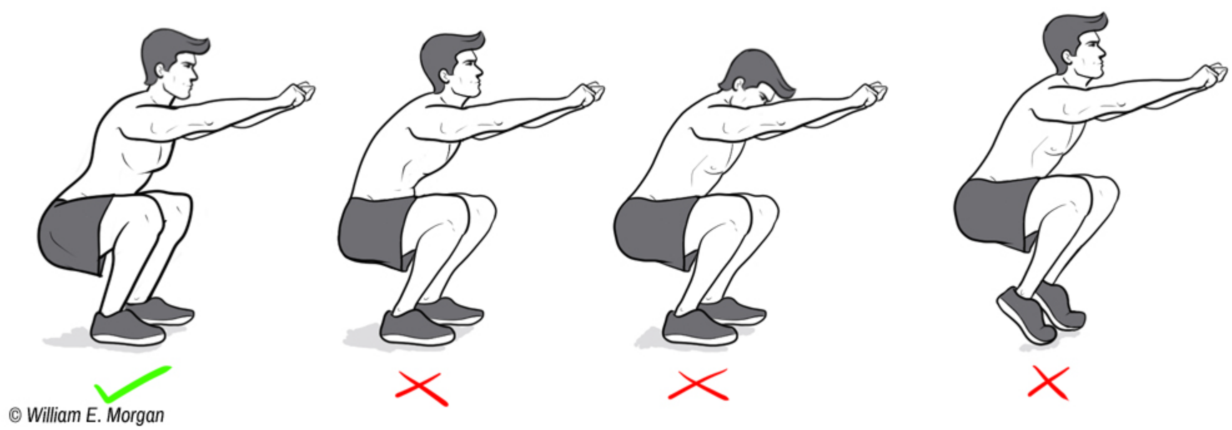


Figure 2. A normal squat (left) will demonstrate a normal lumbar lordosis throughout the squat. The head and neck will remain neutral, not flexed. The body will not bend too far forward, and the heels will not rise from the floor.

What can the squat tell us?

Head alignment and gaze: If the patient is not able to comfortably hold her head up during the squat, it may be indicative of a spinal injury or loss of flexibility of the thoracic or cervical spine. If the neck hyperextends during the squat, it may be a compensation for loss of thoracic motion. Treatment of faulty head position can include spinal adjustments, supported by strengthening or mobility exercise, and coaching the patient in squatting techniques.

Thoracic spine and chest (thorax): The thorax is best evaluated from a lateral position. The thorax should remain stiff and neutral throughout the squatting motion. The chest should be held upward. Curling forward of the thoracic spine and lowering of the chest during the squat may indicate a motor control malady. This can occur from postural protraction of the shoulders, hyperkyphosis of the thoracic spine, muscular weakness of the paraspinal muscles or scapular retractors, or tightness of the scapular protractors.

Lumbar spine: The lumbar spine should be held in a neutral lordosis throughout the squat. Inability to hold the lumbar lordosis throughout the squat can result from weakness of the paraspinal muscles, acetabular restriction (capsular tightness, a deep hip socket, degenerative joint disease of the hip, or cam deformation), lack of lumbar spine mobility, or muscular imbalances (weak or tight muscles).

Hip positon: Excessive abduction of the hips may indicate a bony defect in the hip joint, muscular imbalance of the gluteal complex (weakness, tightness, or motor control disparity), or reduced dorsiflexion of the feet.

An asymmetrical shifting to one side as viewed in the frontal plane may indicate asymmetry of strength, flexibility, and hip motion.

Knee motion: Valgus position of the knees during squatting is indicative of weakness or inhibition of the gluteus maximus and other external rotators of the hip. If I suspect gluteus maximus weakness and the patient is able to tolerate this test, I ask them to perform a single leg squat (Figure 2).

If the knee passes far in front of the toes when viewed from the side, it can indicate gluteus maximus or hamstring weakness, or quadricep dominant squatting motions. It may also be a sign of reduced knee motion in the sagittal plane.

Foot motion: If the feet externally rotate during the squat, this is strongly associated with a loss of normal dorsiflexion. This may be due to tightness of the gastrocnemius and/or soleus or loss of accessory motion of the joints of the foot. Stretching and/or foot adjustments may be indicated.

Advanced Squat Assessments

In addition to observing unloaded two legged squats, there are variants that can be used to assess our more athletic patients. The single leg squat (figure 2) is a simple and efficient way to assess gluteus maximus function in the clinic, especially for more athletic patients. Observe the patient in the frontal plane while he squats with one leg held up and posterior. If the ipsilateral knee migrates to a valgus position, or if the contralateral pelvis drops, you may suspect weakness of the gluteus maximus on the side of weight bearing. This is predictive for a predisposition of anterior cruciate ligament (ACL) injury.

Another more dynamic test reserved for athletes involves the vertical drop jump. The vertical drop jump is performed by having the athlete jump off a platform 31 cm high with the feet 35 cm apart, into a squat, then have her jump back into the air (figure 3). If the knees manifest a valgus position as the athlete lands, it indicates a predisposition for ACL injury. Female athletes are particularly susceptible to this finding and are also much more likely to suffer from ACL disruption.

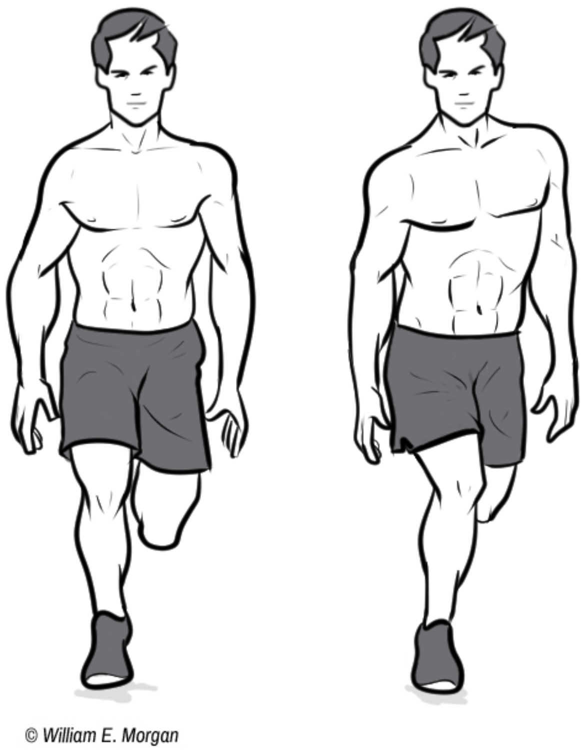


Figure 2. The single leg squat is a useful variant of the squat for assessing more athletic patients. Observe the patient in the frontal plane while he squats with one leg held up and posterior. If the ipsilateral knee migrates in to a valgus position (image on the right), or the contralateral pelvis drops, suspect weakness of the gluteus maximus on the side of weight bearing.

Conclusion

Squat assessments are valuable clinical tools for helping the chiropractor to identify biomechanical deficits and can help to determine which sites would benefit from adjustments, exercise, neuromuscular training, or mobility training. Squats are particularly beneficial for analyzing patients who wish to participate in rigorous activities. The squat is a functional movement complex which is used in many activities of daily living and also in athletics.

The NSCA has a great resource on assessing the back squat which I highly recommend for those who would like to learn more on this topic. *The Back Squat: A Proposed Assessment of Functional Deficits and Technical Factors that Limit Performance*.

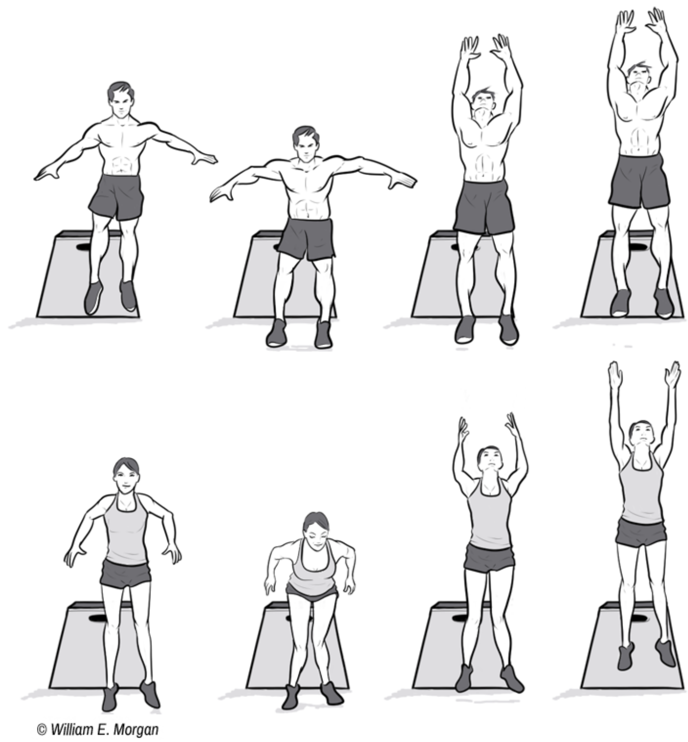


Figure 3. The standardized vertical drop jump has the athlete stand on a 31 cm high platform (which is much lower than the platform depicted in this illustration) with the feet 35 cm apart. She is instructed to drop off of the platform and perform a maximum vertical leap while thrusting her arms into the air. If the knees move into valgus position during this test (female athlete in lower sequence of images), it is highly predictive for a predilection for ACL injury. It is also predictive for those female athletes who would benefit from neuromuscular training to prevent ACL injury.

References and Suggested Reading

Myer GD, Kushner AM, et al. The Back Squat: A Proposed Assessment of Functional Deficits and Technical Factors That Limit Performance. Strength and Conditioning Journal. 36: 4-27.2014.

Myer GD, Brent JL, Ford KR, Hewett TE. Real-time assessment and neuromuscular training feedback techniques to prevent ACL injury in female athletes. Strength and Conditioning Journal. 33: 21–35, 2011.

Kushner AM, Brent JL, Schoenfeld B, Hugentobler J, Lloyd RS, Vermeil A, Chu DA, McGill SM, and Myer GD. The back squat: Targeted training techniques to correct functional performance deficits and teach proficiency. Strength and Conditioning Journal. 2015.

Myer GD, Ford KR, Khoury J, Succop P, and Hewett TE. Biomechanics laboratory based prediction algorithm to identify female athletes with high knee loads that increase risk of ACL injury. Br J Sports Med 45: 245–252, 2011.

Myer GD, Ford KR, Palumbo JP, Hewett TE. Neuromuscular training improves performance and lower extremity biomechanics in female athletes. J Strength Cond Res 19: 51–60, 2005.

McKean MR, Dunn PK, and Burkett BJ. The lumbar and sacrum movement pattern during the back squat exercise. J Strength Cond Res 24: 2731–2741, 2010.

McGill SM, Norman RW. Dynamically and statically determined low back moments during lifting. J Biomech 18: 877–885, 1985.

List R, Gulay T, Stoop M, and Lorenzetti S. Kinematics of the trunk and the lower extremities during restricted and unrestricted squats. J Strength Cond Res 27: 1529–1538, 2013.

McLean SG, Felin RE, Suedekum N, et al. Impact of fatigue on gender-based high-risk landing strategies. Med Sci Sports Exerc, 2007;39:502-514.

Rahnama N, Reilly T, Lees A. Injury risk associated with playing actions during competitive soccer. Br J Sports Med, 2002;36:354–359.

Rodacki AL, Fowler NE, Bennett SJ. Vertical jump coordination: fatigue effects. Med Sci Sports Exerc, 2002;34:105-116.

Orishimo KF, Kremenic IJ. Effect of fatigue on single-leg hop landing biomechanics. J Appl Biomech, 2006;22:245-254.

Prodromos CC, Han Y, Rogowski J, et al. A meta-analysis of the incidence of anterior cruciate ligament tears as a function of gender, sport, and a knee injury-reduction regimen. Arthroscopy, 2007;23(12):1320-1325.

Enhancing Athletic Performance in Cross Fit Athletes

Adapted from the book *Hero Workouts* by William E. Morgan

I have a love-hate relationship with cross fitness. I love the functional aspect of cross fitness workouts and the push toward functional motion patterns versus the use of weightlifting machines and muscle isolation exercises. Additionally I like the metabolic aspect of cross fitness workouts which can have profound effect on athleticism and performance.

On the other hand, what I don't like about cross fitness is the lack of uniformity in the qualifications of cross fitness instructors and the timing of certain exercises, like heavy deadlifts for time or 30 snatches for time after an athlete is already fatigued and prone to injury. There is a wide range of expertise in those who train clients in these functional gyms. Some of the athletic trainers are fantastic. Some boxes (CrossFit lingo for a CrossFit gym) are run by chiropractors or physical therapists or at least have chiropractors as clients or consultants. In my opinion these tend to be more prone to adapt exercise programs to individuals to avoid injuries. Unfortunately, there are also trainers who are not as knowledgeable in adapting fitness programs to the needs of an individual. But to be fair, the same can be said about fitness trainers in any gym.

Certainly CrossFit has disrupted a very well entrenched fitness industry by capitalizing on people's desire to develop social bonds, compete, and to get into really good shape. In several ways CrossFit is more of a sport than a fitness program. Although many doctors feel that cross fitness programs are injuring their patients, I believe it is a good idea to make peace with CrossFit and to communicate the particular needs of our patients. The cross fitness movement is adapting and evolving, albeit slowly, improving the program and reducing the risk of injury.

Cross fitness, as the name implies, combines a cross of various fitness methods to develop athletic prowess. Included in the program are Olympic lifts, gymnastics, kettlebells, plyometrics, calisthenics, running, swimming, rope climbing, and mobility exercises. Certainly there would be a concern if a patient with a hypermobility syndrome such as Ehlers-Danlos began performing dips, push-ups, or muscle-ups on gymnastic rings. These exercises could lead to a dislocated shoulder. Equally distressing is the thought of a lumbar disc patient performing heavy deadlifts in a timed event. Some people should never do particular exercises, but some exercises should not be done by anyone. In this article I am going to address Olympic lifting, squatting motions, and the importance of thoracic spine motion during overhead lifting.

Olympic Lifting

Successful Olympic weightlifters have unique body types. Not everyone has the genetics to be a successful and safe Olympic weight lifter. The combination of hip joint, thoracic spine, foot/ankle, and shoulder mobility must be coupled with shoulder stability and power.

Those with more shallow hip sockets will have a greater range of hip motion and are genetically better suited for performing Olympic lifts and squatting motions. Those with deep, more stable hip joints are no less capable athletes, but they probably won't be great Olympic lifters or proficient at performing deep squats. By having patients perform a few squats in your office, you can get a good idea of whether or not they should progress to performing an Olympic lift like a clean and jerk, or snatch (figure 1). The patient's feet should be slightly wider than shoulder width apart and the toes slightly turned outward. The patient should be able to maintain a lumbar lordosis throughout the squat. The head should be up (not flexed or excessively extended), and the heels should remain on the ground. If there are flaws in squatting patterns, they should be addressed before this patient can progress to an exercise like the clean and jerk. Mobility exercises for the hip, the spine, or the foot can be used to isolate the source of the motion flaw. Chiropractic adjustments to the spine, hip, and foot may be indicated.

The Clean and Jerk

Proper technique is imperative when performing the clean and jerk, and proper technique requires coaching. While not everyone has the genetics to perform the clean and jerk to high levels of performance, most athletes should be able to perform this exercise even if they must modify their technique or performing this exercise with kettlebells.

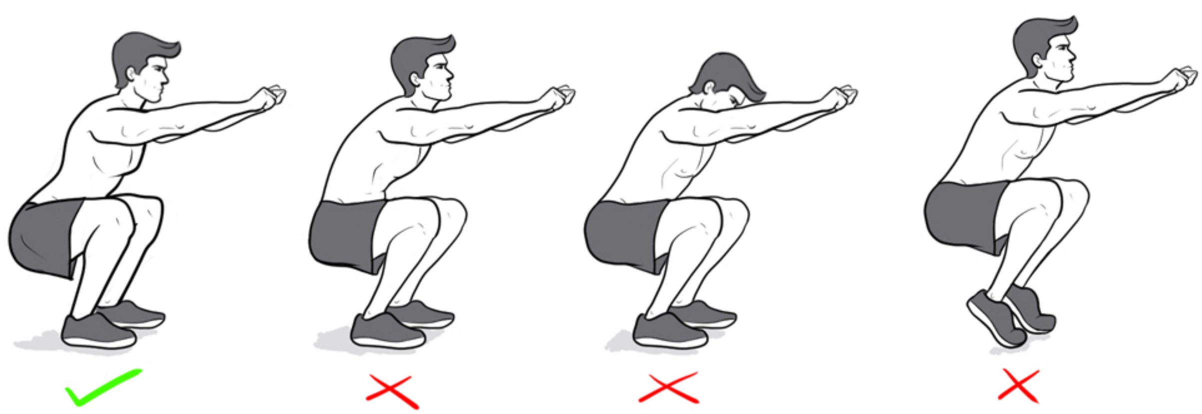


Figure 1. *Before progressing to certain exercises such as squatting or clean and jerk, athletes should be screened with an exam which includes squatting. A properly executed squat should*

include (1) an arch in the lower back, (2) head up, and (3) heels on the ground and the shins near to perpendicular to the ground.

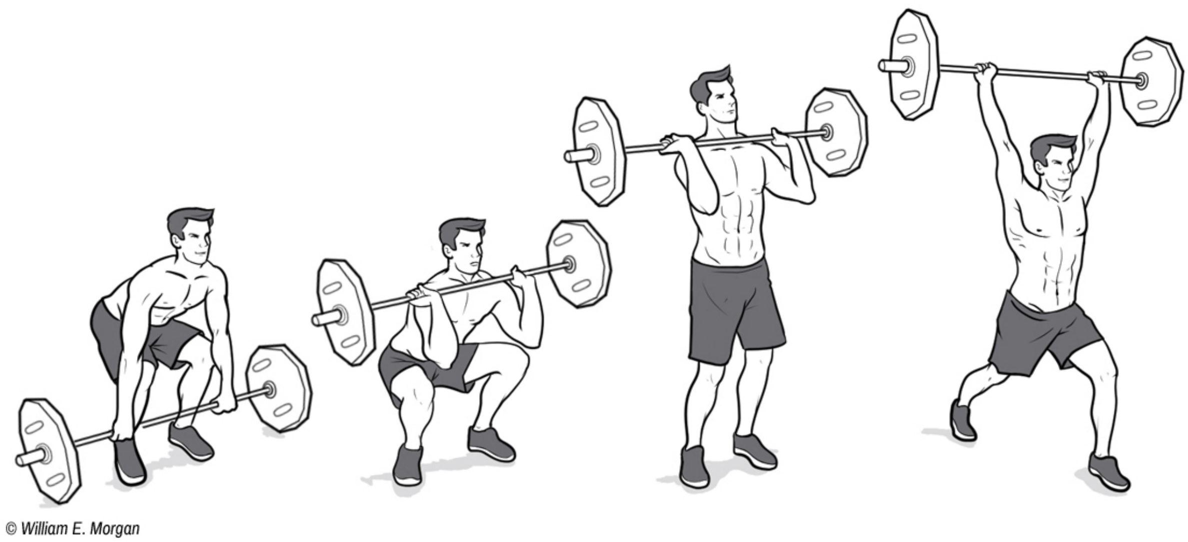


Figure 2. The clean and jerk is a technical lift, which [I feel]is best performed with one or two repetitions at a time. Since this lift requires speed, timing, and power, it should not be done with high repetitions or when fatigued.

The Aggregate of Thoracic Spine-Shoulder Motion in Overhead Lifting

Thoracic spine motion is required for all end range shoulder motions. End range shoulder motions include overhead pressing, clean and jerk, pull-ups, hand stands, and other overhead lifts. If the thoracic spine lacks significant motion, there is a much greater likelihood of having shoulder impairment. Shoulder injuries are particularly prevalent when performing exercises like kipping pull-ups and the overhead snatch. Loss of thoracic motion or a hunched upper back (increased kyphosis) can be treated with adjustments and by rolling the thoracic spine over a foam roller or gymball.

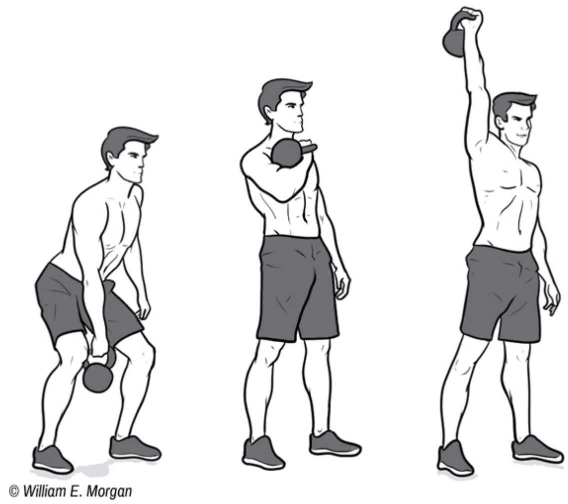


Figure 3. The kettlebell clean and jerk is a full body exercise which builds athleticism and power. It also can be performed by those lacking the ability to perform regular clean and jerk exercises.

Thoracic Adjustments and Shoulder Pain

Thoracic adjustments might be the simplest answer to reducing pain in an impinged shoulder. In a 2009 study by Strunce and colleagues, a thoracic spinal manipulative thrust was performed on a sample of 56 individuals with symptomatic shoulders from impingement. After two days, there was a significant decrease in pain levels in over 50 percent of individuals.

The cross-fitness emphasis on pull-ups and overhead lifting may produce a glut of shoulder injuries from otherwise dormant thoracic and shoulder impairments. By recognizing the functional relationship between the thoracic spine and the shoulder joints, we can help athletes remain active and pain-free as they engage in their preferred activities.

Conclusion

Cross fitness centers are expanding and increasing in popularity. To remain relevant to this growing portion of society, practitioners need to learn about the exercises and injuries common to this group.

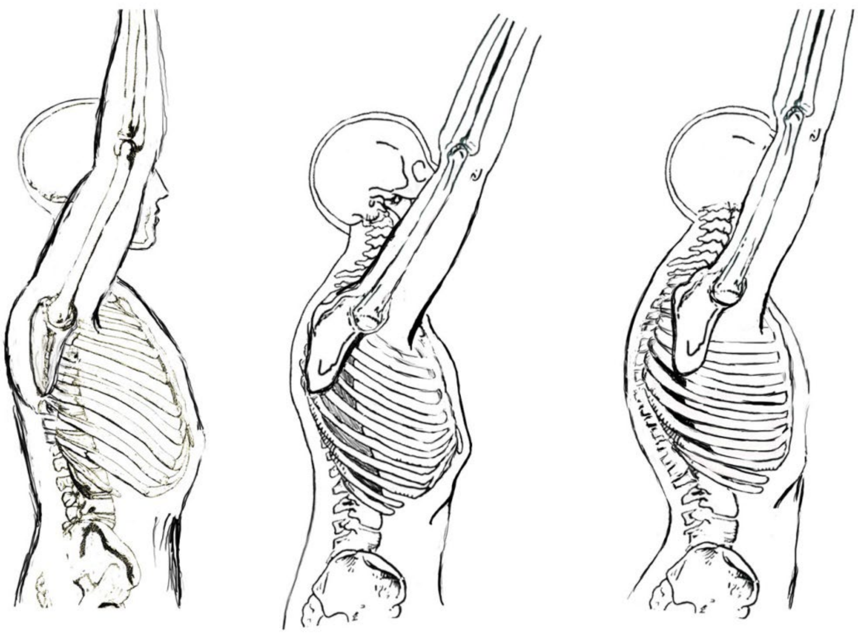


Figure 4. A normal flexible spine will allow normal shoulder motion during overhead activities (left). Reduced spinal motion will impede normal shoulder motion (center). Forcing the shoulder overhead, even though impeded by an increased kyphosis or loss of spinal motion, will result in shoulder impingement.

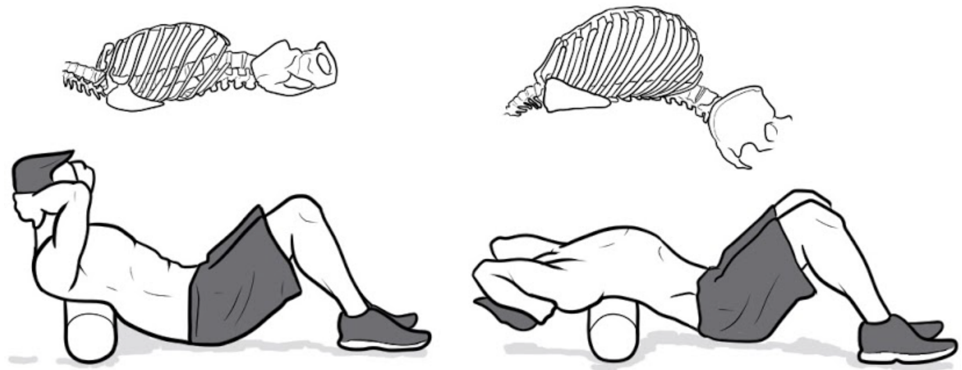


Figure 5. Those lacking sufficient thoracic spine motion will have impeded shoulder function. In addition to chiropractic manipulations to the thoracic spine, the use of a foam roller can enhance thoracic spine mobility which in turn will improve shoulder motion and function. This schematic shows the effect of a foam roller in mobilizing the thoracic spine and opening the chest wall.

Squat Assessment References

Myer, Gregory D., Kushner, Adam M., Brent, Jensen L., Schoenfeld, Brad J.,et al. The back squat: a proposed assessment of functional deficits and technical factors that limit performance. Strength & Conditioning Journal. December 2014 - Volume 36 - Issue 6 - p 4–27

Thoracic-Shoulder References

Borstad JD, Ludewig PM. The effect of long versus short pectoralis minor resting length on scapular kinematics in healthy individuals. Journal of Orthopedic Sports Physical Therapy, 2005;4:227-238.

Codman EA. The Shoulder; Rupture of the Supraspinatus Tendon and Other Lesions in or About the Subacromial Bursa. Thomas Todd, Boston, 1934.

Crawford HJ, Jull GA. The influence of thoracic posture and movement on range of arm elevation. Physiotherapy Theory and Practice, 1993;9:143-148.

Crosbie J, Kilbreath SL, Hollmann L, York S. Scapulohumeral rhythm and associated spinal motion. Clinical Biomechanics, 2008;23:184-192.

DeFranca GG, Levine LJ. The T4 syndrome. Journal of Manipulative and Physiological Therapeutics, 1995;1:34-37.

Greenfield B, et al. Posture in patients with shoulder overuse injuries and healthy individuals. Journal of Orthopedic Sports Physical Therapy, 1995;5:287-295.

Kibler BW. The role of the scapula in athletic shoulder function. The American Journal of Sports Medicine, 1998;26:325-337.

McClure PW, Michener LA, Sennett BJ, Karduna AR. Direct 3-dimensional measurement of scapular kinematics during dynamic movements in vivo. Journal of Shoulder and Elbow Surgery, 2001;10:269-277.

Stewart S, Jull GA, Ng, JKF, Willems JM. An initial analysis of thoracic spine movement during unilateral arm elevation. Journal of Manual & Manipulative Therapy, 1995;3:15-20.

Strunce J, et al. The immediate effects of thoracic spine and rib manipulation on subjects with primary complaints of shoulder pain. Journal of Manual & Manipulative Therapy, 2009;17:230-236.

Theodoridis D, Ruston S. The effect of shoulder movements on thoracic spine 3D motion. Clinical Biomechanics, 2002;17:418-421.

A Big Fat Tumor is Killing our Patients...and Us!

The overwhelming evidence of the adverse effects of excessive intra-abdominal fat on our health should compel all health care providers to declare war on this growing societal problem. Excessive intra-abdominal fat is clinically referred to as central obesity and is colloquially called "belly fat" or a "beer belly." The health effects of excessive intra-abdominal fat (also known as visceral fat) on overall health are so profound that I believe we need to treat this malady with the same vigor we would reserve for a visceral tumor.

Physiologically, intra-abdominal fat differs significantly from subcutaneous fat. Subcutaneous fat cells principally store small amounts of glucose and larger amounts of fat; when metabolized, subcutaneous fat releases fatty acids and small amounts of glycerol. In contrast, intra-abdominal fat is more physiologically active. Intra-abdominal fat cells produce several pro-inflammatory cytokines (like tumor necrosis factor and interleukin), hormones and chemicals. Intra-abdominal fat acts like an endocrine tumor sweeping damaging substances into the bloodstream. These hormones, cytokines and chemicals increase insulin resistance, blood pressure, blood clotting and LDLs and promote systemic inflammation. Central obesity has been linked to Alzheimer's disease, diabetes, heart disease, diffuse idiopathic skeletal hyperostosis (DISH) and several other health conditions.

Researcher Miia Kivipelto, MD, PhD, and colleagues performed a multi-decade study1 of 1,449 participants looking at obesity and dementia. His study revealed that those participants who were obese at middle age were twice as likely to get Alzheimer's disease as they aged compared with the general population.

In case you need more convincing about the risk of central obesity, here is a partial list of diseases linked to belly fat:

Uterine cancer
Renal cancer
Pancreatic cancer
Esophageal cancer
Ovarian cancer
Breast cancer
Stroke
Osteoarthritis
Dyslipidemia
Gallbladder and liver disease
Sleep apnea

Metabolic syndrome or Syndrome X are the common names given to the group of factors that are characterized by central obesity, insulin resistance, systemic inflammation, cardiovascular disease and the conditions listed above. These conditions are endemic in the Western world and threaten to collapse our limited health care resources.

Action steps for addressing central obesity:

Take a moment for self-analysis: Am I overweight? If you are overweight, you have lost your positional authority to broach this topic with your patients. People do not listen to hypocrites. You must solve your own problem before you can engage others on this important topic.

When addressing obesity, always link the discussion to your concern for your patients' health and the health problems they may face: back pain, diabetes, hypertension and so forth.

Use words that are healing. No one likes confrontation or embarrassment, and those who are morbidly obese know they are fat. Be the caring professional. Lovingly bring your patients to the realization of how serious this health crisis is for them.

Develop an office plan for addressing central obesity. The plan should include metrics, goals and a plan of action. If you are not equipped to tackle this condition, be prepared to make an appropriate referral to someone who can help your patients.

The effects of central obesity will soon be the single biggest drain on our limited health care resources. The national debate on the financing of socialized medicine is almost a distracting sideshow when contrasted with the grave effects of the national epidemic of obesity. If we do not control the epidemic of obesity in our country, no amount of funding will be able to cover the tsunami of obesity-related disease.

References

1. Kivipelto M, Helkala EL, Hänninen T, Laakso MP, et al. Midlife vascular risk factors and late-life mild cognitive impairment: a population-based study. Neurology. 2001; 56: 1683–1689.

Don't Shoot the Messenger…of Pain

Medial Branch Neurotomy

I am usually the one encouraging the cause of interdisciplinary collaboration. But there are times when I feel there are interventions that are inappropriately applied in medical pain practices. One that I am particularly skeptical about is a pain clinic procedure called a *medial branch block* or *medial branch neurotomy.* In this procedure the intent is to destroy the nerve (the medial branch of the posterior primary ramus) that innervates the facets in an attempt to treat back pain that originates in the facet.

Why is the Medial Branch Important?

This nerve is a key player in the reactive intersegmental stability and protection of the spine. The medial branch of the posterior primary ramus (division) innervates the zygapophyseal joints, interspinous ligaments, supraspinous ligament, ligamentum flavum, the periosteum of the vertebral arch, and the posterior spinous process. The medial branch also innervates (both motor and sensory) these muscles: multifidus,[i] intertransversarii, the rotatories, and the interspinous muscles.[ii]

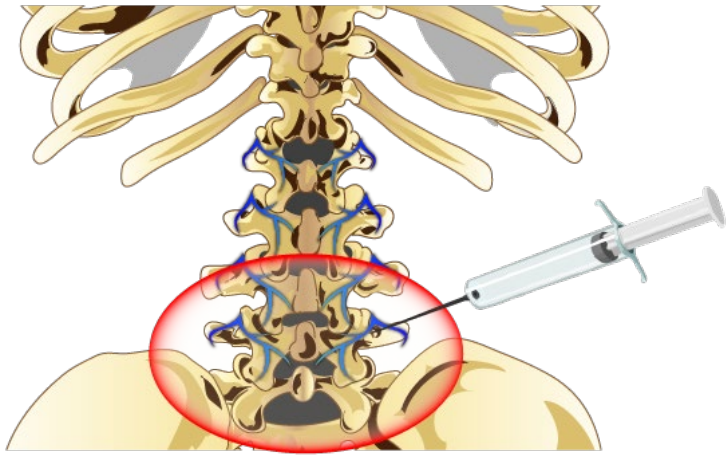
All of these structures are part of a complex reactive mechanism that interacts to provide stabilization and protection to the spine. So when pain physicians treat facet pain with a neurotomy, they are also destroying the nerves to the spinal components that protect the facets from further damage.

Medial Branch Radiofrequency Neurotomy

Prior to performing a neurotomy, the pain physician usually performs a trial injection with anesthesia like lidocaine. The needle is guided with fluoroscopy. If the anesthesia reduces or eliminates the pain, that indicates to the physician that they have isolated the nerves that convey the sensation of pain to the facets. The physician will then use a radiofrequency ablation probe to produce enough heat to destroy the nerve. In time, the nerve may regenerate and the procedure may need to be repeated.

Denervation of the medial branch of the posterior primary ramus has demonstrated some potential for providing long term control of facet pain. While major harm caused by this procedure is very rare, the potential long term effect on the facets and other spinal anatomy (I guess this would be classified as minor harm) has not been adequately studied.

Medial branch block with anesthesia



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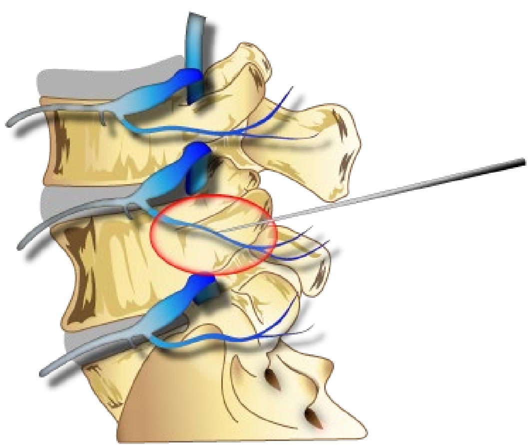

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Radiofrequency Neurotomy

Medical branch denervation procedures are being utilized on a grand scale without being substantiated by rigorous randomized controlled studies. In fact, one study that is highly referenced is a case series with only five patients! In this study, Dreyfus revealed that the multifidus did atrophy after radiofrequency neurotomy, but the authors concluded that this was inconsequential because of the pain relief that lasted for twelve months following the procedure.

[iii] Multifidus atrophy of multiple levels following a single level medial branch radiofrequency ablation was identified through the use of electromyography in a case published by Wu.[iv] This shows diffuse atrophy of the multifidus muscles following radiofrequency ablation (RFA). A case series here and a case there may not seem like much to base so many conclusions on, but that is all we have. There is a deafening silence when it comes to researching the long term effects of this procedure on the zygapophoseal joints.

Something else that concerns me is the long term effects this procedure will have on the facets. Medial branch ablation effectively creates a Charcot joint of the facets. Charcot joint is the term given to a joint that has a neuroarthopathy that renders it devoid of sensation. The name Charcot's joint was given by the French neurologist Jean-Marie Charcot who noted a pattern of joint destruction in patients with the loss of joint sensation. In a Charcot joint the patient is unable to perceive the pain of joint damage so they will engage in joint damaging activities and not even know it. Currently there are no randomized control studies we can look to that address the long term effects of spinal facet joint anesthesia.

Several years ago I was speaking at a foreign spine surgeon conference, the sole chiropractor speaking to hundreds of international spine surgeons. During a panel discussion I expressed my misgivings about neurotomy of the medial branch and its potential harm to the multifidus. One of the spine surgeons on the panel then proceeded to ridicule me in front of his colleagues and state that medial branch of the posterior primary rami is totally sensory; it does not have a motor component. I was dumbfounded. He is performing these procedures and did not even know that he was ablating a motor nerve.

I cornered the surgeon later in the conference and showed him the evidence that this nerve was indeed both motor and sensory. I was vindicated when, much to his credit, he acknowledged his mistake and apologized to me from the podium of the conference in front of the attendees.

From my experience and research I draw these conclusions: these procedures do reduce facet pain and can do it for a long time. These particular spinal procedures rarely cause life threatening harm. However, this procedure has risks for causing further harm to the facets and other structures of the spine and this procedure should only be performed after all other conservative care, including chiropractic, has failed. I also conclude that the long term effects of this procedure are understudied, and there is not nearly enough evidence for this procedure to be utilized at its current level.

References

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[i] MacDonald DA, Moseley GL, Hodges PW. The lumbar multifidus: does the evidence support clinical beliefs? Man Ther 2006;11:254–63. Epub 2006 May 23

[ii] Cramer G, Darby S (2013). Basic and clinical anatomy of the spine, spinal cord, and ANS (third edition). Elsevier Mosby. Page 303

[iii] Dreyfuss P, Stout A, Aprill C, et al. The significance of multifidus atrophy after successful radiofrequeny neurotomy for low back pain. PM R 2009;1:719–22

[iv] Wu PB, Date ES, Kingery ES. The lumbar multifidus muscle in polysegmentally innervated. Electromyogr Clin Neurophysiol 2000;40:483–85

Phantom Limb Pain

Phantom limb pain (the perception of pain, paresthesia, itching, tingling, and other sensations of a missing limb) occurs in more than 90% of those who have lost a limb to amputation.[8] This phenomenon has been called phantom limb pain and has been documented for centuries in medical textbooks and in literature. While the perception of phantom limb pain may be a mild painless annoyance to some, in others it is very disruptive and interferes with work or sleep. Phantom limb pain is a hallucination created in the subconscious mind that a missing limb still exists. This hallucination involves a very realistic perception of the missing limb even though the conscious mind clearly conceptualizes the lost limb.

Particularly interesting is that phantom limb pain has been noted in those missing limbs due to birth defects.[9] People who never had a limb can still have the perception of phantom limb pain. This points to the prospect that the brain is disposed to an interaction with its limbs. The brain is hardwired to send and receive neurotransmissions with the various body parts. The perception of having limbs is implanted into the brain rather than learned. In response to this knowledge, Ronald Melzack introduced the concept of the presence of a *neuromatrix.* [1]

The Neuromatrix

In essence the neuromatrix theory states that pain is not produced from passive recognition of nociception, but rather pain is created by an aggregate of the central nervous system (the brain and spinal cord) actively working together to generate the perception of pain. The neuromatrix may or may not actively produce pain based on nociception and many other factors. The neuromatrix may produce pain when there is not significant amounts of nociceptive input. We see this in phantom limb pain, complex regional pain syndrome, and other chronic pain syndromes. There are other times when little or no pain is perceived although there is a significantly large amount of nociceptive input. For example, in the heat of battle it is common for troops to receive wounds that would normally be very painful, yet they do not feel the pain. The brain apparently recognizes that the distraction of pain in a crisis could compromise the individual's ability to overcome the immediate threat and could result in death. Therefore the input of nociception is ignored by the brain and pain is not perceived. The brain actively prioritizes survival over localized tissue preservation. It chooses not to produce the perception of pain.

Key points:

- Tissue damage does not cause pain. It may result in the transmission of nociceptive impulses, but it does not directly cause pain.
- The central nervous system (brain and spinal cord) produces the perception of pain. This is often an interpretation of nociceptive input, but not always.
- Nociception and pain are not the same thing.

- Production of the perception of pain is a neurologically active phenomenon, not a passive one.

The Homunculus

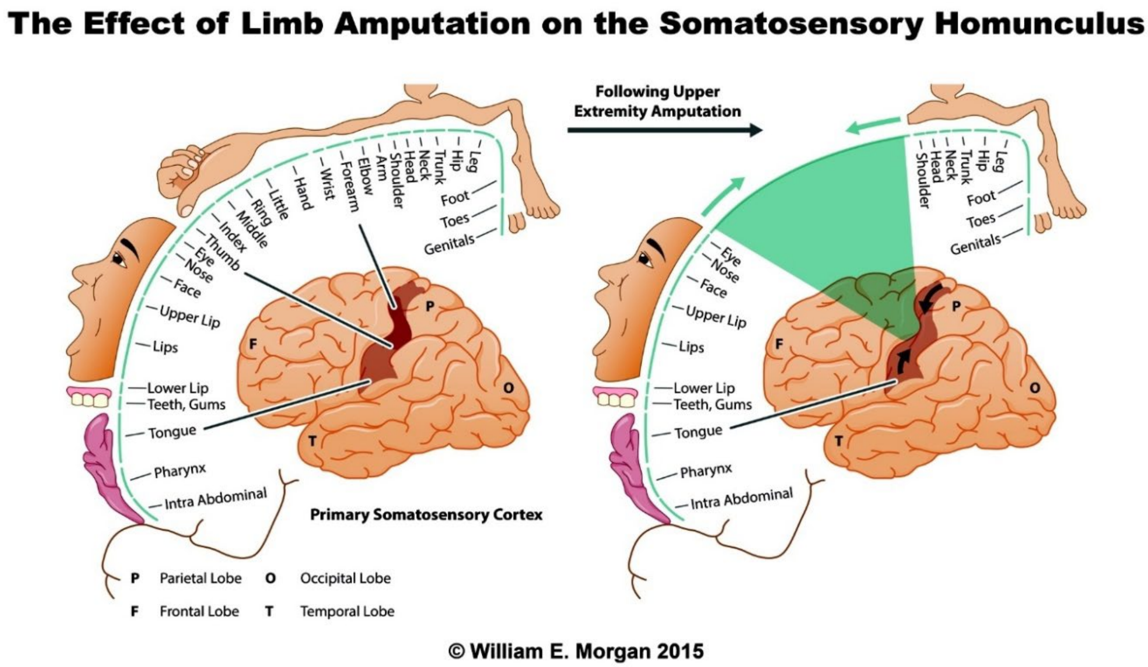

Figure 1. These schematics of the somatosensory homunculus attempt to illustrate and map the regions of the brain responsible for interpreting the sensory input from various portions of the brain. The image on the left illustrates an intact somatosensory homunculus. Note the large amount of the homunculus that the upper extremity occupies. The image on the right illustrates the void that is formed in the brain when an amputation occurs.

Homunculus literally means "little man" in Latin. The brain has been mapped out as a blueprint in the cortical homunculus. There are two renditions of the cortical homunculus: the somatosensory and the motor. In the somatosensory homunculus we see that certain parts of the brain are responsible for the innervation of certain parts of the body (figure 1, left image). Note that the hand and arm occupy a significantly large portion of the homunculus. In the case of an upper extremity amputation (figure 1, right image), there is a large portion of the brain once designated to innervate the arm, but it has no arm with which to interact. There is a vacuum of interaction, a void. Nature abhors a vacuum. So the neuromatrix fills the "vacuum" by actively creating the missing perceptions and sensations that the arm may feel resulting in phantom limb pain.

In the absence of sensory input from a limb, as seen in the amputation of a limb, the brain creates its own sensory input to satisfy its need to account for that body part. These manufactured sensations may be the perception of warmth or cold, itchiness, achiness, or pain, sometimes severe refractory pain. Phantom limb pain can be incapacitating and disruptive to sleep, work, and relationships.

In addition to phantom limb pain, patients with amputations can also experience hypersensitivity of the adjoining body parts within the somatosensory homunculus. When looking at the somatosensory homunculus (figure 1, left image) the face is located next to the upper extremity, and the genitals are located next to the leg. Following an amputation, the portion normally designated to account for the upper extremity melds with the portion which normally accounts for the face. A missing leg might meld with the portion which normally accounts for the genitals. This can result in altered sensations and increased sensitivity of the neighboring body parts in the homunculus. For example, a patient with a missing arm may experience hypersensitivity or pain in the face and jaw. A patient with a leg amputation may experience hypersensitivity or pain of the genitals. This was demonstrated when Ramachandran used light stimulation of patients' faces with a Q-tip to produce the perception of sensations in the missing limb.[10] The neurological complications of amputation combined with the more obvious and visually apparent consequences of a lost limb (stump care, prosthetics, wheelchairs, ambulation, and activities of daily living) can prove very disruptive to patients.

Figure 2. Navy Cmdr. (Dr.) Jack Tsao, associate professor of neurology at the Uniformed Services University of the Health Sciences, in Bethesda, Md., encouraged Army Sgt. Nicholas Paupore, an outpatient at Walter Reed Medical Center, in Washington, D.C., to try mirror therapy to treat phantom pain in his amputated right leg. Tsao conducted the first clinical trials in mirror therapy and says he hopes to advance the study to bring relief to amputees from Iraq and Afghanistan.

There is a strong connection between the brain's awareness of the body and sight. The brain coordinates its perception of self through the combined senses of proprioception and sight. When there is conflict between what the brain expects to see, proprioception, and the reality of a missing limb, phantom limb pain can occur.[11] Recognizing the distinct visual association between the brain and the neuromatrix and how strongly the interactive sense of self responds to visual cues, researchers sought to develop a non-pharmaceutical treatment for phantom limb pain. Ramachandran and colleagues identified the contribution of sight to phantom limb pain and devised a novel treatment for phantom limb pain: Mirror therapy.

Mirror Therapy

Mirror therapy utilizes a mirror placed in such a way that the patient can look in the mirror and not see the missing extremity, but rather the mirror image of the non-amputated limb. Somehow this treatment is successful in reducing or eliminating phantom limb pain. The mirror tricks the brain into thinking that the missing limb is still there, resulting in a significant therapeutic response. For many patients the phantom limb pain resolves or the intensity of the pain decreases.

Figure 3. In cases where the patient has had bilateral amputation, the use of surrogates (another person whose legs are used to provide the image of having legs) has been effective in treating phantom limb pain. Lynn Boulanger, an occupational therapy assistant and certified hand therapist, uses mirror therapy to help address phantom pain for Marine Cpl. Anthony McDaniel. The Occupational Therapy department provides patients with rehabilitation services to heal and restore service members to their highest level of everyday functional outcomes.

In one randomized controlled study, every one of the amputees in the mirror therapy group showed a reduction in phantom limb pain.[12] The therapy consisted of 15 minutes of mirror therapy, five days per week for four weeks. While this study was done with the most basic of equipment, a mirror, the success of this study and others has led to the production of mirror systems specifically created to treat phantom limb pain. Mirror boxes and inflatable mirror boxes are now available commercially.

In cases of bilateral amputation, there is no limb to mirror. For this, the use of a surrogate has proven effective. Essentially the patient sees the limbs or mirror images of the limbs of another person, a surrogate.[13]

Research is continuing to uncover the mysteries of the neuromatrix, pain, and phantom limb pain. Studies currently underway are using advanced brain imagery to determine the effects of mirror therapy on the somatosensory cortex of the brain. In the future expect to see a refining of both the explanation of phantom limb pain, the utilization of mirror therapy, and in all likelihood, the use of visual goggles and virtual reality to treat patients with phantom limb pain and other conditions.

As research continues we can anticipate a refinement and expansion of non-invasive and non-pharmaceutical treatment of phantom limb pain. We can also expect to see the knowledge gained in treating phantom limb pain applied to other pain syndromes. It will certainly be exciting to see the trend of supporting and enhancing the brain's own innate self-healing and the increased reliance on neural plasticity over the use of pharmaceuticals.

Looking Ahead

With hundreds of chiropractors working in the VA and DOD healthcare systems and with an increase of veterans entering the civilian sector of healthcare it is very likely that chiropractors will become increasingly likely that chiropractors will contribute to the multidisciplinary care of war wounded amputations. We should be well versed in the unique neurological and physiological nuances associated with amputations as well as the mechanical changes which

In addition to war wounded amputees, there has been a dramatic increase in adult onset diabetes in the United States and Mexico. Adult onset diabetes is another major cause of amputations.

Disclaimer

The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of the Army, Department of Defense, nor the U.S. Government.

Acknowledgement

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Additionally, I would like to thank Paul Pasquina, MD and Jack Tsau, MD for their work in advancing the state of the science in treating phantom limb pain and other pain syndromes. I thank them for freely engaging with me and sharing their knowledge as I try to understand their work.

References

Melzack R. Phantom limbs and the concept of a neuromatrix. Trends Neurosci 1990;13:88-92.

Melzack R, Israel R, Lacroix R, Schultz G. Phantom limbs in people with congenital limb deficiency or amputation in early childhood. Brain. 1997 Sep;120 (Pt 9):1603-20.

Ramachandran VS, Rogers-Ramachandran D, Cobb S. Touching the phantom limb. Nature 1995; 377: 489–90.

Ramachandran VS, Hirstein W. The perception of phantom limbs. Brain 1998;121:1603-1630

Chan BL, Witt R, Charrow AP, Magee A, Howard R, Pasquina PF, Heilman KM, Tsao JW (2007) Mirror therapy for phantom limb pain. N Engl J Med 357:2206–2207.

Tung ML, et al. Observation of limb movements reduces phantom limb pain in bilateral amputees. Annals of Clinical and Translational Neurology .2014: 1: 9: 633–638.

Hip Flexion Contractures and Lower Back Pain in Above-the-Knee Amputations

Patients with above-the-knee amputations (AK or AKA) are particularly prone to developing hip flexor contractures. Contractures, not to be confused with muscle tightness, are a permanent shortening of tissues which cause deformity or distortion. They also can lead to pelvic and spinal complications, including back pain, anterior pelvic tilt, and lumbar hyperlordosis, when a patient begins walking with a prosthetic limb. In fact, 81% of those with a transfemoral amputation will experience lower back pain,[xiv] in contrast to 47% of the general population who experience lower back pain.[xv] Severe back pain is reported by more than 25% of those with amputations.[xvi, xvii]

Three Causes of Hip Flexion Contractures Following Above the Knee Amputations

Following an amputation, particularly a traumatic amputation, the main concern by the medical team may not be the effect on the patient's future gait, biomechanics, or spinal mechanics. They are concerned with patient survival, wound healing, infection, and thromboembolism. As healing progresses, inpatient rehabilitation will address hip flexion contractures. There are three main causes of hip flexion contractures:

1. The reduced weight of the leg is no longer able to overcome the tension of the powerful psoas and iliacus muscles while resting in a supine position, so the femur flexes. Most amputees have other concurrent health problems such as secondary effects from trauma or disease which keep them in a hospital bed for long periods of time.
2. Sitting in a wheelchair while waiting for the residual limb (stump) to heal allows the amputation to heal in a flexed posture (figure 1).
3. The insertions of the strong hip flexor muscles (psoas and iliacus) remain wholly intact in an AKA, while most of the insertions of their antagonist muscles are amputated. The antagonist insertions of the semitendinosus, semimembranous, biceps femoris, and the iliotibial band (which is essentially the tendon of the gluteus maximus) are gone, while the powerful hip flexor muscles remain intact.[xviii] Thus, the counterbalance of strong hip extension is greatly diminished.[xix] The shorter the residuum, the greater the likelihood of contracture.

The Effects of Hip Flexion Contractures in AKA

Hip flexor contractures create a problem when AKA patients transition from using a wheelchair to using prosthetic limbs. If an uncompensated prosthetic socket is used, the hip flexors will create a hyperlordosis of the lumbar spine when the patient begins to walk upright (figure 2). This may also create asymmetrical torsion of the lumbo-pelvic region in cases with unilateral AKA. These aberrant patterns can cause lumbar facet and sacroiliac dysfunction.

Contractures, even if accommodated by a specially fashioned prosthetic socket (figure 4), will limit the stride length of that limb.

Identifying Shortened Hip Flexors

Contractures and muscle tautness are not the same. Contractures can be permanent or near permanent. Contractures occur when connective tissue loses its normal elasticity and flexibility. The tissues become shortened, stiff, inflexible, and infiltrated with tough fibrous tissue.

In many patients with AKA, hip flexor shortening can be identified by simply having the patient lie supine. If the residual limb points up, instead of lying flat, it is a sign of hip flexor shortening. Another method to determine hip flexor shortening is the Thomas Test (figure 3). The Thomas Test is performed with the patient lying supine on an examination table. The patient or doctor flexes a leg toward the chest until the thigh contacts the abdomen or the lumbar lordosis is flattened. If the non-flexed thigh remains on the examination table, the Thomas test is negative. If, however, the leg rises from the table, it is indicative of tightness in the hip flexors. To establish a baseline metric, measure the amount of tightness with a goniometer.

Figure1. After a period of bedrest, the patient can be transferred to a wheelchair while the stump heals. Unintentionally, this allows the amputation to heal with the iliopsoas muscles in a shortened state.

Chiropractic Treatment

Caring for patients with amputations, especially recent amputations, should involve a team. This team usually includes physiatrists, prosthetists, physical therapists, orthopedic surgeons, and, increasingly, chiropractors.

Spinal problems arising from AKAs can and should be treated with chiropractic adjustments, utilizing techniques intended to normalize the sacroiliac joints, facets, and other spinal structures. The underlying problems of hip extensor weakness and hip flexor contractures must also be addressed in a rehabilitation program.

If performing side posture adjustments, I recommend having the patient leave the prosthetic limb on. This will provide a lever arm to give the chiropractor a mechanical advantage. However, in cases of a very high transfemoral amputation, the prosthetic limb may fall off during treatment. If this occurs, move the limb aside and perform the adjustment without the prosthetic leg.

To make the patient more comfortable, I usually use a folded towel as a pad between the metal shaft of the prosthetic limb and the bones of the knee or tibia when performing a side posture adjustment.

While chiropractors strive for symmetry and balance, it is difficult or even impossible to attain symmetry in treating amputees. In reality, the patient will adapt to a new functional normal, which will likely have asymmetry. This adaptive asymmetry is part of the body's ability to compensate and adjust to impairment. One thing that should be avoided is the use of traditional leg length indicators to determine how to adjust the patient. These methods are less consistent in this population of patients.

If, through the course of treatment, the patient's hip flexion contracture is diminished and hip extension strength is normalized, then re-evaluation should be done by the patient's prosthetist, who may revise the socket's angle.

Treating amputees with hip flexor contractures requires an understanding of the condition and the options available. Preventing contractures in the early stages of healing is certainly much easier than trying to correct or compensate for them later.

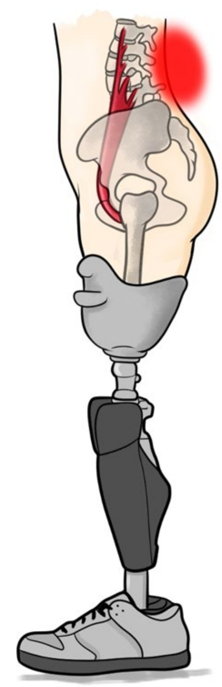

Figure 2. In amputees with hip flexor contractures, it is common to have lower back pain and fatigue when beginning to ambulate with a prosthetic limb. This is due, in part, to the increased lordosis and tension of the iliopsoas muscles pulling on the lumbar spine. In patients with refractory hip contraction, a walker or prosthetic socket cast in flexion (see figure 4) may be required for ambulation.

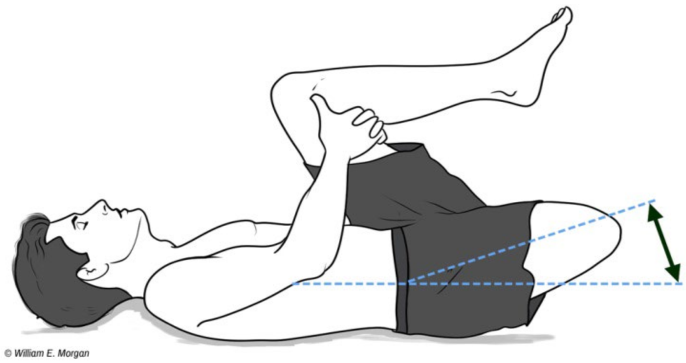

Figure 3. The Thomas Test. Have the patient pull the opposite thigh toward the chest. If the leg (or stump, as in this illustration) flexes, it is positive for tight hip flexors.

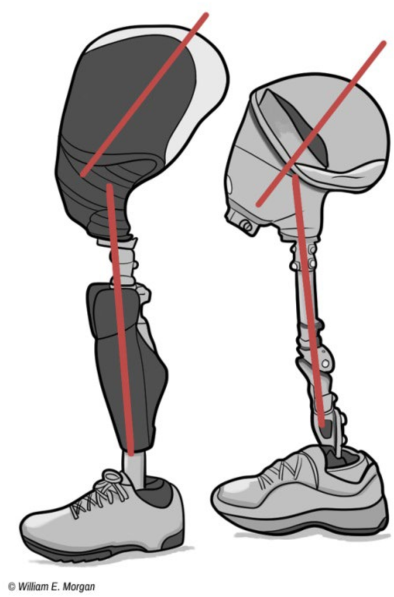

Figure 4. To accommodate the shortened iliopsoas (and other hip flexors), prosthetists frequently create a prosthetic limb socket which keeps the hip in flexion. This compensation allows the patient to begin walking earlier during the healing process, but it may impede correction of flexion contractures.

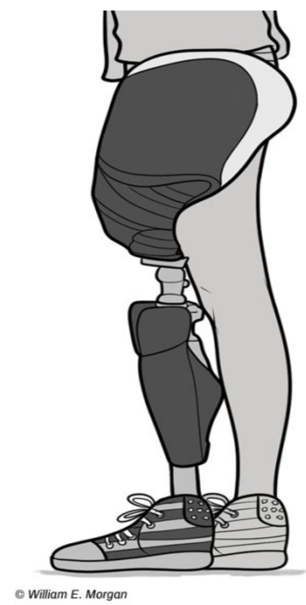

Figure 5. Creating a prosthetic limb with the hip in flexion ensures an asymmetrical gait and stance.

Disclaimer

The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of the Army, Department of Defense, nor the U.S. Government.

References

Hanley, Marisol A., et al. "Chronic pain associated with upper-limb loss." *American journal of physical medicine & rehabilitation/Association of Academic Physiatrists* 88.9 (2009): 742.

2011 Gallup-Healthways Well-Being Index

Devan, Hemakumar, Steve Tumilty, and Cath Smith. "Physical activity and lower-back pain in persons with traumatic transfemoral amputation: a national cross-sectional survey." Journal of rehabilitation research and development 49.10 (2011): 1457-1466.

Rahimi, Abolfazl, et al. "Pain and health-related quality of life in war veterans with bilateral lower limb amputations." Trauma monthly 17.2 (2012): 282.

Jaegers SM, Arendzen JH, de Jongh HJ. Changes in hip muscles after above-knee amputation. Clin Orthop Relat Res. 1995 Oct;(319):276-84.

Sherk VD, Bemben MG, Bemben DA, Interlimb Muscle and Fat Comparisons in Persons with Lower-Limb Amputation. Arch PMR. 2010 July; 91 (7):1077–1081

Campbell M, Dudek N, Trudel G. Joint contractures. In: Frontera WR, Silver JK, Rizzo TD Jr., eds. Essentials of Physical Medicine and Rehabilitation. 3rd ed. Philadelphia, PA: Saunders Elsevier; 2014: chap 126.

Fergusson D, Hutton B, Drodge A. The Epidemiology of Major Joint Contractures: A Systematic Review of the Literature. Clinical Orthopaedics & Related Research: 2007 March; (456) :22-29.

Magee DJ. Orthopedic Physical Assessment. 5th ed. St. Louis, MO: Saunders Elsevier; 2008.

Cook CE, Hegedus EJ. Orthopedic Physical examination Tests: An evidence based approach. Upper Saddle River, NJ: PEARSON Prentice Hall; 2008.

Peeler J, Anderson JE. Reliability of the Thomas test for assessing range of motion about the hip. Phys Ther Sport. 8(1):14-21;2007.

Gaunaurd I, Gailey R, Hafner BJ, Gomez-Marin O, Kirk-Sanchez N. Postural asymmetries in transfemoral amputees. Prosthetics and Orthotics International. 2011; 35(2) 171–180.

About Dr. Morgan

William E. Morgan, DC, DAAPM, FICC, FIM, FPAC, LLD (hc)

Dr. William E. Morgan, is the president of Parker University, Dallas Texas. He previously served as the White House chiropractor (2007-2016) and as the chiropractor to the United States Congress and Supreme Court (2000-2016). He has provided care to all levels of government leadership. Aside from serving patients in the White House, and hundreds of members of Congress, he has cared for dozens of presidential candidates. He was credentialed at Bethesda Naval and Walter Reed military hospitals. He was also the team chiropractor for the U.S. Naval Academy football team. In 2015 he was awarded the Master Clinicians award by Walter Reed National Military Medical Center. He has worked at Walter Reed with wounded warriors of all sorts, including limb salvage, amputees, blast injuries, and TBI. He championed opiate free options while serving at Walter Reed.

Dr. Morgan was the team chiropractor for the United States Naval Academy football team. A veteran of military service, he has served in Naval Special Warfare Unit One, Marine Corps Recon, and in a Mobile Dive and Salvage Unit.

Dr. Morgan is a 1985 graduate of Palmer College of Chiropractic-West. In addition to many other awards, he has received the American Chiropractic Association's Chiropractor of the Year Award. He has also been featured on CCN.com and has been interviewed by the *Washington Post*. Morgan has authored scores of articles and papers: These writings range from technical peer-reviewed papers, to educational expositions, to clinical articles, and opinion-editorial articles. He is an international lecturer for both medical and chiropractic venues in the United States and abroad.

About Dr. Morgan

The Navy's Secret Weapon
U.S. Navy Names DC to Musculoskeletal Board
A Day with Dr. William Morgan
An Interview with Dr. William E. Morgan
The State of the Chiropractic Profession
Spotlight on William Morgan
CNN
Parker Presidency
Washington Post
Kansas
Iowa

Dr. Morgan's Academic Appointments

- Adjunct Assistant Professor of Family Medicine, Department of Family Medicine, F. Edward Hébert School of Medicine, Uniformed Services University of the Health Sciences, October 2, 2006-present.
- Adjunct Professor New York Chiropractic College. September 1, 2008-2016. NYCC faculty member since 2000.
- Preceptor for F Edward Hébert School of Medicine, Uniform Services University of Health Sciences (USUHS). Preceptor for fourth year medical students from the Uniform Services University of Health Sciences (USUHS) taking the CAM elective.
- Preceptor for National University of Health Sciences. May 1, 2006-2016.
- Adjunct faculty for Palmer College of Chiropractic. October 1, 2007-2016.
- President Parker University. June 15, 2016- present.