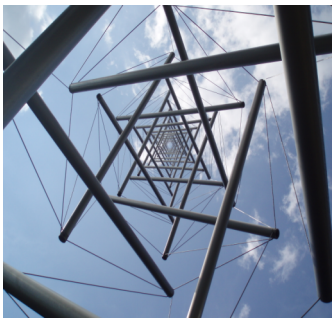
Before we can talk about injuries, we need to familiarize ourselves with how the body works normally.

We will start with concepts that are relatively new to healthcare and then to the well-researched physiological responses to injury. In the end we will put the pieces together so you can apply them yourselves to address many common injuries.

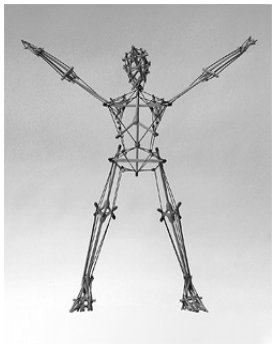
The first concept is a newer way to look at how we function biomechanically. It is called tensegrity.

Tensegrity is a word coined by designer Buckminster Fuller to describe the tensional integrity of his student Kenneth Snelson's 1948 sculpture. In this sculpture and subsequent sculptures, Snelson used some type of cable or tensional element and some sort of wood or metal as a compression element. The compression members float within the tension element, not affixed to other compression elements.

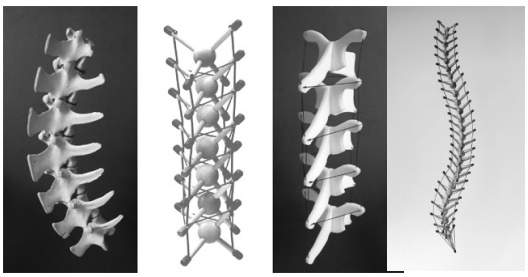


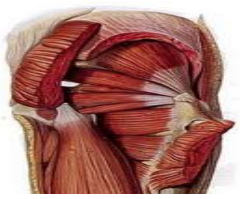
This makes the sculpture as a whole very flexible and able to maintain its shape regardless of gravity or pressure. All the components are dynamically linked so force is absorbed not just by the compression pieces or the tension pieces but by the system as a whole. It is strong yet flexible. Prior to Snelson's sculptures, strength in architecture and building was based on rigidity and mass. That is, if an object fell on the corner of a wall built with bricks, the corner would absorb all the force and would crumble. If an object fell on the corner of a tensegrity wall, the whole wall would absorb the force and the wall would flex. Just as significant is the lack of a heavy support structure or anchoring mechanism in a tensegrity system. This makes tensegrity structures very light as well. Strong, flexible and light allows tensegrity structures to withstand huge amounts of leverage forces as seen in the pictures below. The tensegrity system's

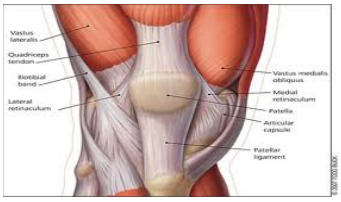
principles are not only revolutionizing the way we build but also, the way we look at human biomechanics and physiology. The older concept of bones holding us up and the muscles moving the bones doesn't allow for the absorption of stress when a boxer gets hit in the ribs or when a dancer lands on one foot after a jump.

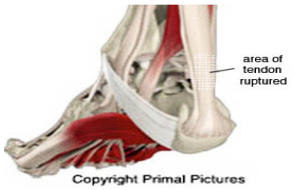


This newer concept of people as balanced self-supporting structures is called biotensegrity. Biotensegrity provides a better model to understand how stress or imbalance affects our bodies. It can be applied directly to familiar examples as when too much stress on our soft tissues or tension elements creates a sprain/strain or on our compression elements or bones creating a stress fracture. However, we can no longer look at ourselves as separate pieces, but must look at ourselves as an integrated system. The idea of interrelated parts is not an entirely new concept in physiology. The closest example of this concept in older models is the kinetic chain. A kinetic chain is a series of joints whose movements are interdependent. Let's take the low back, hip, knee and ankle for instance. If the foot is not weight bearing, called an open chain, one can move the joints independently. If one closed the chain and the foot becomes weight bearing, all joints must move at once. This model however does not take into account any muscular or tension elements or the distribution of stress within the structure. The





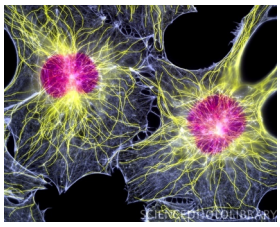




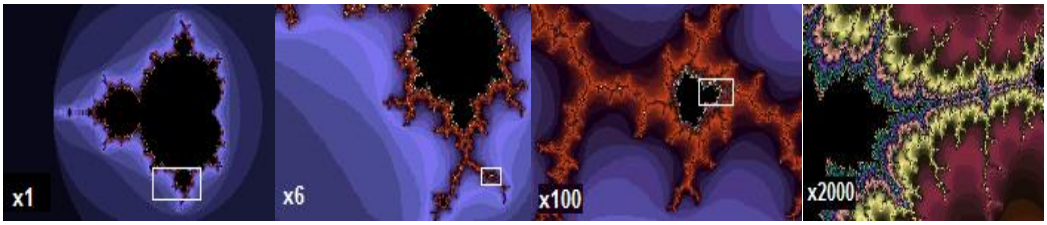
tensegrity model would account for the tension elements during the movement of a closed chain and the larger tensional changes needed to balance the structure as a whole when the chain is open. The tensegrity model forces us to re-evaluate what are important elements of our structure and our function. Take for instance our fascia. Fascia is the connective tissue that is found everywhere in the body that holds us all together while allowing us to flex and move. Until recently it was ignored and cut away by researchers to see muscles, bones and organs. Today, largely due to biotensegrity, it is one of the hottest topics in biomechanics. Entire treatment protocols, such as the system Thomas Myers's details in his 2001 book Anatomy Trains, are aimed directly at fascia.

It is so hot in fact that in 2007 Harvard hosted the first international Fascia Research Congress. This was two days where varied disciplines presented topics on how

fascia and tensegrities influence not only large biomechanics but also how they are found in smaller and smaller versions all the way to the cellular level. This idea of a form or pattern found at different scales within a system is called a fractal and it's the second concept we need to talk about.



We all know of the scaled patterns of nature, like the tree's trunk, branches and twigs. Mathematicians have been studying these patterns for centuries. However it wasn't until 1975 that Benoit Mendelbrot coined the term fractals after using the computer to illustrate these concepts.

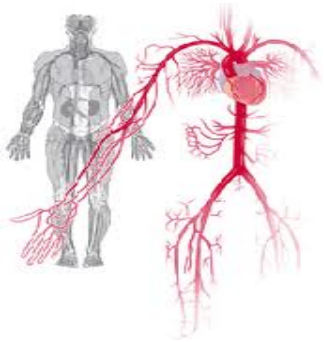


Now that we can visualize fractal patterns and calculate the huge amounts of data involved in fractal mathematics, we are finding fractal patterns in the most surprising areas. As an example I have included an article in the back of this handout describing how physicist and artist Richard Taylor has applied fractal mathematics to Jackson Pollock's work. The article tells how Taylor found that Pollock's work not only contained fractals but also contained the fractal ratios found in nature. People perceive fractal ratios found in nature as most pleasing. Pollock himself later destroyed the one painting of his that fell out of this range because he didn't like it. After reading that article you should head next door to MOCA where they have an original Pollock. After looking at that you will know why fractal mathematics are involved in the explanation of the universe called the chaos theory.

Fractal patterns in the body are everywhere as well. Fractal patterns in the brain, lungs, kidneys and vascular systems are easily visualized, but now that we are looking at fascia and fractals, new concepts are emerging. How we move and function all the way to the cellular structure is all changing. So what you're learning in school right now is probably wrong. For more on this topic look to Dr. Jean Claude Guemberteal's You-Tube clip "Strolling Under the Skin" from the first fascia congress.

I know that is all fascinating, but how can you apply this information yourself as a dancer? We need to look at the fascia and the vascular system for that.

We know that the fascia as a whole is involved as a tensegrity system and now know that it displays fractal patterns to the cellular level. The vascular system displays fractal patterns as well. Arteries get smaller forming capillaries to bring nutrients and oxygen to the tissues. The venous system works in reverse. It takes waste away from cells to be re-nourished or destroyed. Unlike the fascia, the vascular system does not reach each individual cell. Because of this the vascular system must drop off nutrients and pick up waste through the fluid that surrounds the cells called the extra cellular or interstitial fluid. The interstitial fluid stays in place because it is contained within the smaller fractals of fascia. If the fascia is tight due to lack of use or trauma the interstitial fluid comes under pressure and becomes thicker or more gelatinous. This makes it difficult for the nutrients to get to or waste to get away from the cell. This decreases your function and makes you feel old and tired.



If you add heat or mechanical energy to the fascia, the fascia will loosen and the interstitial gel will become more fluid again. This is called thixotropy. By the way, thixotropy is why ketchup won't pour if left sitting around, but will pour after you shake the bottle.

So let's say your thigh is sore and stiff, but you have a big performance. Would you use the foam roller or the myofascial stick?

The foam roller puts a significant amount of pressure directly onto the tension element of a large tensegrity structure; let's say the ITB of the thigh. The idea is to stretch or elongate this element. Because the thigh is a tensegrity, changing one element will put it out of balance and may temporarily disrupt optimal performance.

A myofascial stick will add energy only to the smaller tensegrities of the fascia and interstitial fluid creating loosening through thixotropy.

So foam roller for larger effect and thus longer adaptive recovery response or myofascial stick to warm you up without a notable stress to the system. If you need to perform at optimal levels quickly – choose myofascial stick. For long-term change choose foam roller.

Let's take a moment to highlight the main points of what we have just discussed.

- We have to look at ourselves as a system of equal and interdependent parts.
- Breakdown of that system can show-up anywhere within the system and may or may not be at the point of applied stress.
- The creation or advancement of these ideas came through art.

The importance of the first two points is directly related to how you need to look at your body as an athlete and dancer. Along with our next sections, it will help you understand many seemingly unrelated and insidious problems.

The third point is subtler but directly relates to you as a dancer and artist. As Richard Sennett discusses in his book The Craftsman, it is not until we experience something physically that we can then create the language to describe it. Even so, there are still many concepts and emotions that lack a direct verbiage to express it. Take for example love or fear. They are usually described through physical experience, e.g. I couldn't move, my heart raced, my palms were sweaty etc.

Kenneth Snelson created the physical model that was later explained and advanced. The idea of fractal mathematics was around for centuries, but until Mendelbrot showed us in picture form others didn't apply it. As Einstein said, "information is not knowledge." Fractals were just mathematical equations until they could be applied. This is why art is important. This is how art advances our society. What you are learning right now can be applied the rest of your life. How? We'll go back to Einstein for that. Einstein also said, "Logic will get you from point A to point B, but imagination will take you everywhere."

Let's now talk about some concepts closer to performance and injuries. We'll start with a Russian Gastroenterologist named Ivan Pavlov.

In 1927 Ivan Pavlov was studying dog drool in an effort to learn more about the digestive process. He was studying dog drool because it is the first reflex event in the digestive process. Reflexes are not a voluntary response in dogs or in anything else. So Pavlov was surprised when the dogs started to drool at the sight of his lab assistants not just at the sight of food. What had happened was that the dogs had become accustomed to the assistants feeding them. Over time they developed normal biological reflex to an abnormal stimulus. This has become known as a conditioned response or conditioned reflex. It tells us that we can develop a neurological reflex pathway also known as an engram if we repeat a process over and over. That is what you do everyday in rehearsal so now when you hear the music you have conditioned yourself to drool. I mean dance.

Our bodies have many reflexive engrams that are pre-programmed from the start. One of the most important ones that allow us to move freely is called reciprocal inhibition.

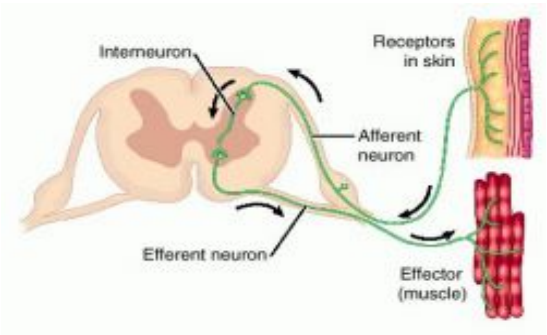
Reciprocal inhibition, also known as Sherrington's Law of Reciprocal Inhibition is the process of inhibiting one muscle when you stimulate its opposite or antagonistic muscle. Let's say you want to flex your bicep in the front of your arm. The nervous system will send an impulse for its contraction while at the same time inhibiting the activity of the tricep in the back of your arm. That way there is no resistance to the bicep's movement. This process is going on all day, every day, anytime you move at all. You can override this response if you try, but otherwise it happens as a subconscious reflex.

Reciprocal inhibition and conditioned engrams are why poor posture and poor ergonomics can lead, over time, to repetitive stress injuries. For more information on that subject look up Vladimir Janda and his upper cross and lower cross syndromes. It is very helpful in understanding the long-term problems from long-term reciprocal inhibition engrams. Now that we're talking injuries, let's discuss how your body responds to injury.

The injury response is really a cascade of reflexive events throughout the body, but only two of these events are important to our discussion. The first one everyone knows as swelling.

Swelling is a cellular response triggered when tissues are damaged. Let's say you sprain your ankle. A sprain is really a disruption or tearing of some of the fibers of a ligament. When this happens proteins are released that signal for an aggressive response of plasma and white blood cells (primarily) to come in and kill any foreign substances (as in a puncture or cut) and eat the frayed ends of the damaged tissue. After that process, a fibrous repair patch can be done much more easily. However, swelling is like calling in the SWAT team. They are needed for times of trouble but you don't want them running around your neighborhood all week. Prolonged swelling will increase your pain and sensitivity and inhibit healing. This is when we recommend ice and not heat. Icing an area for around twenty minutes will constrict the blood vessels limiting its flow and decrease nerve conductivity causing numbness. Heat will loosen tissues but will cause more blood flow and increase nerve activity, both of which you are trying to limit.

The final injury response to be discussed may be the most important to the life of a dancer. This is the splinting or guarding reflex.



Whenever your body is injured or anytime your nervous system senses danger it signals to your muscles to contract, pull back and limit movement of the affected area. This is known as splinting or guarding. This not only happens when you touch a hot object or feel sharp pain

but also in a much more subtle way if you are put under low-grade stress or stress over a prolonged period of time. That means if you sprain a joint or strain a muscle it will tighten, loose some degree of function and disrupt tensegrity balance. Again this is to limit your activities and thus limits potential danger. As we all know most of the time a dancer will try to push through these limits and continue dancing. Once the tissues are warm, you may no longer feel the tightness. However, if it is splinting or guarding, the nervous system will re-establish the tightness once you are cooled down. If this process is repeated you will get tighter and tighter until something in the tensegrity system is put under too much stress and you are forced to stop dancing. The response is also not limited directly to the point of stress but can happen anywhere along the nerve that is involved. This is how a neck problem can lead to a shoulder injury or hand numbness. Also quite common is a low back issue causing tight hamstrings, calves or foot problems. This is a very important point to you as a dancer.

You must recognize a nerve response by the sharpness of pain or the prolonged tightness. If it is a nerve response and you ignore it, the nervous system will always win and somehow stop you from doing the aggravating activity. A tight muscle will loosen with activity and stay looser. A muscle problem will also feel good when kneaded or stretched. A nerve problem will have a painful, sharpness if stretched or kneaded. Chronic tightness is not normal. It says it is a nerve response not just a tight muscle. Nerve issues must be soothed not provoked. Muscles can be aggressively worked, nerves cannot. Again, if you have a tight muscle; start with stretching, heating or kneading. If it keeps coming back or gets worse stop. That is a sign that you may need treatment.

Everything we have discussed so far all leads to this next section.

- If you have an acute injury you will have a swelling response and a guarding response. If you do not get rid of the swelling, sooth the guarding and re-establish the appropriate engrams, you are very likely to either re-injure the same area or injure an area somewhere else.

- Remember that exercise, by definition is a stress applied to the body to which the body adapts. The result is that the body is able to do more work or accept more stress.

- If the body is splinting or guarding to protect you it will not adapt, it will just cause more splinting. Without adaptation there is no exercise. It is only more stress.

- Muscle response is dull and achy. It responds well to stretching, kneading and heat.

- Nerve response is sharp and painful. It does not respond well to stretching or kneading. Ice and seek treatment.

- If you have a chronic tightness or re-occurring injury it means that you are out of balance somewhere in the system. Look to restore balance.

- To restore balance, especially if you do one activity frequently, use the law of reciprocal inhibition to strengthen. This should be a main component of any conditioning program in season or off-season.

- Easing stress on your system creates a freedom of movement, strength and balance. Movement is how we stay healthy. It applies not only for dance but in all systems of our bodies.

The following article taken from a 2004 *Fine Woodworking* magazine is included not only because it is very cool, but also because it shows a commonality of seemingly dissimilar objects like we found when discussing Tensegrities and fractals.

Finding commonalities helps one to understand things at a much greater rate. It creates quicker mental organization and references allowing one to simplify the learning process. Interesting thoughts on the subject of simplified organization can be found in John Meada's 10 Laws of Simplicity and Mathew May's In Pursuit of Elegance.

Enjoy,
Dr. Brian J. Litchfield

"Education is not the filling of a bucket, but the lighting of a fire."

William Butler Yates

Glossary

Conditioned Response
A reaction learned from a repetition of action; a learned response to a stimulation.

Engram
Neuromuscular pattern; conditioned response; muscle memory; learned skill.

Fractal
A fragmented geometric shape that can be broken into parts, each of which is a scaled copy of the whole; a pattern repeated at different sizes within a larger structure.

Heat or Thermotherapy
Heating tissues to induce blood flow, thixotropy, and to break superficial bonds in connective tissue. Generally applied no longer than twenty to thirty minutes.

Ice or Cryotherapy
Cooling an area to reduce fluid accumulation by vasoconstriction, reduce sensitivity by slowing nerve conductivity. Maximum efficacy is twenty minutes, after which the effects are diminished or reversed.

Kinetic Chain
A series of joints within an extremity.

> Open Kinetic Chain
> A non weight bearing series of joints where the joints can be moved independently.
>
> Closed Kinetic Chain
> A weight bearing series of joints that are dependent on each other for movement. If one joint moves all joints must move.

Reciprocal Inhibition
The process in which the stimulation of one muscle will inhibit the opposite or antagonistic muscle.

Reflex
A neurological pathway that goes to the spinal cord and back to an area. It is without conscious thought, that is, it does not go to the brain for processing. It is involuntary.

Splinting or Guarding
Reflexive neurologic response to a perceived threat in which the body will tighten muscles to brace or limit movement of an area.

Swelling
Accumulation of fluids in tissues. In response to trauma, swelling is usually white blood cells, macrocytes and phagocytes to clean and protect the area of injury. Usually lasts two to three days unless retriggered.

Tensegrity
A contraction of the word tension and integrity to describe a structure of floating compression members within a series of tension members.

Thixotropy
The property of some gels that are thick or viscous to become thinner, more fluid or less viscous. Mechanical or heat energy is needed to induce this change.

Injury Prevention Lecture

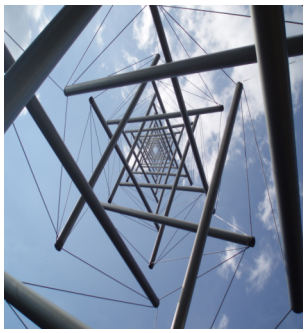
Colburn School
Professional Training Program
April 25, 2011

Dr. Brian J. Litchfield
Litchfield Joint & Muscle Therapy
(626) 792-3057 ljmt@att.net

General Concepts

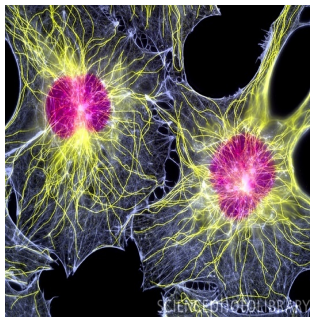
Tensegrity

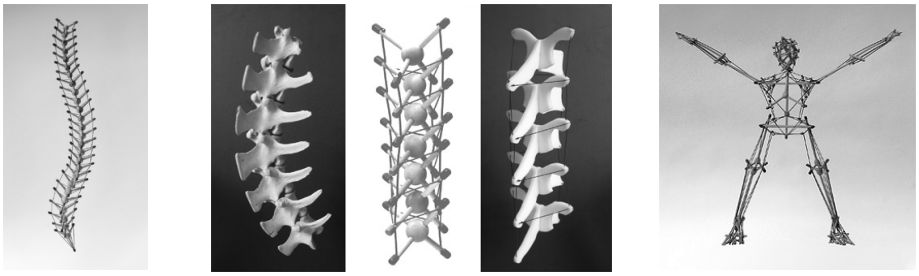
1948 Kenneth Snelson sculpture
Buckminster Fuller
Floating compression members within tension members
Strong, light, flexible
New principles for building, withstands large leverage forces

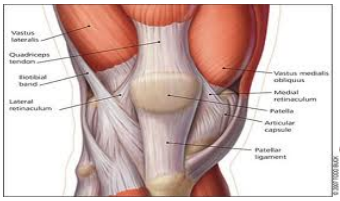


Biotensegrity

Better model to explain movement and the absorption of stress
Soft tissues – tension members
Bones – compression members
Changes on focus of research
Fascia – connective tissue
Increasing importance of fascia
Anatomy Trains by Thomas Myers
2007 First International Fascia Research Congress
How fascia touches every process in the body down to the cellular level

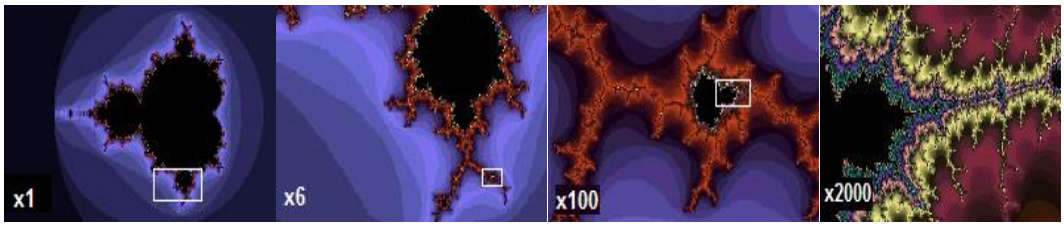




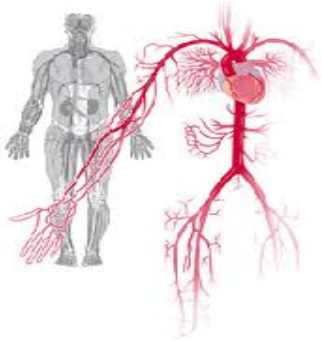


Fractals

Pattern repeated at different scales within a larger structure
1975 Benoit Mandelbrot
Series of computer images now being applied to many
Seemingly unrelated subjects



Richard Taylor and Pollock
Fractal ratios in nature
Fractals in biology
Everywhere in the body
Extra cellular fluids within smaller fascia fractals
Transports nutrients to and waste away from cells
Tight fascia – thick extra cellular fluid



Thixotropy
Mechanical or heat energy makes thick fluid (gel) more flowing
Myofacial stick uses principle of thixotropy
Foam roller loosens tension member of a tensegrity
Creates temporary imbalance

Recap Summary

We have to look at ourselves as a system of equal and interdependent parts

Breakdown of that system can show up anywhere within the system and may or may not be at the point of applied stress

The creation or advancement of these ideas came through art

Neurological and Physiological Concepts

Ivan Pavlov 1927

Drooling dogs
Conditioned response (reflex)
A learned response to a stimulus through repetition

Reflex

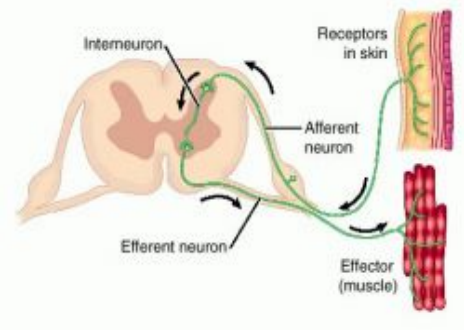
Neuromuscular response made without conscience thought

Engram

Neuromuscular pattern
It's how we perform skills

Reciprocal Inhibition

The process of inhibiting one muscle when you stimulate its opposite or antagonistic muscle



Injury Response

Cascade of reflexive events
Swelling
Aggressive cells to clean an area of debris and foreign substance
Usually lasts two to three days, but is often retriggered
Increases sensitivity
Inhibits healing

Ice

Twenty minutes
Decreases sensitivity
Decreases swelling response

Heat

Increases blood flow (swelling)
Increases nerve activity (sensitivity)

Splinting or Guarding Reflex

Reflex response to an injury or threat
Tightens the muscles surrounding an irritated or injured area to limit movement and thus limit further damage
Can create negative engram if not corrected
Chronic tightness/imbalance
Triggers reciprocal inhibition
Creates more imbalance
Will lead to future injury

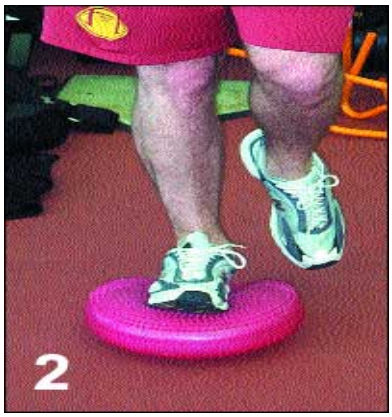
Nerve Response

Sharp, painful, does not respond well to stretching/kneading

Muscle Response

Dull, achy, responds well to stretching/kneading

Injury Prevention Summary



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