TENSEGRITY & Osteopathic Medicine

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Objectives

1. Define Tensegrity and Biotensegrity and the key people who contributed to these concepts
    1. Buckminster Fuller, Kenneth Snelson, Stephen Levin, Donald Ingber
2. Identify the key elements/ principles of tensegrity and Biotensegrity
3. Describe the attachments of the thoracodorsal fascia and understand the layers
4. Discuss the components of the cytoskeleton
5. Describe Mechanotransduction
6. Identify the roles of fascia and fibroblasts
7. Discuss how OMT is proposed to affect Fascia and fibroblasts
8. Correlate the principles of tensegrity with concepts of osteopathic philosophy
9. Testable Materials in **GREEN** throughout this presentation

Tenets of Osteopathic Medicine

The body is a unit: the person is a unit of body, mind and spirit

The body is capable of self regulation, self healing and health maintenance

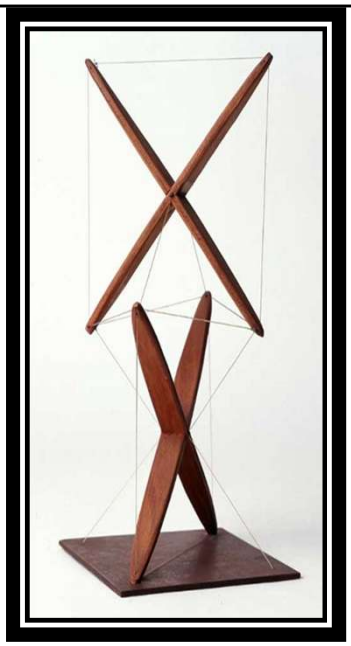
Structure and function are reciprocally interrelated

Rational treatment is based upon an understanding of the basic principles of body unity, self regulation, and the interrelationship of structure and function

Structure and function- we will look a lot at structure through the lens of tensegrity both on a micro and macro scale and see how alterations affect our patients health

TENSEGRITY

- Tensegrity is a design principle that applies when a continuous set of compression elements is opposed and balanced by a continuous tensile force, thereby creating an internal pre-stress that stabilizes the entire structure
  - Ingber and Landau, Wyss Institute for Biologically inspired engineering at Harvard
- Stable- due to distribution and balance of stresses
- Irrespective of gravity or change in shape
- Can change shape with minimum effort- energy efficient- without losing stiffness or stability
- Every component influences **all** others- globally integrated
- Pre-stressed
- Light, resilient
- Compression elements that seem to float in a tensioned network



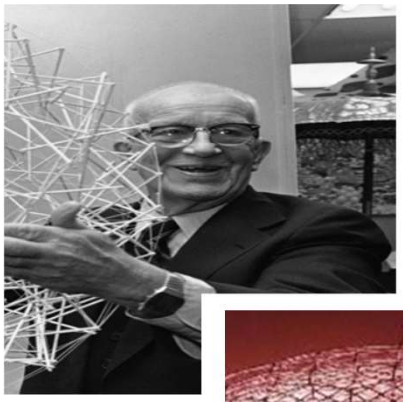
Kenneth Snelson's *Early X-Piece*, 1948

Tensegrity- combination of Tension and integrity

So my job today it to try to explain to you how this concept came about, why it is important and how it fits into concepts of osteopathic medicine

"These mechanical forces, compression and tension or push and pull are invisible- just pure energy- in the same way that magnetic or electric fields are invisible" (Heartney, 2009)

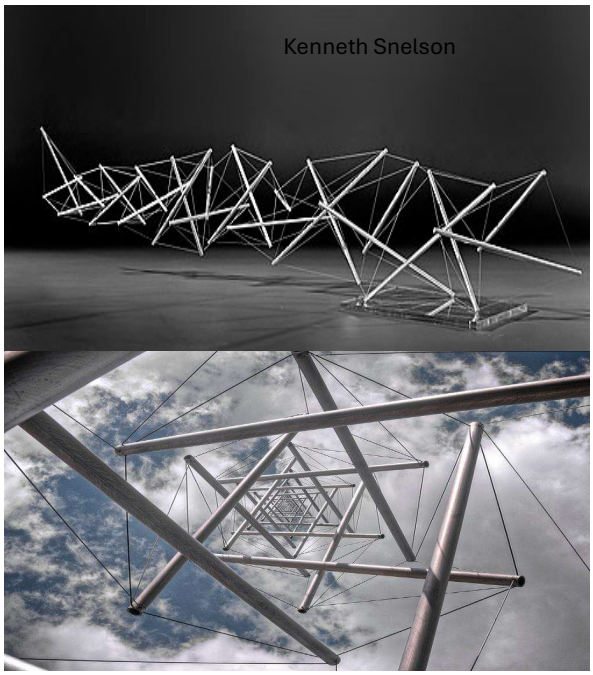
- Coined by Buckminster Fuller (1895-1983)
  - Looked to geometry and natural forms
  - Geodesic dome (montreal expo 1967)
    - Buckminsterfullerine (carbon molecule)
- His student Kenneth Snelson created the structure that inspired the concept
  - Struts and tensioned cables



The way butckminster fuller saw it- nature had already spent billions of years creating designs that were fluid dynamic lightweight and efficient
Simple patterns and shapes
That don't just appear out of nowhere-
Result of interactions of basic rules of physics

Tensegrity Models

- Tensegrity models reduce to the simplest form
  - "sticks and string are intrinsic displays of the force vectors that are active within them"
  - Strong, lightweight, become stronger when loaded
  - Struts float in the tensioned network
  - Can change shape with minimum effort
  - Each cable is under tension
  - Each strut is under compression
  - Nasa Tensegrity Robots
    - NASA 360 Talks - Super Ball Bot (youtube.com)



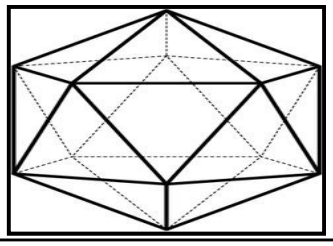
Traditional Forms of Architecture vs Tensegrity

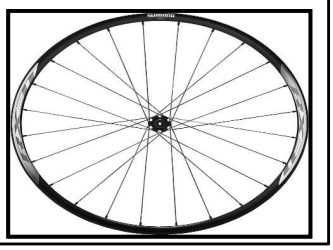
Traditional

- Blocks Piled on Blocks
- Bricks and stone are good at supporting compressive load
- Too much compression and stone cracks
- Poor ability to account for rotational forces
- Weight is always transmitted down to the ground in accumulating compression

Tensegrity/Geodesic Dome

- Minimization of energy
- Stabilization through continuous tension and local compression
- Sphere- leading to hexagon- icosahedron
  - Tetrahedron- smallest volume of unit space within the largest surface area- minimal energy shape
- Strong- stable- light- cheap- easy to build- relatively immune to surroundings





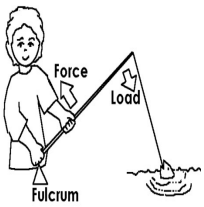
Spheres- ultimate compression element because it resists compression equally from any direction
Icosahedron occupies a greater volume within the smallest surface are of any regular structure apart from a sphere.

Hub and the rim are isolate and discontinuous compression elements held together by tensioned spokes
This balance maintains the wheels integrity-
The tension and compression elements remain distinct and the function of each one depends on the stability of all the others.

Mechanics Vs Biomechanics

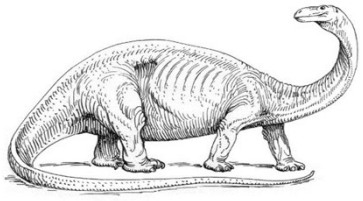
Mechanics

- Linear stress/strain effect
- Man made materials weaker when stressed
- Square cube law- scale an object up in size (double the height of a building)- surface area squared, volume cubed- leading to an eight fold increase in weight
- If this were true of large animals they would collapse under their own weight
- Pillars, Beams, Levers
  - If the body is thought of in this way- then motion is analyzed via joints and levers- where bones compress and each joint moves in isolation
    - This is incomplete and doesn't work
    - Fishing example



Biomechanics

- Non linear stress/strain effect
- Resist much higher strains- become stronger as force increases
- "Bones and tendons can thus store much larger amounts of energy and return it like a spring"
- Tensioned cables and compressed struts
- Strong, light, flexible, can change shape
- Nervous system influence- reflex loops and supraspinal influence
- Based on geometric relationships



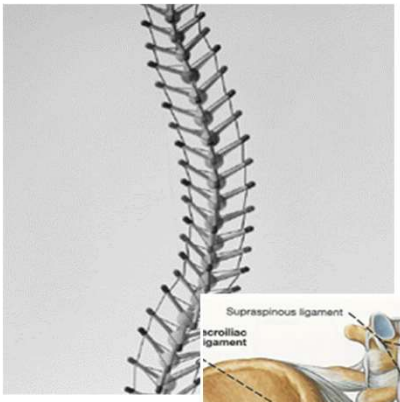
Mechanics would have us look at bones stacked like bricks one on top of the other and the muscles and connective tissue like the rigging in a sail

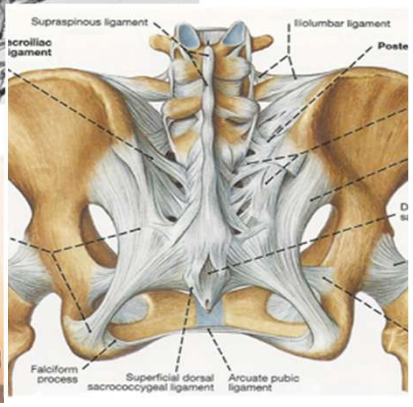
Simple level arms have an amplifier effect- however if we look at the fishing example Depending on how long the rod is and how heavy the fish is- our muscular contraction should not be enough to be able to pull in the fish without Significant damage to our own structures
However we can- helping to prove that we aren't just a simple lever system- we use a different system of mechanics

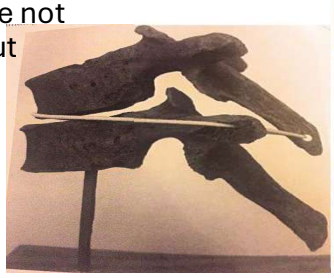
We don't work according to lever theory- which causes compression
We have actually been found that when muscles contract they gap the joint to avoid compression

Biotensegrity- “A dynamic architecture that unifies the whole organism”

- “Even minor changes in one body region may affect significant biomechanical, tensile and ergonomic changes elsewhere”
- Stephen Levin MD
  - Orthopedic surgeon- interested in tensegrity in the 1970’s
  - Started to think about the spine not as blocks and squishy discs but how does tension hold them together







Scarr, Biotensegrity the structural basis of life

At the macro level we can see that our own body structures closely resemble the-
sticks and strings
become bones, ligaments, muscles and fascia

Dr. Levin was an orthopedic surgeon who went to the museums in Washington dc and tried to figure out how the dinosaurs immense weight didn’t create enormous strain on their tissues
He realized that the neck didn’t work like a lever or a crane
But the tension was distributed the force throughout the neck and avoid stress concentrations and points of potential weakness.

He started changing the idea that the spine was solid blocks and squishy disks and their compressive load down to the pelvis
He started to see how tension could hold the spine together
A model like this would allow the spine to function well in any postion regardless of gravity or loading and with minimal compression
Discs are then facilitators of movement

He also noticed that during surgery if you tightened up the cruciate ligaments it

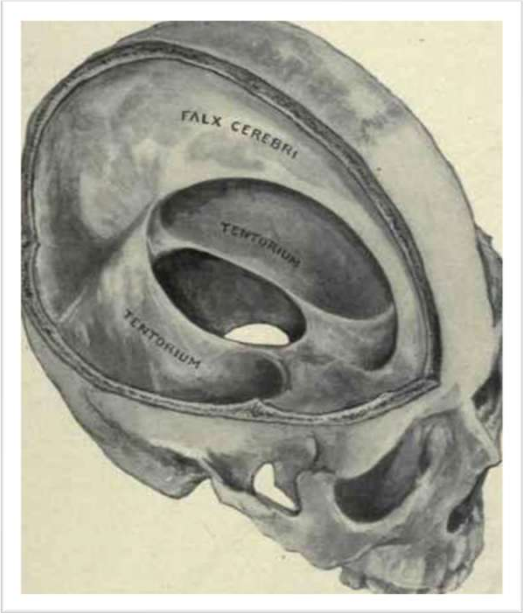
caused the knee joint to move apart- he noticed that normal joints had a slight spacing in between then causing the bones to move apart
This doesn't happen in a lever system- it was like "the bones were floating in soft tissue"
He actually was under an arthroscopic surgery awake and saw the constant 1-3 mm of space between the patellofemoral joint and the femoro-meniscal articulations
Even when the quads were contracting- even when the leg was being loaded.

It is thought that the normal cartilage functions more as a protective end-cushion rather than major load bearer with tensioned muscles and connective tissues regulating the joint spacing and surface pressure.

This is tensegrity on a macro level

Cranial Considerations

- Tensegrity helps to explain how the bones can enlarge without the brain pushing them out
- Flexibility of the skull
- Explanation for how cranial base somatic dysfunction (sphenoid/occiput) could alter tension patterns and cause plagiocephaly



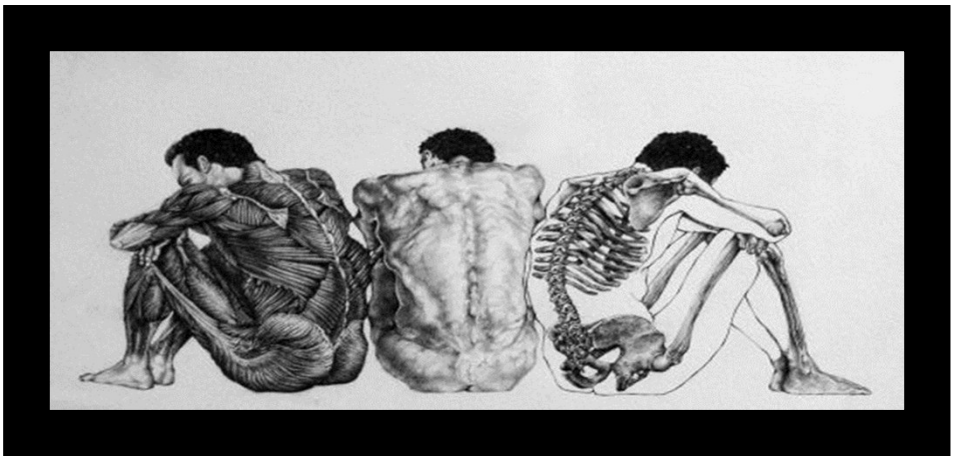
Want to know more?
https://www.journalofosteopathicmedicine.com/article/S1746-0689(08)00032-1/abstract

OPTIONAL reading
“A model of the cranial vault as a tensegrity structure, and its significance to normal and abnormal cranial development”
Graham Scarr

Anatomy Trains

- Whole body patterning in posture, function and movement
- "individual muscles acting on bones across joints' simply does not adequately explain human stability and movement"
- Think of how muscles and fascial systems work
  - "enabling the controlled transfer and amplification (or attenuation of force, speed and kinetic energy"[10]
- Transfer of Power example
  - Closed Kinetic chains
  - Jumping
  - Rock climbing
- www.anatomytrains.com
- Anatomy Trains by Thomas W. Myers

Anatomy has moved from classification of structures to really looking at function and adding back in the importance of connective tissue.

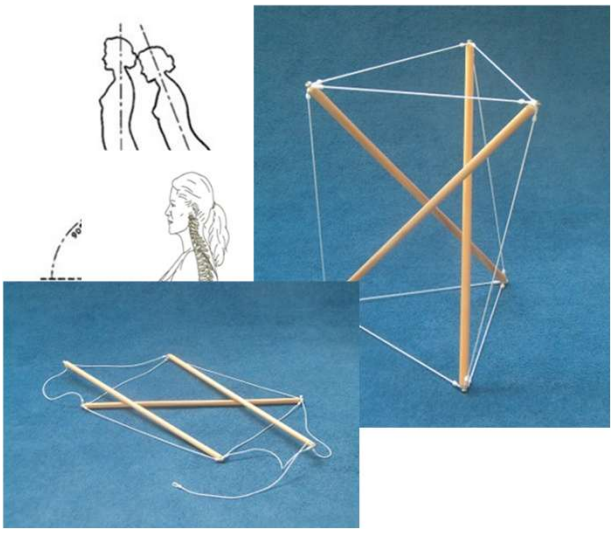


Found on urkel-grue.tumblr.com

POSTURE AND TENSEGRITY

Tensegrity considerations for POOR Posture

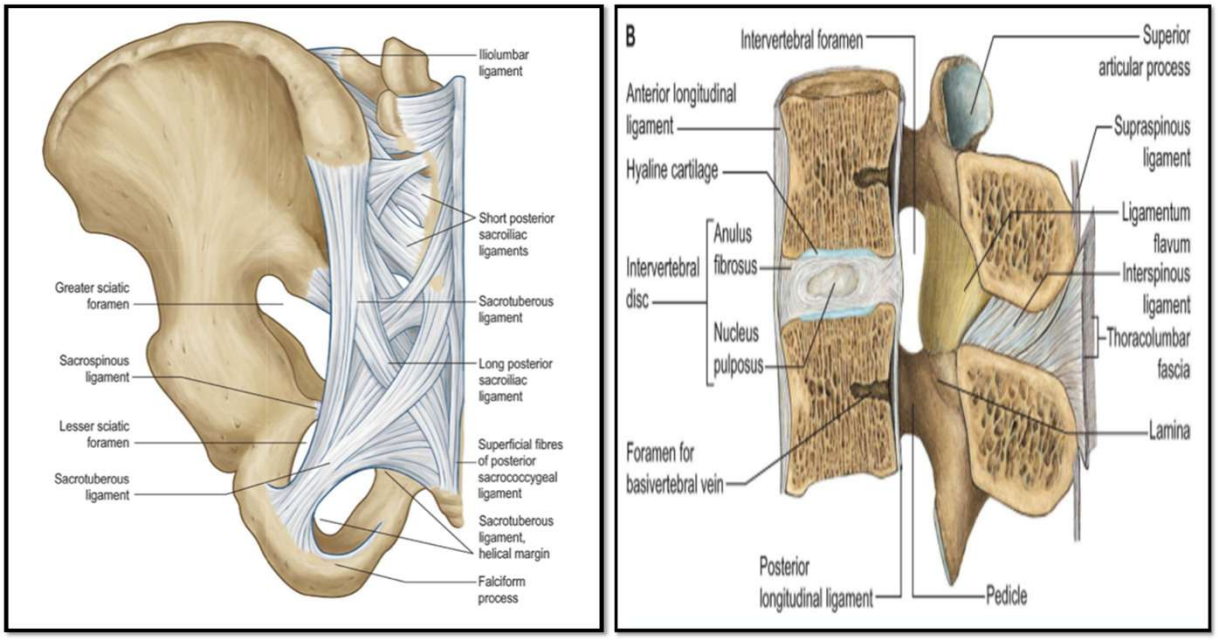
- Increased energy demands
- Increased muscle contraction to counteract gravity
- Gravitational stressors amplified
- Functional capacity will be limited by less than ideal structure
- Patterns that are compensated can decompensate
- Loss of normal muscle firing patterns
- Bone Remodeling
- Tissue Texture changes in Length and quality
- Fascial Changes
- Somatic Dysfunction



Compensated posture will remain asymptomatic- until it's not

A persons functional capacity will be limited by less than ideal structure- might be ok for you or me- but think about your less healthy patients- someone with COPD or CHF who has few reserves to begin with

Compensation requires work of muscles- fascial strain- predisposes to SD- reoccurring patterns and SD even after treatment



Standing S. Gray's Anatomy the anatomical basis of clinical practice. Elsevier 2016

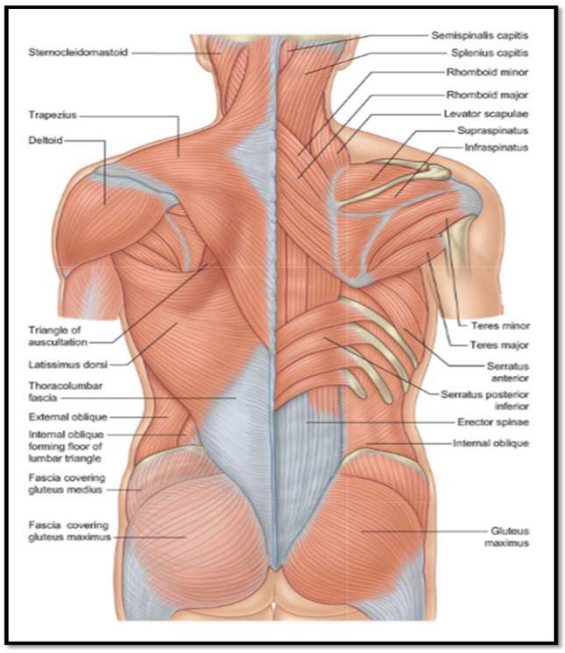
To begin to think about the anatomy we need to not think of it in terms of individual structures but as a continuous ligamentous stocking to which our primary movers have attachment- multifidus, gluteus maximus, biceps femorsis etc- they stabilize the lumbar spine and transfer energy from the upper body to the lower extremities and form a "self bracing mechanism as coined by Dr. Andry Vleeming-
These ligamentous structures have nociceptors which may activate the inflammatory response and play a major role in degenerative disease and low back pain.

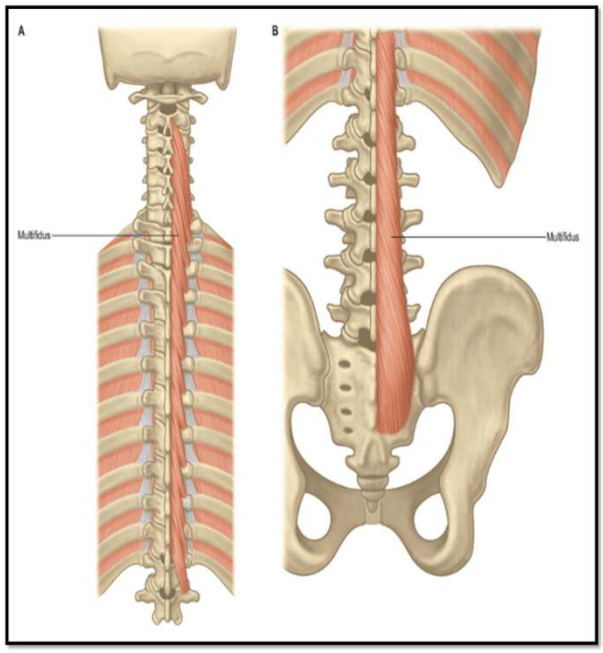
The ligamentum flavum which is a continuation of the articular capsule of the facet joint is between the laminae- but it's medial fibers fuse with the interspinous ligament- running between spinous processes and thickens to form the supraspinous ligament- these connections are then important because the supraspinous ligament is anchored to the thoracolumbar fascia.

The fan like orientation of the interspinous ligaments indicate that it's job is to anchor the A/P pull of the TDF and transmit tension into the ligamentum flavum- potentially preventing the ligamentum flavum from buckling into the spinal canal as well as influence lumbar spinal alignment. The supraspinous/interspinous thoracolumbar complex act as force transducers from the TLF into the lumbar vertebral column.

We consider the ALL- basiocciput to sacrum blending with the SIJ capsule- where it has connections with the crura of the diaphragm and attachment sites for the psoas muscle.
PLL also basiocciput to sacrum attaching stronges to the annulus fiborsos and weakest to the vertebral bodies- these both stabilize in flexion (PLL and LF) and extension (ALL) and are vulnerable to injury in rotation.

Iliolumbar ligament L4-L5 SIJ capsule and iliac crest. The SIJ itself is of particular interest as it is often thought of as a major source of low back pain-Blending of so many of the ligaments here- interconnection- transmission of tension





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MUSCLES

When we think about the muscles in the lumbar region it helps to think about Global vs local players
Global- large torque producing- general trunk stability
Local- directly attach to lumbar vertebrae and provide segmental stability

As we start to look at the muscles we have iliocostalis and longissimus which arise from the iliac crest and thoracolumbar fascial with with the exception of a few slips do not attach to the lumbar vertebrae.
Multifidus however has major attachments to the sacrum , interosseous si ligaments lumbar vertebra and the thoracolumbar fascia, as well as the SIJ capsule and fibers that connect to the sacrotuberous ligament.
We should think of the multifidis as not only a spinal extensor but a stabilizer of the lumbar spine through it's orientation and connection and part of the self bracing mechanism

Multifidis has been implicated in playing an important role in standing and seated posture, gait, trunk movement, and carrying loads.

Size changes of multifidis have been noted in idiopathic scoliosis- lumbar disc herniation is associated with histochemical changes in the multifidsi consistent with atrophy and fibrosis- low back pain is associated with a decrease in the side of multifids and reduced size and fatty deposits show up in low back pain patients more than in healthy patients.
Part of it is loss of stabilizing strength but also loss of fascial tension generating ability into the thoracodorsal fascia.

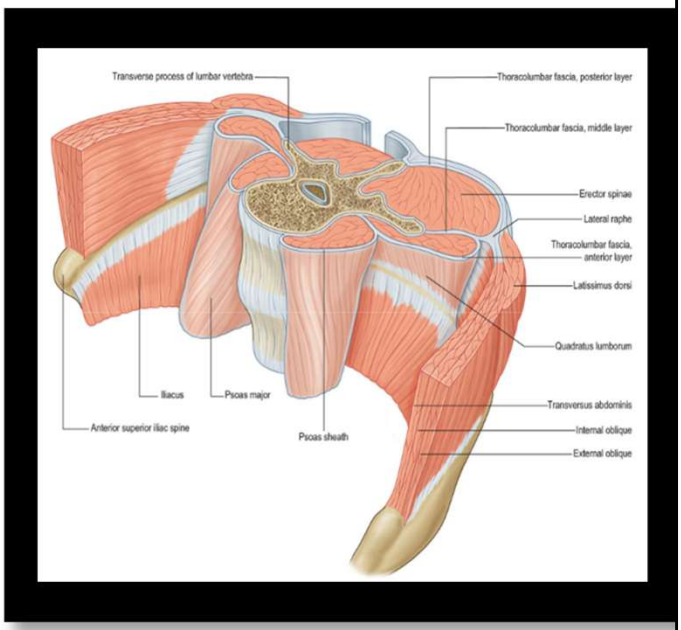
Some of the other key players include
Latissimus dorsi- with attachments to the thoracodorsal fascia- linking UE to LE
Gluteus maximus- with attachments to the thoracolumbar fascia and its associated raphe (connected to multifidis) and the sacrotuberous ligament- considered part of the self bracing mechanism of the pelvis

Biceps femoris- this muscle represents a continuum of SI ligaments to the fibula and investing fascia of the leg- when extending the thigh- contraction will pull the sacrum against the ilium compressing and stabilizing the SIJ (which happens at heel strike- force transfers)
Piriformis- another self bracing muscle – besides lateral rotation stabilizeds the femur in the acetabulum, places tension on the SIJ capsul and pulls the sacrum against the ilium.

In summary activation of these muscles helps to tighten the connective tissue support- assist in stabilizing and self- bracing- increasing strength may lead to increased stiffness, increased resting muscle tension and increased tension on the posterior layer of the thoracolumbar fascia- stability!

Thoracolumbar Fascia System

- Three layers
- **Posterior**
  - Attaches at spinous processes envelopes ES, MTF, QL
  - Linked to lats, GM
- **Middle**
  - Attaches to lumbar transvers processes, separates deep ES and QL, continuous with TA
  - Posterior and middle can act like a hydraulic amplifier
- **Anterior**
  - Anterior surface of QL- contributes to the lumbocostal arch of the diaphragm
- Point of attachment for abdominal musculature (EO, IO, TA)



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Three layers- enclose ES, MTF, QL
Posterior layer- spinous processes- strongest and thickets- and is the only later that extends up into the thoracic region- posterior to the erector spinae group- transmits forces from LE and UE lumbar spine and pelvic girdle
Some studies note connections up into the rhomboids, serratus posterior inferior and splenius cervicis
Latissimus and gluteus max are linked to this layer- and contraction can increase tension across the thoracolumbar fascia contralaterally and ipsilaterally as well as compressing the sacrum and ilium and enhancing the ability to attenuate shear loads.

Middle layer- attaches to lumbar transverse processes- seperates deep erector spinae from the QL- it is also continuous with the TA

The PL and the ML can act as a hydraulic amplifier- by restricting radial expansion of the paraspinals and enhancing their contraction and then the extension moment generated by them- functioning of this fascial system leads to increased efficiency of the muscle
Wearing compression stockings

Anterior layer- anterior surface of the QL- lies just posterior to the iliopsoas and controbues to the lumbocostal arch and attachments of the diaphragm

The transversus abdominus, pelvic floor and diaphragm all work together to increase intraabdominal pressure- assisting in stabilization of the lumbar spine
Serve as points of attachment for EO, IO and TA

ABDOMINALS

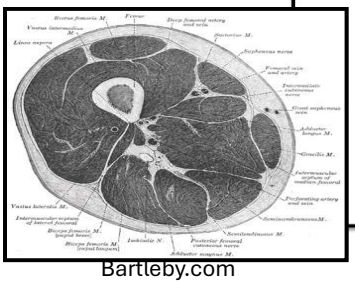
The posterior/middle layer forms the lateral raphe- TA, IO, EO- so these muscles also exert influence over the lumbar spine- TA all lumbars IO lower, EO upper- contraction of TA stabilizes the spine- especially through the middle layer and can actually pull on the direct connections to the lumbar transverse processes.

The abdominal muscles are also important to the stability of the lumbar spine- and there is evidence that their recruitment is altered in the prescense of low back pain.
EO- fibers contract- pull is cranial and posterior- interdigitates with serratus anterior and pectoralis major linking the abdominals with the shoulder
IO- attachment at iliac crest and thoracolumbar fascia at the lower lumbar segments- its pull is medially directed- compressing the pubic symphysis
TA- key stabilizer of the lumbar spine- been demonstrated that rehabilitation of this mucle helps to decrease low back pain.- optimally oriented for a posterior pull- this in combination with the angled vectors of EO, IO and TA "**cinches**" the abdomen pulling the abdominal contents closer to the lumbar spine.
Imagine this with contraction of the diaphragm and the pelvic floor increases intra-abdominal pressure –further assisting in stabilization of the lumbar spine.
Additionally many of the fibers of OI and TA extend beyond the iliac crest-so they may have compressive force generating capabilities to provide SIJ stability

It's been hypothesized that weakening of transversus abdominus decrease thoracolumbar fascia tension- leading to diminished self bracing- the body attempts to use other strategies- hamstrings and glutes- higher tension in the hamstrings causes the pelvis to rotate backwards- flattening the lumbar spine- unnatural distribution on lumbar- degenerative processes

Fascial systems of the LE, Pelvis

- Strengthening of the Pelvis and LE muscles is important for low back rehabilitation due to muscular, fascial and ligamentous linkages
- Fascia Lata system
  - GM serves as a muscular linkage between two major fascial systems
    - Thoracodorsal fascia
    - Fascial lata
- Iliopsoas as a stabilizer



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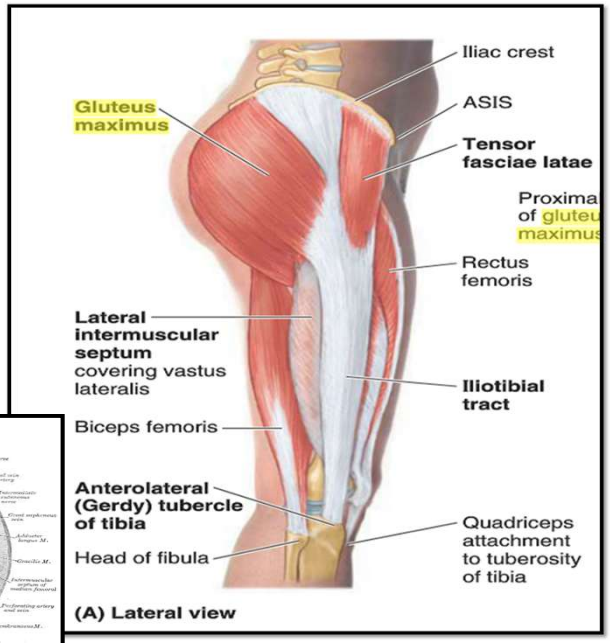

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Fascia Lata- connective tissue that surrounds the thigh- thickest laterally at the ITB- muscles attach here- GM, TFL and muscles are incased in this fascia including quads, hamstrings and adductors

The gluteus max serves as a muscular linkage between the two major fascial systems- the thoracolumbar fascia and the fascia lata- so contraction in the glutes results in stiffness across these networks.

Thinking of the glutes as not only hip extensors- but tension generators-
HANDS ON LOW BACK SQUEEZE GLUTS ACTIVITY

Hamstrings due to their connections limit nutation of the sacrum and assists in the stability of the sacroiliac joint

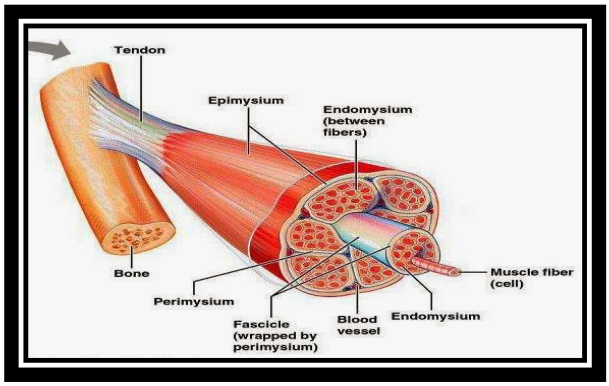
Bicepts femoris connection to fibularis longis and brevis fascial tensions- which makes sense- during gait- on heel strike we need to be fully engaging a self bracing mechanism- with dorsiflexion of the ankle you are adding tension into the hamstrings and throughout the thoracodorsal fascial system.

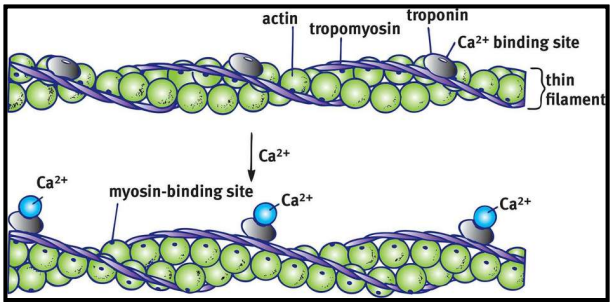
Iliopsoas lumbar discs-TP- bodies to lesser trochanter- continuous with medial arcuate ligament giving it a diaphragm connection and is also continuous with the pelvic floor fascia
Some new considerations that psoas major is less for hip flexion than it is for spinal stability- it may eccentrically lower the spine during side flexion

So through our tour of anatomy you can begin to see how the practice of treating isolated muscle groups would not be as good as training multiple muscle groups through muscular slings and anatomic linkages that serve to stabilize the lumbar spine.

Helixes within Helixes

- "It is easy to think of bones as compression struts and muscles as tensioned cables, and most of these stick and string models are built on a similar size scale, the essence of bio-tensegrity is structural and functional interdependency between components at multiple scale sizes."
- Helixes within helixes
- Hexagonal close-packing arrangement of actin and myosin in each myofibril
- Actin and myosin are their own tensegrity structures with tension and compression in their atoms





Fascia often considered packing tissue however it has significant influence over muscle generated force transmission
Endomyseium- around muscle fibers continuous with perimysium groups of fibers connecting with the fascia that invests the whole muscle group
These fascia are crosslinked collagen

Fascia- A component of Tensegrity

- **Active role**
  - Complex physiological and functional roles
  - Force closure
  - Transfer/ storage of energy (oscillatory or coupled motions)
  - Coupling of motions
  - Largest organ system- architectural support and scaffolding
  - Neurovascular lifeline
  - Proprioception- a "sense organ of human mechanics"
  - Electrically activated (semiconductive- piezoelectric)
  - **Fibroblast** is the principles cell- (homeostasis and remodeling)
    - Secrete Extracellular matrix, proteins, cytokines, growth factors, IL, IF delivered locally and systemically
- **Can be affected by somatic dysfunction**
  - Re-organizes along lines of tension
  - Remodeling of tissue- fibrosis
  - Stress on the structures it envelopes
  - Cellular migration in injury

"I know of no part of the body that equals the fascia as a hunting ground" A. T. Still

Previously though to be passive- cushion- attach- invest body structures- now seen as more complex physiological and functional role

Every body tissue is wrapped in fascia creating a structural continuity that gives form and function to every tissue and organ- the body truly is a unit
Every area is communicating with another through the fascial continuum

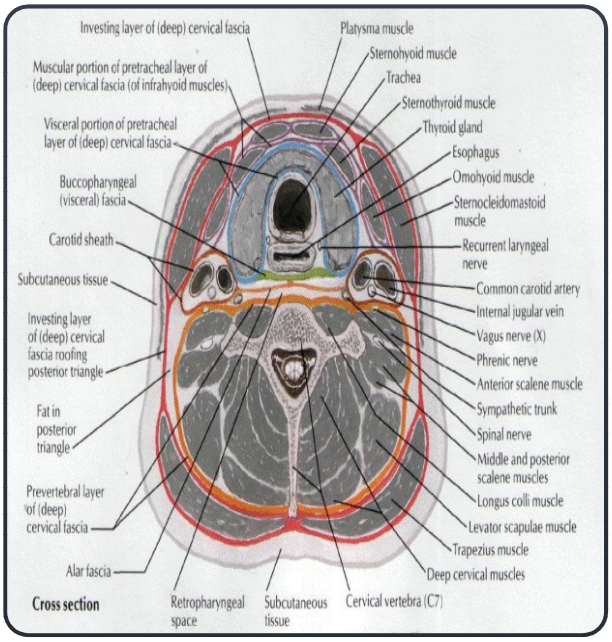
Envelopes and interacts with blood vessels, nerves, viscera, meninges, bones and muscles creating depths and a tridimensional metabolic and mechanical matrix.
The fascia then becomes an organ that can affect an individuals health

Awareness of its function and of the areas it controls becomes significant with a patient's wellness and health.
Connective tissue system- dynamic storage of energy during **oscillatory motion/coupled motions**
FOM largest organ system- moveable conduit- neurovascular lifeline-

FIBROBLAST PRINCIPLE CELL SENSITIVE TO MECHANOTRANSDUCTION (homeostasis and remodeling)

Fibroblasts convey tension can dynamically affect mechanical tension, rapidly remodeling cytoskeletons to sustain tension without difficulty

Ready to adapt in real time



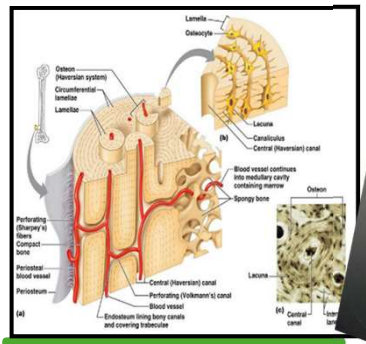
Meta System

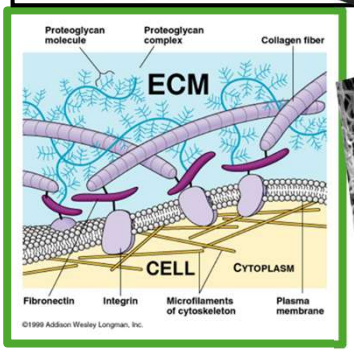
- "Since connective tissue plays an intimate role in the function of all other tissues, a complex connective tissue network system integrating whole body mechanical forces may coherently influence the function of all other physiological systems. Demonstrating the existence of such "meta-system" would therefore change our core understanding of physiology."
    - Langevin, 2006
- Fascia "connects every bone and muscle into a single tensioned network"
- Develops compartments, "tubes within tubes"

Tensegrity at the Cellular Level

- **Donald Ingber PhD Professor of bioengineering**
- Cells also have tensegrity scaffold

- **The Cytoskeleton**
- Microfilaments, Microtubules, Intermediate filaments
- Respond to mechanical forces
- connects to the nucleus of the cell
- connects to the outside of the cell
  - Connects to the ECM via
    - Integrins and cadherins
    - "transmembranous strain gauges"
  - "A change in ECM tension also causes a realignment of structures within the cytoskeleton and alters cell shape and function"
- "Influences the shape of the cell and position of organelles, activates multiple intra-cellar signaling cascades and has links to other cells and tissues."





Donald ingber was a graduate student in the 1970's- he was taking a sculptural class and he recognized similarities with the behavior of cells in a petri dish
He realized that cells also have tensegrity structures

When we move muscle and bone we add mechanical energy
There is stress channeling through load bearing elements and distortion of tissues- so it movement and posture doesn't just affect us at a gross anatomical level but also at a micro level

There are systems within systems- bony matrix of chondrocytes- each chondrocyte linked to the ECM via integrins- and integrins link to the cytoskeleton- it is proposed that these then affect biochemistry and gene regulation

The ECM is constantly affected by biophysical strains from normal and injurious strain patterns- it is an efficient conduit for the transmission of strain to the cell matrix-activating cascades within the cell itself.

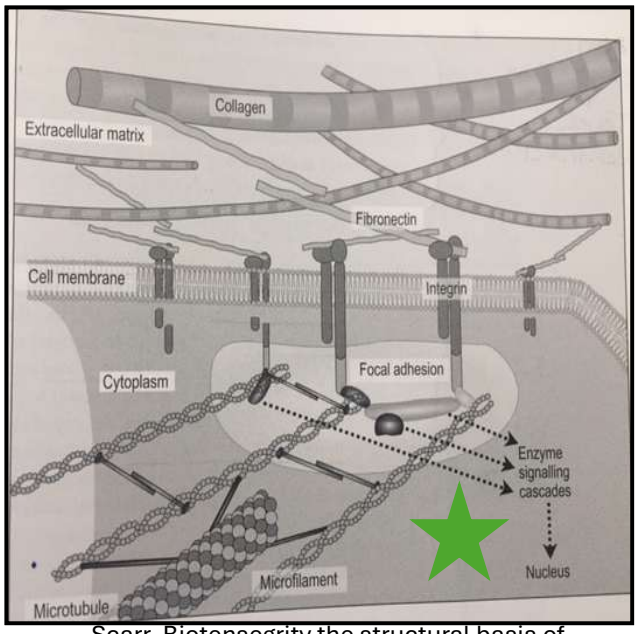
This matrix allows for bidirectional communication between the cytoplasm and the extracellular fluid in regard to cytoskeletal architecture, cellular alignment and

cellular migration.

Think about this system occurring every day as we walk or sit- preserving blood vessels and nerves
You can see how a non physiological state can alter the ability of the fiboblast to respond and work properly.

Mechanotransduction

- Mechanotransduction is where mechanical signals are turned into chemical ones
- Figure demonstrates how "the internal cytoskeletal lattice with links to the outer extracellular matrix through integrins in the cell membrane, and showing its influence on the activity of enzyme signaling cascades that lead to changes in cell function"
- ECM changes affect intracellular forces
- Changes may be acute or long term
- Can activate ion channels, adhesion proteins, and cause conformational changes in the cytoskeleton
- Ultimately results in changes in gene transcription factors and gene expression



Scarr, Biotensegrity the structural basis of life

Tension is a language

The adaptation of the cells (and their survival and the survival of allthe systems) depends on the cells ability to adjust themselves ad change their form

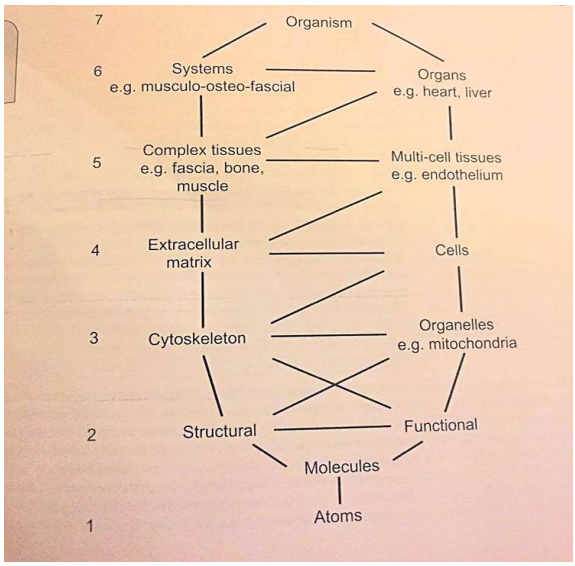
Biophysical strain regulates cellular proliferative capacity, production of extracellular matrix molecules, gene expression patterns, and the contractile state of fibroblasts through the actions of transmembrane mechanoreceptors.

May enzymes and substrates are attached to the cytoskeleton and mediate metabolic function like glycolysis, messenger RNA transcription, protein synethesis and DNA transcription and replication

All of these things can lead to growth, differentiation and apoptosis

Mechanopathology

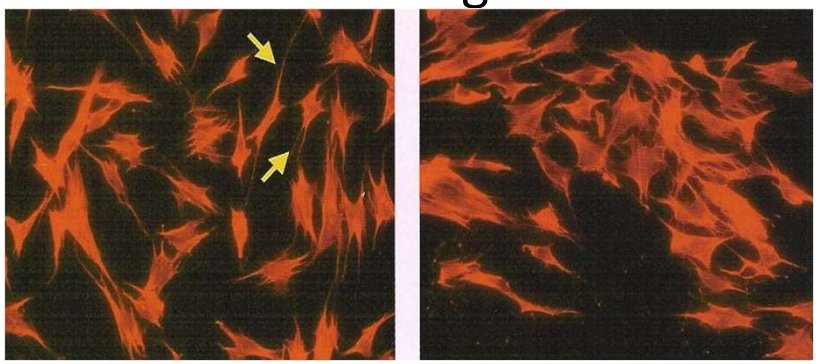
- External forces affecting mechanotransduction potentially leads to pathology
- Disease states thought to be influenced by altered mechanotransduction include:
  - Cardiomyopathy
  - Atherosclerosis
  - Asthma
  - Osteoporosis
  - Muscular dystrophy
  - Cancer



Scarr, Biotensegrity the structural basis of life

How Does OMT Integrate into this?

- JOM "Modeled Repetitive Motion Strain and Indirect Osteopathic Manipulative Techniques in Regulation of Human Fibroblast Proliferation and Interleukin Secretion"
- 3 groups
  - Repetitive mechanical strain (RMS)
  - OMT
  - RMS + OMT
- Measured IL and fibroblasts immediately after and 24 h
  - RMS- increase in IL- decrease in fibroblast
  - OMT-decrease in IL 3
  - RMS + OMT-decreased IL6 and increased fibroblast proliferation
- "fibroblast proliferation and expression/secretion of proinflammatory and anti-inflammatory interleukins may contribute to the clinical efficacy of indirect osteopathic manipulative techniques"



Control Strained

- "Human fibroblasts responds to in vitro strain by secreting inflammatory cytokines, undergoing hyperplasia, and altering cell shape and alignment."
- By using this model we can simulate injuries and somatic dysfunction
  - Then investigate underlying mechanisms of OMT

These two articles started with the assumption that normal physiologic movement, pathologic conditions and OMT have an effect on the shape and proliferation of human fibroblasts

So these authors started by looking at fibroblasts and what happened if we biophysically strained them.

In the picture the contral had long discrete actin containing pseudopodia
In the strained fibroblasts the pseudopodia were absent

This first study validated fibroblasts as an appropriate cell model because of the role they play

Remember in the beginning we said that fibroblasts are the primary cell of the fascia
They secrete ECM- architectural support for many tissues, scaffolding for celluar support and support of cellular migration to sites of injury
Cytokines growth factors
And those can all be local or systemic
Fibroblast proliferation and collagen production regulated by biophysical strain

Abnormal collagen secretion may decrease tissue compliance or cause fibrosis
We may affect all this with OMT

JAOA article- these authors were looking for cellular mechanisms by which OMT may work.
They looked at
Human fibroblast proliferation and interleukins present
Modeled indirect osteopathic manipulative techniques
Took fibroblasts and exposed them to
8 hour repetitive motion strain
A 60 second treatment
Or a 8 hour repetitive motion strain followed by a 60 second treatment
So they looked at it immediately after treatment and 24 hours after each one

Those cells that had RMS- increased proinflammatory interleukins and 15% less fibroblast proliferation
Omt- no increased interleukin or proliferation- but 44% decrease in IL3
RMS + OMT- 46% reduction in IL6 and 51% increase in fibroblast proliferation

OMT had an effect on interleukin secretion and cellular proliferation

So not only do we mobilize tight ligaments and drain congested lymphatics- affecting properties of fascia such as density, stiffness and viscosity

And this allows the fascia to better adapt to physical stressors

With regards to the cytokines omt may increase or decreas pain, inflammation or tissue regenerations our soft tissue and indirect treatments may directly influence the fibroblasts

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Gratitude

- Appreciation for how understanding of these concepts, including biotensegrity, mechanotransduction, posture, and the application of OMT can dramatically influence our care for our patients
- For the development of these materials through the efforts of faculty member Stacey Pierce-Talsma, DO