EMBRACING INTEGRATION: CREATIVITY IN OSTEOPATHIC MEDICINE

Gait Biomechanics

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"THE RULE OF THE ARTERY IS SUPREME"

When blood and lymphatic’s flow freely, the tissues can perform their physiologic functions without impedance. With the occurrence of trauma (physical or emotional), the tissues contract, twist, and compress. The fluid flow becomes obstructed. Andrew Taylor Still, D.O.

"The soul of man, with all the streams of pure living water, seems to dwell in the fascia of his body.” Andrew Taylor Still, D.O.

"Be sure the foundation is level and all will be well.” Andrew Taylor Still, DO


“But what is the role of these extracellular mitochondria? The answer to that could be linked to the structure of the mitochondrial DNA, similar to that of bacterial DNA, which gives it the ability to induce immune and inflammatory responses. Based on this observation, the researchers hypothesize that these circulating mitochondria could be implicated in many physiological and/or pathological processes requiring communication between the cells (such as the mechanisms of inflammation). Indeed, recent studies have demonstrated the ability of certain cells to transfer mitochondria between themselves, such as the stem cells with damaged cells. "The extracellular mitochondria could perform various tasks as messenger for the entire body," Thierry explains
The pelvic-thyroid-adrenal syndrome of Owens

Loss of torsional movement decreases fluid drive from the lower extremity to the heart, which increases sympathetic tone, leading to a Neuroendocrine HPA Gonadal response.

In Dr. Chapman's book, Dr Owens states that a leg that does not internally rotate is a sign of pelvic congestion and therefore a sign of endocrine dysfunction (pelvic-thyroid-adrenal syndrome).

Loss of Lower Extremity minor motion predisposes the patient to increased sympathetic tone.

**And low grade inflammatory sustained response.**


The adaptation of the immune system, control of inflammation and control of the nociceptive system (related to pain and hyperalgesia) by the CNS, all require a sympathetic system which functions in a differentiated way.

During real or impending tissue damage, this integrated protective system organized by the Hypothalamus is strongly activated, leading to protective illness responses including pain and hyperalgesia, and other aversive sensations.
During fast defense, organized by the hypothalamo-limbic system, fast analgesia, mobilization of energy, activation of the sympathetico-adrenal system and activation of the HPA axis occur.

This fast defense is preferentially activated from the periphery by stimulation of nociceptors of the body surface and is accompanied by an increase in arterial blood pressure and heart rate, and an increased vigilance and alertness.

During slow defense, the body switches to recuperation and healing of tissues.

This slow defense system is activated by peripheral signals mainly in afferent nociceptive neurons from deep body tissues (deep somatic tissues, viscera) and from the immune system by cytokines via afferent vagal neurons.

It is accompanied by decreased arterial blood pressure and heart rate.

The involvement of cytokines in sensitization of nociceptors during inflammation, is via the terminals of sympathetic fibers and/or the activity of the sympathetico-adrenal axis.
Think of the **Great toe, Midfoot, Ankle Mortice, Femoral Head and Pelvis**, as levers attached to a hollow cavity filled with organs, that is aided in fluid drive by the action of certain muscles (Iliopsoas, Diaphragm, and Pelvic floor) and as an agitator for fluid drive (electrochemical gradient potential), and immune response and function. This is what walking is.

The Plantar Venous Pump.

Gardner and Fox proposed a hypothesis which stated that it is the **stretching** of the **medial and lateral plantar veins** with each step that pushes the blood into the **saphenous veins** and the **deep venous network**, and that the **pump of the foot** and the **calf function sequentially**.

The pump (shown in green) comprising the plantar veins is polarized and contains 3 parts going from distal to proximal: a suction pole (A), a reservoir (R), and, an ejection pole (C) the calcaneal confluent

B: relations with the weight-bearing area.
Red circular patch = weight-bearing area on the ground.
Blue circular patch = manual compression area of the plantar veins.

The intramuscular veins that are part of the PVP system are concentrated in the soleus, medial head of the gastrocnemius, and vastus lateralis.
These veins act as a blood reservoir.

Contraction ejects the volume of blood and muscle relaxation allows filling of this reservoir.

But what if the mechanics are dysfunctional, or what about high resting muscular tone?
All the deep veins of the calf join to form the popliteal vein which is the calf pump outflow tract. The calf muscle pump generates systolic pressures of 200–300 mmHg. The foot pump also plays an important role in venous return in that it contains a pump powerful enough to propagate a column of blood to the right atrium.

Matricryptic, heprin-binding site of the ECM fibronectin stimulates an NO-dependent increase in the arterial diameter, providing the first evidence that that ECM fibronectin fibrils play a dynamic role in regulating arterial response with exercise. i.e. **fascia can direct blood flow in the same way that the SNS can.**

Fascia invests the arterial wall and is the largest organ in the body, not the skin. **But we only push out what the venous system returns.**

This process starts at the feet.
“Cell- and tissue-derived mechanical forces drive fibronectin fibril extension, opening homophilic binding sites for lateral and longitudinal fibril growth, and revealing matricryptic epitopes that further impact cell and tissue behaviors.”

Proper load and torsional forces enhance this tissue-derived mechanical force drive fibronectin fibril extension. Loss of these secondary forces change the ECM aiding in maintaining homeostasis.

Fascia matters.

Torsional movement in the system is important. We move in rotation but life requires sidebending – minor motion rules, you are only as old as your fascia

Movement gives life, stillness gives death.

Age related issues then decrease fascia signaling of NO and we age quicker secondary to loss of local signaling which leads to impaired peripheral vascular response, - arthrosclerosis, and hypertension are 2 examples. This increases NO production, which leads to smooth muscle relaxation and, vasodilation, and increased blood flow.
Gait in a nutshell

The heel hits the ground slightly lateral of center. The calcaneus is inverted about 2 degrees.

At this point the foot aids in shock absorption and accepts leg rotation from above.

The key to this transfer load is the ability of the muscle system and the heel to drive the forces in the right direction without loosing kinetic advantage; ligaments keep joints from coming apart not together.

The talus is a load transfer bone not a loading bone.

Loads from below and above are also transferred from talus backward to calcaneus and then forward to navicular through the cuneiforms (the 3rd) bearing the most importance and finally the 2nd ray.

The third cuneiform then is the keystone for the arch and venous flow.
The calcaneous and the talus comprise the rear foot which is a **pivoting mechanism**.

To function, the calcaneous needs 1° of inversion for each 2° of eversion.

Ligaments are critical to guiding the motion at the ankle and rearfoot complex.

From the heel, forces travel **lateral to the cuboid** – as an adapter for force transition - This needs to be a frictionless joint as is the SIJ. And finally to **second metatarsal head**.
Need to look at foot as two different systems – cuboid for balance (frictionless joint) – navicular for movement and to make the world flat

The lateral two rays along with their tarsus bones represent the weight bearing truss and function in the walking portion of movement: training wheels.

The medial three rays function is to carry the load of standing and walking, balance comes from the lateral aspect of the foot while the foot is in motion.
Longitudinal Arch Load-Sharing System (LALSS)


Four layers of tension load-bearing elements of the LALSS: the plantar fascia, plantar intrinsic muscles, extrinsic muscles of the plantar longitudinal arch and plantar ligaments.

The most important plantar intrinsic muscles
   The abductor hallucis, flexor digitorum brevis, abductor digiti quinti and quadratus plantae

Prevents longitudinal arch flattening and elongation
The next layer of tension load-bearing elements of the LALSS, just deep to the plantar intrinsic muscles. The posterior tibial, flexor digitorum longus, flexor hallucis longus and peroneus longus.

Longitudinal Arch Auto-Stiffening Mechanism, allows automatic stiffening of the whole longitudinal arch as the foot progresses from the beginning to the end of the midstance phase of gait. All work together under CNS control to make the foot a more mechanically efficient and stable weightbearing organ. The CNS has the ability to make either the medial or lateral longitudinal arches stiffer if the CNS determines that these increases in arch stiffness will optimize the weightbearing activities of the individual.

The Achilles tendon, by attaching to the posterior calcaneus and being posterior to the ankle joint axis, exerts both a simultaneous ankle joint plantarflexion moment and a rearfoot plantarflexion moment with increases in its tension forces.

This increase in rearfoot plantarflexion moment due to increased Achilles tendon tension during late midstance tends to cause longitudinal arch flattening, automatically increasing longitudinal arch stiffness.
**Subtalar Joint** joint is made up of:

- Posterior
- Middle and Anterior portions
Two capsules allow for independent functions, and there motions are coupled to other specific distal targets

The posterior subtalar joint has its **own joint capsule** and functions separately from middle and anterior joints

The middle and anterior joints share common capsule with navicular joint forming a functional joint

Peña Fernández, Marta & Hoxha, Dorela & Chan, Oliver & Mordecai, Simon & Blunn, Gordon & Tozzi, Gianluca & Goldberg Obe, Andy. (2020). Centre of Rotation of the Human Subtalar Joint Using Weight-Bearing Clinical Computed Tomography. Scientific Reports. 10.1038/s41598-020-57912-z.

The facet of the posterior calcaneus slides medially as it moves counter clockwise in the sagittal plane.

The slide of calcaneus is opposite of the direction of movement

The middle and anterior portions of subtalar move in the same direction as calcaneus along with navicular.

The navicular is subject to intense compressive forces over its middle one-third during the foot-strike phase of gait when it is compressed between the talus and the cuneiforms.
During walking, peak loads acting on the plantar foot range from 1.1 to 1.5 times body weight but, during running, peak loads are double compared to walking.

During jumping activities, peak loads acting on the plantar foot can easily exceed over four times body weight.

In addition, internal forces, consisting of tibial compression force acting on the dorsal talus and Achilles tendon tension force acting on the posterior calcaneus, add to the flattening moments of the longitudinal arch.

The key thing to remember about the mid foot is that it distributes the **rearfoot motion to the forefoot** and if there are any problems, the entire mechanism fails.

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**Talocalcaneal Joint shares its influences**

- **Posterior**
  - Pitch: Pubes/ UE
- **Middle**
  - Rock: Lumbar
- **Anterior**
  - Roll: Sacrum
- **Cuboid**
  - Glut med
- **Navicular**
  - Psoas
- **Great Toe**
  - Sacrum
TALOCALCANEAL JOINT:

If BOTH middle and posterior facets are tender to palpation check for BACKWARDS SACRAL TORSION.

Pain with movement = navicular side
Pain with standing = cuboid side

The medial longitudinal arch is related to the navicular and psoas muscle

The lateral longitudinal arch is related to the cuboid and the hip abductors (gluteus medius and gluteus minimus).

NAVICULAR:

Every time the navicular pronates, the psoas contracts. Works with semitendinosis, posterior tibialis and concentrates forces to the posterior lateral knee.

PSOAS:

The anatomy of the psoas is “ideally suited” for lateral stabilization of the lumbar spine. Most authors agree that psoas activity increases with larger hip flexion, while Yoshio et al. concluded that psoas mainly works as a stabilizer of the lumbar spine and the femoral head in the first 15° of hip flexion, and does not become an effective hip flexor before 30-45° of flexion.

Talus can only glide posterior if psoas is not tonic (tight – neurology shortened to protect dome)

Heel strike, fibular = drops inferior

When the fibula drops inferior it loads, by traction, three structures: the peroneus longus; the tibialis anterior and the long head of the biceps femoris.

Popliteus is a sensory muscle at this point for tibial rotation

Key to LE for weight transfer is the posterior lateral part of knee.

Key to posterior lateral part of knee = popliteus (intracapsular, intrasynovium, and extracapsular – just like biceps tendon of shoulder

Popliteus = posterior lateral horn of meniscus = for stability; engaged after 112 degrees of flexion
Fibular = ankle and knee bone
Biceps Femoris-Semitendinosus = extension into sacrotuberous ligament
Sacrotuberous ligament in children is more muscle like
It becomes a ligament when the child reaches puberty

HAMSTRINGS:
Problems occur due to loss of internal hip rotation coupled with same side C2 rotation loss – Semimembranosis feeds proprioception to SOT

Biceps Femoris & Sacrotuberous ligament = set up inferior lateral angle for normal sacral mechanics
With QL firing on opposite side & Glut maximus firing on same side

Biceps femoris = loses contraction when Glut maximus takes over
Piriformis = eccentric decelerator of sacral torsion

Iliolumbar ligament = controls rotation of L5 to heel striking foot
Integrity of TL fascia initiates from plantar fascia

The pubic plate is a hub that links the adductor muscles & fascia lata of the lower limbs to the tendons & pyramidalis muscle of abdominal wall. This allows muscle co-contraction to actively stabilise the symphysis when walking, running, pivoting

The Torque of the R LE through the ITB -Vastus Lateralis- is transferred through the Thoracolumbar Fascia, that then translates the load upward to the opposite side of the pelvis to be used in arm swing, to conserve energy.

Pubic dysfunction = mirrored as SC joint dysfunction

Back to fluids

So, in looking at foot biomechanics, not only are we dealing with harnessing kinematic forces on the lateral side, but we are also looking at vascular supply and demand on the medial side. IT Band/tract tightness may have a different etiology, and in fact is only present if the system becomes inefficient.

Loss of foot function leads to increased cost of doing work, which in turn makes us much less efficient, and leads to a reduced recovery potential.

The first metatarsal interspace (1st Ray) vein gives rise to the greater and lesser saphenous veins.
Contact of the foot on the ground produces direct compression of the reservoir in the sole of the foot between weight-bearing areas.

When a subject goes from the seated to the standing position, under the influence of gravity, the weight of the column of blood exerts a pressure of about 80mm of mercury.

Weight bearing on the forefoot with **flexion of the toes** which fix the foot on the ground, resulting in compression of the pump in the musculotendinous plane by muscle contraction.

After a certain number of steps (about 10 - 25 m), ankle pressure falls to 30mm of mercury, due to activation of the different venous pumps in the lower limb during walking.

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**Flexor digitorum brevis**, **quadratus plantae**, abductor hallucis and the flexor digiti mini brevis are all involved.

Contraction of these muscles compresses and empties the **lateral and medial plantar veins of the foot reservoir**.

The plantar venous pump is the only one effective up to the calf, where its action is taken over by the calf pump of the **soleus muscle**. This is where **tibial advancement** needs to be able to advance at least 10-15 degrees. Talus is key.

Great toe, peroneal longus, Posterior Tibialis, Soleus – all function to drive ground forces to the Posterior lateral corner of the knee.
The Achilles gets more fibers from the **soleus** than the **gastrocnemius** in forming the actual tendon.

During their descent, the fibers of the Achilles tendon internally rotate 90° so that the posterior fibers of the soleus insert into the MEDIAL aspect of the Achilles foot print, and the gastrocnemius (initially anterior) inserts **LATERALLY**.

Torque at the foot is maintained by torque at the Achilles.  
**This is a spring ligament - Sacrotuberous, lats and levator scapula**

The latissimus dorsi and the sacrotuberous ligament dynamic springs that enable us to conserve and expend large amounts of energies at the precise moments of need.  
The vastus lateralis, the tensor fascia latae, and the iliotibial tract all function in a coordinated attempt to create stability and to disperse forces of tension created by the **gluteus maximus contraction**.

The sacrotuberous ligament, like the latissimus dorsi, has fibers that coil so that the inferior fibers become the superior one, and the superior fibers become inferior ones.
Osteopathy in the Cranial Field

The Temporalis often compensates for inhibited neck flexors and glute medius.

The Masseters often inhibit neck flexors and gluteals but also the iliopsoas.

The pterygoids often inhibit the scalenes, the latissimus dorsi, the obliques, the quadratus lumborum, and the hip abductors.

About 60–70% of ongoing and bradykinin-induced synovial plasma extravasation is dependent, in physiological conditions, on the presence of the sympathetic innervation of the joint (but not on activity in these neurons and not on norepinephrine released by them).

The extravasation is modulated in an inhibitory way by epinephrine released by the adrenal medulla.

Thank you for your time.

I would like to thank AAO and program chair, Dr. J'Aimee Anne Lippert, DO for the invitation to speak.

Gennie Watts, Event Planner
EMBRACING INTEGRATION:

CREATIVITY IN OSTEOPATHIC MEDICINE

Gait Biomechanics

Lino Cedros AT,OMT,CAMTC
Evaluative Portion:

Patient Standing

1. Squat Test
   a. Positive- Foot / ankle / talus require further testing as source of LE dysfunction that will drive loss of Hip Internal Rotation.

2. Latissimus Dorsi Couple / Uncouple Test
   a. Positive- look to area of greatest restriction as indicated by test to improve adaptability and to help determine what type of adaptive pattern is present.
      i. T6 and Above-
         1. Sphenoid Greater Wing Dysfunction
         2. Check for dysfunction of:
             a. Respiratory Tract and Alveoli,
             b. Tympanic Cavity, Auditory Tube,
             c. Thyroid / Parathyroid,
             d. Tonsils,
             e. Thymus
             f. Stomach
      ii. Upslip
         1. Temporal Dysfunction
         2. Check for dysfunction of:
             a. Caecum,
             b. Ascending, Descending, Transverse and Sigmoid Colon
iii. T10 and Below-
   1. Occipital Dysfunction
   2. Check for dysfunction of:
      a. Bladder, Urethra,
      b. Vagina, Uterus, Prostate

iv. T6 not Independent of T10
   1. Whole Cranium Dysfunction- Pre-Sphenoidal
   2. Check for dysfunction of:
      a. Ileum and Jejunum
      b. Hepatic Portal Vein
      c. Liver, Pancreas

b. Return to the next portion of this evaluation for longer term treatment strategy.
Evaluative Portion:

Patient Supine

3. Check Neutral-Flexion Hip Internal Rotation

   a. Negative- Go to #4: Both hips IR equally/evenly.

   b. Positive- for lack of rotation unilaterally. Continue to #5.

   c. NB- Watch for “Swing-gate” motion of the hip (lack of posterior glide of the hip). This can mean Tight VI/VL or the test is still positive. If there is not a rubbery end-feel to the Hip IR test and the LE’s IR evenly and equally then there is still a problem in the area.

   d. Remember that the GT-Navicular drives the Talus drives the posterolateral knee drives the psoas drives the piriformis drives obturator internus. If something can’t be driven the structures that try to drive it will be dysfunctional as well.
4. Check Heel Sign

   a. Positive- Midline Pelvic Structure Disturbance
      i. Check Hypogastric Plexus for Tenderness
         1. If +: Check bil Inferior Hypogastric Plexuses
            a. + Bilateral- Inhibitory pressure on Hypogastric Plexus, retest all three
            b. + Unilateral- look at structures on that side. Ovary, Uterine Tube, Sigmoid, Appendix, Ileocecal Valve, Rectum, side of Uterus
            c. – Bilateral- treat midline structures. Uterus, rectum, urachus, bladder, prostate, pubovesical / prostatic ligaments.
   b. Negative- Continue to #5

5. Cervical Hip Bias Test

   a. Hold hips in neutral flexion hip Internal Rotation.
      i. Observe hip lacking IR.

   b. Have patient turn head toward hip lacking IR

   c. If the lack of rotation goes away then this test is positive for cervical origin of limited neutral hip IR.

   d. Negative- Return to treat LE and Hip or continue with Squat Test.
**Talar Glide Test**

**TEST FOR TRUE ANKLE MOTION:**

**Fred Mitchell JR Test**

With the patient sitting and the legs dangling, the operator grasps the foot with one hand. The fingers should be on the plantar surface, the palm around the side of the foot, and the thumb resting on the anterior surface of the talotibial joint. – on the talus

Swing the foot-leg into flexion while you hold the dorsiflexion

As this is accomplished, **further foot extension occurs as the talus glides slightly posteriorly on the distal tibia.**

The end point is a physiological or a restrictive barrier.

The side that allows the most posterior translation of the foot will also be the side that allows the most extension (or dorsiflexion) of the true ankle joint. Both feet are tested and the findings are recorded.

**TENDERNESS AND ITS MEANING**

Tenderness on the rostrum of the talus indicates a problem with the talus on the tibia / fibula area.

Tenderness of the tibia / fibula ligaments indicates a problem with the tibia / fibula on the talus.
Foot Squeeze Test

PURPOSE:

This test indicates foot dysfunction that requires further evaluation and treatment before treatment of the pelvis can begin.

PROCEDURE:

Patient is lying supine, squeeze midfoot bilaterally and compare for stiffness.

KEYS TO REMEMBER:

A positive result indicates the presence of a lower extremity barrier that requires attention. If this is not addressed, lumbopelvic dysfunctions will return as soon as the patient walks around.
CUNEIFORM SOMATIC DYSFUNCTION

Somatic dysfunction of the cuneiforms is described as an inferior glide without rotation.

3rd cuneiform depression- most often dysfunctional
Anterior talocalcaneal joint: rolls (A-P) and represents pubes in the action of the joint. This will give you UPPER EXTREMITY PAIN - it will lock upper extremity because SC cannot roll forward.

Medial talocalcaneal joint: rocks (transverse plane) represents lumbers. You will then get LUMBAR PAIN because the ankle cannot rock. Check Sphinx test for muscle energy assessment of L4 and L5 position.

Posterior talocalcaneal joint / Rearfoot: pitches (oblique plane) represents sacrum. This will give you Sacral pain - because at heel strike, this is the only facet working.

If BOTH medial and posterior facets are tender to palpation check for BACKWARDS SACRAL TORSION.
If you do Sphinx test, and a deep sacral sulcus gets deeper with extension it is a backwards sacral torsion. Piriformis fires and locks L5.
*Permission was gained for this picture from Mcgraw Hill*
PUBES SECTION

Rectus abdominus inserts on the superior pubic ramus and the inguinal ligament inserts on the lateral surface of the pubic ramus.

Pubococcygeus inserts into the inferior-posterior surface of the pubic ramus and the pectineus, adductor brevis, adductor magnus and longus attaches to the inferior surface of the pubic ramus.

**Rectus abdominus holds the pubic bone up.**

**Adductors hold the pubic bone down.**

**Iliac dysfunction will be toward the side of the positive pubes testing.**
A = adductor longus tendon, O = obturator foramen, P = pyramidalis muscle, R = rectus abdominis muscle, S = superficial inguinal ring, e = external oblique aponeurosis, Arrowheads = conjoint tendon, Asterisks = pubic tubercle.

The pubic plate is linked to the rectus abdominis tendon, pyramidalis muscle, conjoint tendon, inguinal ligament, external oblique aponeurosis, superficial fibers of adductor longus origin, anterior fibers of adductor brevis origin, upper fibers of gracilis insertion.

Deep muscles are always recruited. The masseters often inhibit neck flexors and gluteals but also the iliopsoas.

Navicular
Functions primarily with psoas. Every time the navicular drops, the psoas contracts. Works with semitendinosis, posterior tibialis and lateral knee.
Piriformis

Superior gluteal artery

First and second sacral nerves

Inferior gluteal artery

Origin: Anterior surface sacrum between sacral foramina, margin of greater sciatic foramen, and sacrotuberous ligament

Insertion: Greater trochanter
Obturator-goes with hip pain
Clavicle dysfunction = Hyoid Dysfunction

The clavicle uses the thickened cartilage at the posterior part of the facet to anchor and pivot at the SC joint. C3-4 innervation.

A/C joint C4 innervation

The sternoclavicular joint absorbs shock and transmits it to the thorax and neck.
CERVICAL SPINE

C2

RCPM-considered a sensory organ

Semimembranosus-feeds to upper cervical

Glute med - Is the balancer between LE and cervical mechanics

Pubococcygeus
The temporalis often compensates for inhibited **neck flexors and glute medius**.

The masseters often inhibit neck flexors and **gluteals but also the iliopsoas**.

The pterygoids often inhibit the scalenes, the **latissimus dorsi, the obliques**, the **quadratus lumborum**, and the hip abductors.

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