

Paraspinal Cutaneous Temperature Assessment in Gonstead Chiropractic

By Mark Lopes, D.C.

- ▶ Why this topic now?
- ▶ *Triano. Review of methods used by chiropractors to determine the site for applying manipulation. Chiropractic & Manual Therapies 2013, 21:36*
- ▶ *“Recommendation: The evidence from studies with high validity and reliability is favorable for the use of thermography/thermometry of the lower limb in confirming frank sciatica. The evidence from high quality studies is unfavourable toward the use of paraspinal skin temperature measures to locate the site of care, due to limited reliability.”*

Paraspinal Cutaneous Temperature Assessment in Gonstead Chiropractic

- ▶ Letter to the editor response:
- ▶ *Paraspinal skin temperature assessment rating incongruent with the data from studies. Mark Lopes, D.C. (2013-11-27) GCSS.*
- ▶ *"There is enough data from the studies accepted for this review that show moderate to excellent reliability, however, that at least a conditional designation such as 'favorable with limitations' or 'unclear' should have been given for the paraspinal skin temperature assessment, although a 'favorable' rating appears more appropriate. The noninvasive nature of the assessment, lack of an expense burden to a patient, and a reasonable number of studies showing decent reliability should be enough to suggest this as a favorable assessment or at least unclear or favorable with limitations. Instrumentation thermography is close to a gold standard for this aspect of the P.A.R.T.S. concept."*

P.A.R.T.S. (Triano)



- ▶ Pain–P.
 - ▶ Self-reported and/or reproduction of pain through diagnostic maneuvers are spatially related to the local presence of pathology/dysfunction.
- ▶ •Asymmetry–A.
 - ▶ Location, motion and compliance/stiffness asymmetry.
- ▶ Range of motion–R.
 - ▶ Disproportionate local and/or regional mobility.

P.A.R.T.S. (cont.)

- ▶ Tissue temperature, texture, and tone–T.
 - ▶ Spatially related muscle hypertonicity, hypotonicity, hypertrophy or atrophy.
 - ▶ Spatially related edema, or texture changes.
 - ▶ No mention of temperature!
 - ▶ *Bergmann T. P.A.R.T.S. Joint assessment procedure. Chiropractic Technique 1993;5(3):135-136*

P.A.R.T.S. (cont.)

- ▶ Special tests–S.
 - ▶ Spatially consistent neurogenic activity that demonstrates a muscular, kinematic, vascular, or secretory response that is observable.
- ▶ Inclusion criteria aimed the review away from several studies:
 - ▶ For validity studies, at least some of the subjects must have been symptomatic or have had a known anatomical anomaly.
 - ▶ Since they were trying to connect the assessment to site of care.

Gonstead Paraspinal Cutaneous Temperature Assessment

- ▶ Gonstead Technique is one of a few that still use paraspinal cutaneous temperature (PCT) assessments.
- ▶ Gonstead Chapters mechanistically wrong.
 - ▶ There have been tremendous additions to skin thermology.
 - ▶ If one continues to use old theories to explain what they think is happening without considering current knowledge, they are clinically misled.
- ▶ Textbook of Clinical Chiropractic and related research by GCSS further investigated PCT mechanisms and reliability in early 1990s.
 - ▶ Nothing done by Gonstead Technique representatives since then.
 - ▶ Now chiropractic PCT is mostly associated with religionists by academia.

Gonstead Paraspinal Cutaneous Temperature Assessment

- ▶ GCSS and MOM is an opportunity to begin the next phase of Gonstead PCT clinical usage and position in academia.
- ▶ Has to be done in light of scientific evidence, clinical experience and the needs of the patient.
- ▶ Consensus must be reached to promote appropriate usage of PCT going forward.

Gonstead Paraspinal Cutaneous Temperature Assessment

- ▶ Our goals today:
 - ▶ Present and discuss scientific evidence and clinical usefulness of PCT
 - ▶ Science vs how it's actually used in practice
 - ▶ Consider all the best options for instrumentation in PCT
 - ▶ Break into groups and compare and contrast instruments
 - ▶ Summarize experience, opinions as a group
 - ▶ Identify problem areas

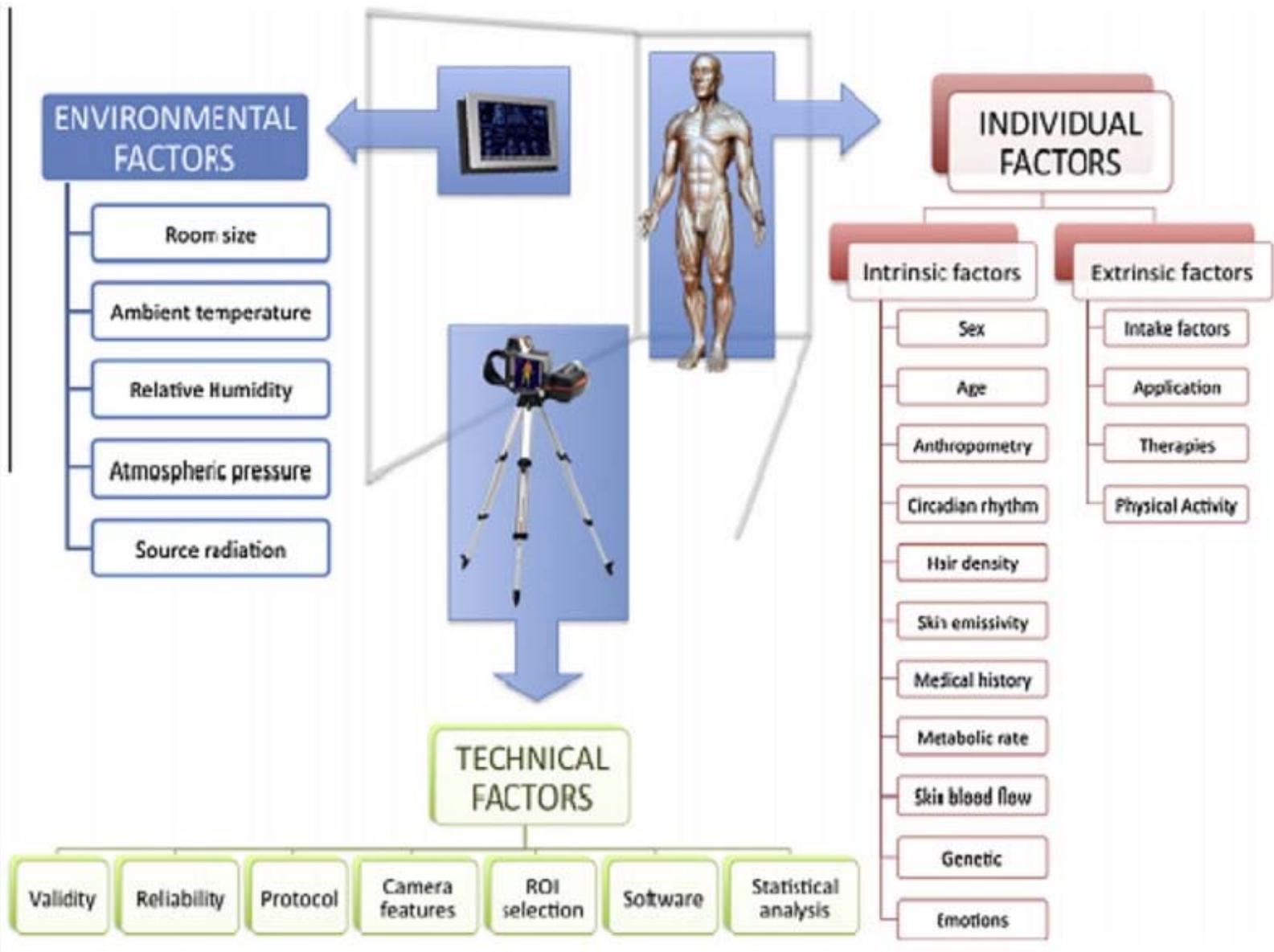
Practical Questions for Consensus

- ▶ Why does ΔPCT occur?
 - ▶ What mechanisms contribute to it?
- ▶ Why should we use thermography?
- ▶ Should we only or mostly focus on paraspinal and if so or if not, why?
- ▶ How often are we individually using it as a group of people.
 - ▶ When do we use it in the steps of the examination?
- ▶ How much, if any, acclimatization to ambient temperature are we employing?
 - ▶ What is the standard?
- ▶ What weight do we place on the presence or absence of a temperature imbalance?

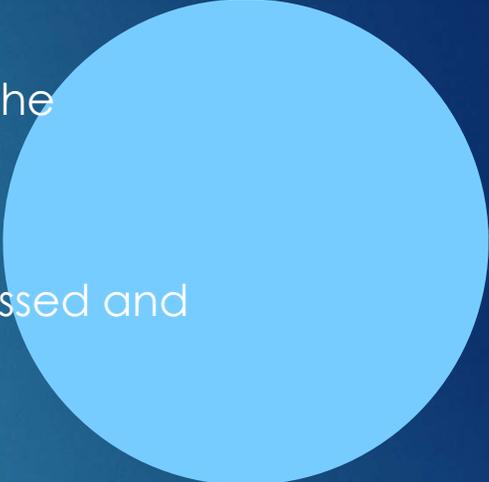
Summary of Pertinent Research Papers



- ▶ Sympathetics control cutaneous microcirculation through vasoconstriction or vasodilation.
- ▶ A sensitive innervation site corresponds to a microvascular region, as sympathetic fibers follow sensitive fibers along the same nerve.
- ▶ Therefore, a nervous disorder alters the microvascular tone of the region corresponding to the sensitive innervation.



Factors That Influence PCT



- ▶ Environmental factors: Those related to the place where the evaluation is performed.
- ▶ Individual factors: Those related to the subject being assessed and his/her personal characteristics that could influence skin temperature (intrinsic and extrinsic).
- ▶ Technical factors: Those linked to the equipment used.
- ▶ *Cuevas. Classification of factors influencing the use of infrared thermography in humans: A review. Infrared Phys & Tech 2015;71:28-55.*

Skin Emissivity

- ▶ Emissivity: efficiency of a surface to emit thermal energy.
 - ▶ Emit electrons from hot surface.
- ▶ Human skin emissivity very high, constant.
 - ▶ nearly like a 'black body', which neither gives up or absorbs heat from normal environment temp.
- ▶ 0.98 is standard value for skin.
 - ▶ (Black body is 1.0)

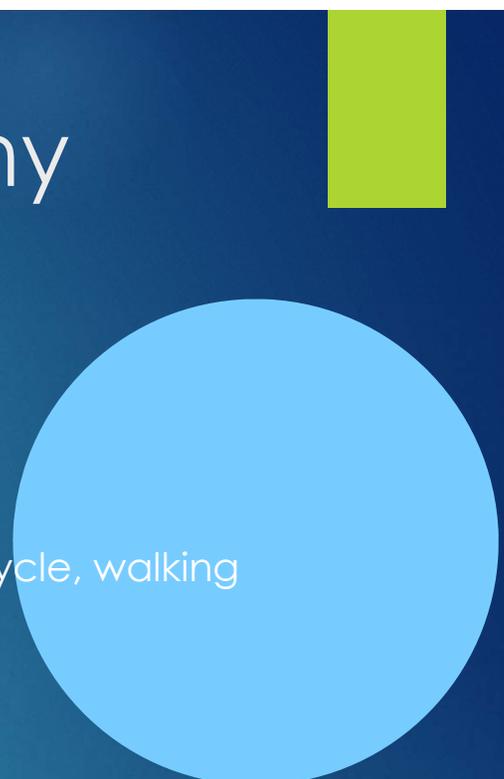


Factors Influencing Skin Temp



- ▶ Hyperthermia:
 - ▶ Tendonitis, bursitis, fracture, arthritis, tennis elbow, acute muscle injury, compartment syndrome, Ant. Cruciate lig surgery hx., any inflammation.
- ▶ Hypothermia:
 - ▶ DJD, vessel occlusion, nerve damage, RSD, Raynaud's, avascular tissue from wounds/burns.
 - ▶ Tattoos may alter it

Standards of Thermography



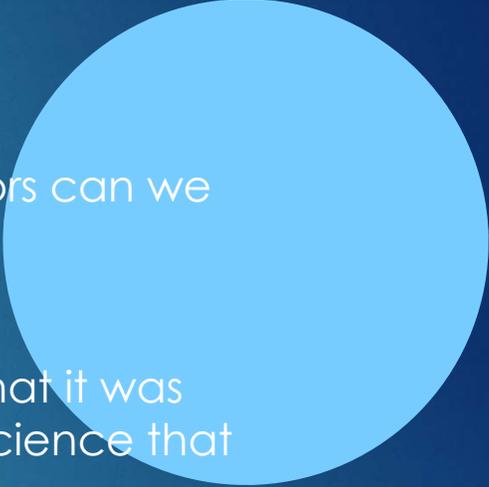
- ▶ Record time of exam.
- ▶ No physical activity for at least 6 hrs prior to eval.
 - ▶ Driving (seat and seat belt and driving activity), riding a bicycle, walking or running a long distance - may alter thermograms.
- ▶ Avoid application of creams, gels or sprays on the skin.
- ▶ Avoid coffee, alcohol or stimulants for 6 hours prior to the evaluation.
- ▶ Do not smoke in the 6 hours prior to the assessment.
- ▶ Avoid direct sun or UV sessions before evaluation.

Standards Cont.

- ▶ Previous day avoid drugs or treatment with any substance that may alter the thermogram, or inform if you have taken them.
- ▶ Avoid taking a shower or bath 1-2 hrs. before the eval.
- ▶ Do not alter rest or meal habits; though in some cases, it is preferable to not assess subject under normal conditions.
- ▶ Room temperature: ideal 70 - 74°F; critical values 65- 77°F; and reduced humidity (35 – 40 %).

▶ *Quintana MF. TERMOINEF Group protocol for thermographic assessment in humans, TECHNICAL REPORT. SEPTEMBER 2015*

Complex Considerations



- ▶ Only after considering all complex and inter-related factors can we make sense of thermal measures.
- ▶ “Part of the problem with thermography in general was that it was hard to separate the claims made for it from the actual science that existed to either support or refute it.” ...Dana Lawrence

Practicality of Daily PCT Evaluation

- ▶ It may be infeasible to control for all factors that may affect PCT.
- ▶ Be aware of all factors to properly judge the value of a positive finding.
 - ▶ Did patient exercise immediately prior?
 - ▶ Heated seats in car?
 - ▶ Sweat and then cool?
 - ▶ Overheated?
 - ▶ Office environment?
 - ▶ Proper equipment function/use?
 - ▶ Hair on skin?
 - ▶ Blemishes, surface vessels?
 - ▶ Rub or scratch?

PCT Asymmetry



- ▶ Most important theoretical background of skin thermography is that the distribution of body heat in a normal body is symmetrical.
 - ▶ When comparing heat on both sides:
 - ▶ Region of interest is an equal size on each side.
 - ▶ Mean temperature within each ROI is calculated to compare the difference.
 - ▶ Tilt Nervoscope?
 - ▶ Not likely valid
- 

PCT Asymmetry



- ▶ Theory:
 - ▶ Healthy: skin temp patterns will change but w/in symmetrical limits as body adapts to environment.
 - ▶ Vertebral subluxations: thermal asymmetries and/or patterns.
 - ▶ Outside of Gonstead theory, specific levels of asymmetry are not necessarily considered levels of subluxation.
- ▶ Value of PCT:
 - ▶ Determining the mechanisms and the response to the adjustment.

History of PCT Asymmetries in Chiropractic

- ▶ Thermal readings - used in chiropractic to detect PCT asymmetries since 1920's.
 - ▶ B.J. Palmer-fixed pattern of skin temp asymmetry vs adaptable and changing patterns of symmetry.
 - ▶ First NCM patented in 1925.
 - ▶ Source of intra-professional disagreement since 1930s.
 - ▶ Thermeter, Nervoscope (1945-Gonstead consultant for EDL, helped define Nervoscope's sensitivity, parameters, and function), DermaThermograph (Kimmel, 1969), Visual Nerve Tracer (Novick, 1969), Synchrontherme, (Haldeman, 1970), Visitherm (Stillwagon, 1984), Tytron (Titone, 1988), Modern Medical Thermography (1960s ->)
 - ▶ Uncertainty and lack of scientific documentation prevented their diffusion in chiropractic.
- ▶ *Prof. Dr. Marcos Leal Brioschi. The history of thermography. Old concepts of the production of heat. Brazilian Society of Thermology. PanAmerican Thermography Society Presentation.*
- ▶ *Amman MJ. The machines and tools of Dr. Clarence S. Gonstead. Chiropractic History 2007;27(2):55-58.*

PCT Stability

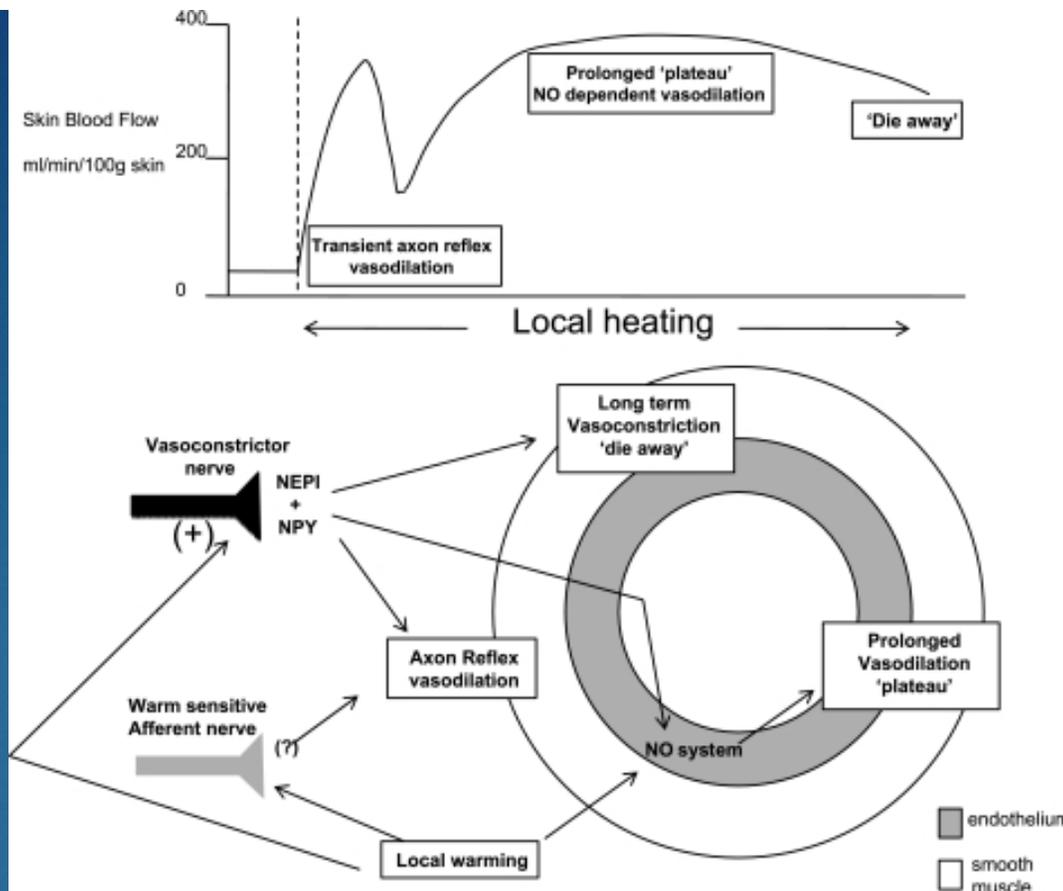


- ▶ Ptnt's back exposed to cooler room temp., skin temp. decreases constantly for 31 mins.
 - ▶ Pattern becomes stable after 16 minutes.
- ▶ During first 16 mins. pattern analysis may be unreliable.
 - ▶ 16-minute acclimation period is recommended.
- ▶ However, these were 30 students, not patients necessarily.
 - ▶ Fixed patterns of subluxation theory vs healthy adaptability must be considered.
- ▶ *Hart. Stability of paraspinal thermal patterns during acclimation. J Manipulative Physiol Ther 2004;27:109-17.*

Local Cutaneous Circulation Control

- ▶ Cutaneous blood flow has tremendous range:
 - ▶ Nearly zero in extreme cold to a total of 7 L/min at high temps.
 - ▶ Controlling reflexes use nearly this entire range.
- ▶ Cooling raises SNS vasoconstriction to skin through reflexes by low skin or core temp.
- ▶ Body heating inhibits SNS vasoconstriction.
- ▶ As body heat increases in duration significantly, SNS cholinergic vasodilator system is activated in nonglabrous skin.
 - ▶ Potential to bring skin blood flow to maximal levels in those areas in "tolerable" heat stress.

- ▶ *Johnson. Local thermal control of the human cutaneous circulation. J Appl Physiol 2010 Oct;109(4):1229-1238.*



Cutaneous vascular response to rapid local skin warming. *Top*: pattern of the blood flow response to local warming, including an early transient vasodilation (axon reflex), a more sustained plateau vasodilation, and a later die-away phenomenon. *Bottom*: our current understanding of the mechanisms leading to that pattern, including roles for the endothelium and nitric oxide (NO) generation, sympathetic transmitters and co-transmitters, and warm-sensitive afferents. NEPI, norepinephrine; NPY, neuropeptide Y

Nitric Oxide

- ▶ A locally synthesized vasodilator substance in essentially all tissues.
- ▶ Importantly involved in the vasodilator response to direct warming of the skin.
- ▶ Clearly acts by its direct effects on smooth muscle activity.
- ▶ Also a sympatho-inhibitory role for NO.
- ▶ At least two independent mechanisms contributing to the rise in SkBF during non-painful local heating:
 - ▶ Fast-responding vasodilator from axon reflexes.
 - ▶ Slowly responding vasodilator from local production of NO.

Sensory Nerves

- ▶ Thermally sensitive afferents in the skin are important in the vasodilator response to local skin warming.
- ▶ CGRP and/or substance P are likely important in afferents in response to local skin warming.
 - ▶ But specific tests for that possibility do not yet exist.

SKIN: Blood flow

- ▶ Almost entirely for the purposes of thermoregulation.
 - ▶ Very little of total required to support metabolism of skin cells.
- ▶ Most heat is lost this way.
- ▶ **Nerves** control skin arterioles.
 - ▶ Release of norepinephrine causing **vasoconstriction**.
- ▶ Neutral conditions - some steady SNS activity to skin.
 - ▶ Reduction of the sympathetics allows vasodilation.
- ▶ Unlike many structures, arterioles don't have dual innervation by both sympathetics and parasympathetics.



Skin Blood Flow Mechanisms

- ▶ “Intuitive that SNS function would be from reflex control of vasculature, but evidence strongly supports some local thermal control of skin blood flow during skin warming.
- ▶ ...Recent findings show a role for SNS adrenergic nerves in support of the vasodilator response, also counterintuitive...”
- ▶ NO system(s), sensory nerves, and sympathetic nerves are contributors to heat-induced cutaneous vasodilation, with the latter two mechanisms having at least some of their effects through NO.

Skin Blood Flow Mechanisms



- ▶ Likely that CGRP and substance P (vasodilators) are involved in at least the axon reflex part of the response.
 - ▶ But that has not been directly tested.
- ▶ Histamine does not appear to play an important role in *normal* response, according to several studies.
- ▶ Nociceptor stimulation releasing vasodilating prostaglandins might contribute to local control reaction to skin warming.

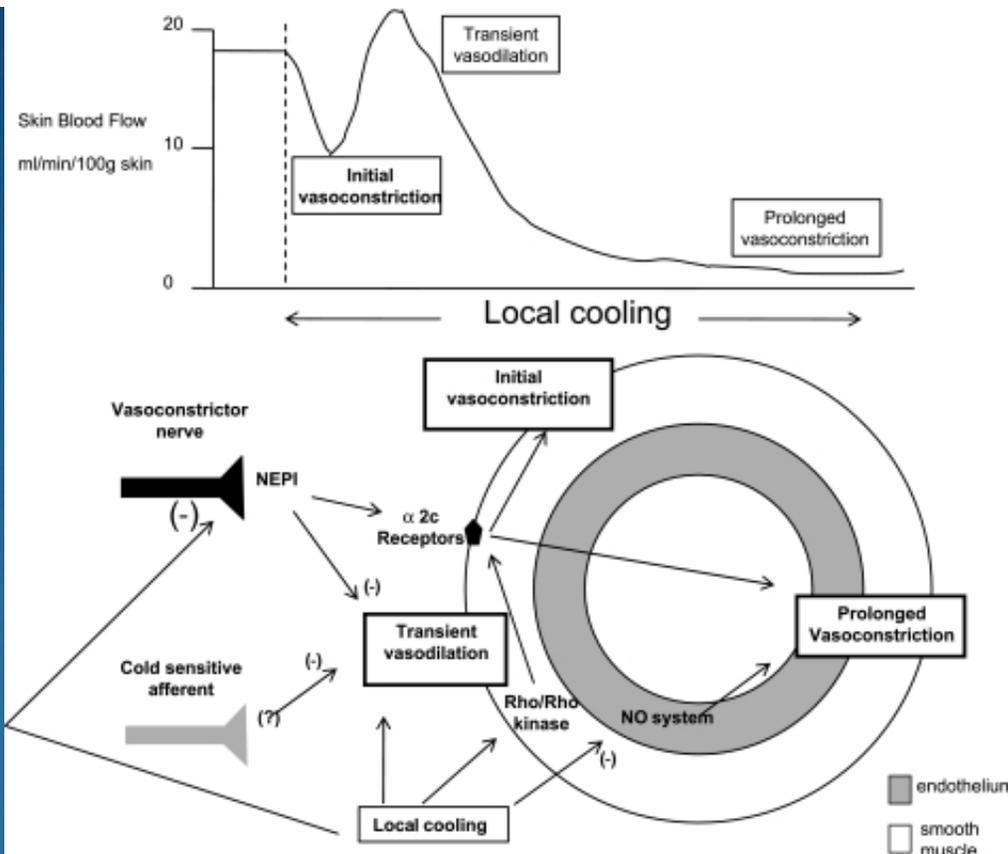
Skin Blood Flow Mechanisms



- ▶ Initial sensory and later NO-dependent phases of the response are impaired by aging; cutaneous vasodilation is less in older subjects.
- ▶ Small but significant increase of the vasodilation with elevated estrogen and progesterone, compared with the low-hormone phase of the menstrual cycle
- ▶ Vascular dysfunction in skin is the reason for loss of limbs in diabetes, and primarily cutaneous vascular lesions are an early signal and often the primary tissue at risk.

Local Skin Cooling

- ▶ The important elements appear to be an inhibition of the NO system at more than one point, an involvement of vasoconstrictor function through postsynaptic up-regulation of α_{2c} -receptors and a role for cold-sensitive afferents
- ▶ local cooling has a significant portion of its vaso-constrictive effect through inhibition of the NO system
- ▶ Most of the remaining vasoconstriction was due to adrenergic function, the major alteration in adrenergic function with cooling takes place post-synaptically
- ▶ How this happens remains unclear
- ▶ These normal mechanistic responses to heating or cooling the skin are attenuated or changed in the presence of numerous conditions mentioned above, possibly one being subluxation



Cutaneous vascular response to rapid local skin cooling. *Top*: pattern of the response in skin blood flow to local cooling, including a transient early vasodilation (made more obvious when cooling is rapid or sensory, or adrenergic nerve function is blocked locally), followed by a sustained vasoconstriction when the cooling is prolonged. *Bottom*: mechanisms and structures important in generating that pattern, including inhibition of the endothelial NO synthase system, an upregulation of α_{2c} -receptors, sympathetic vasoconstrictor nerves, and cold-sensitive afferents

PCT Gonstead Reading Mechanisms?

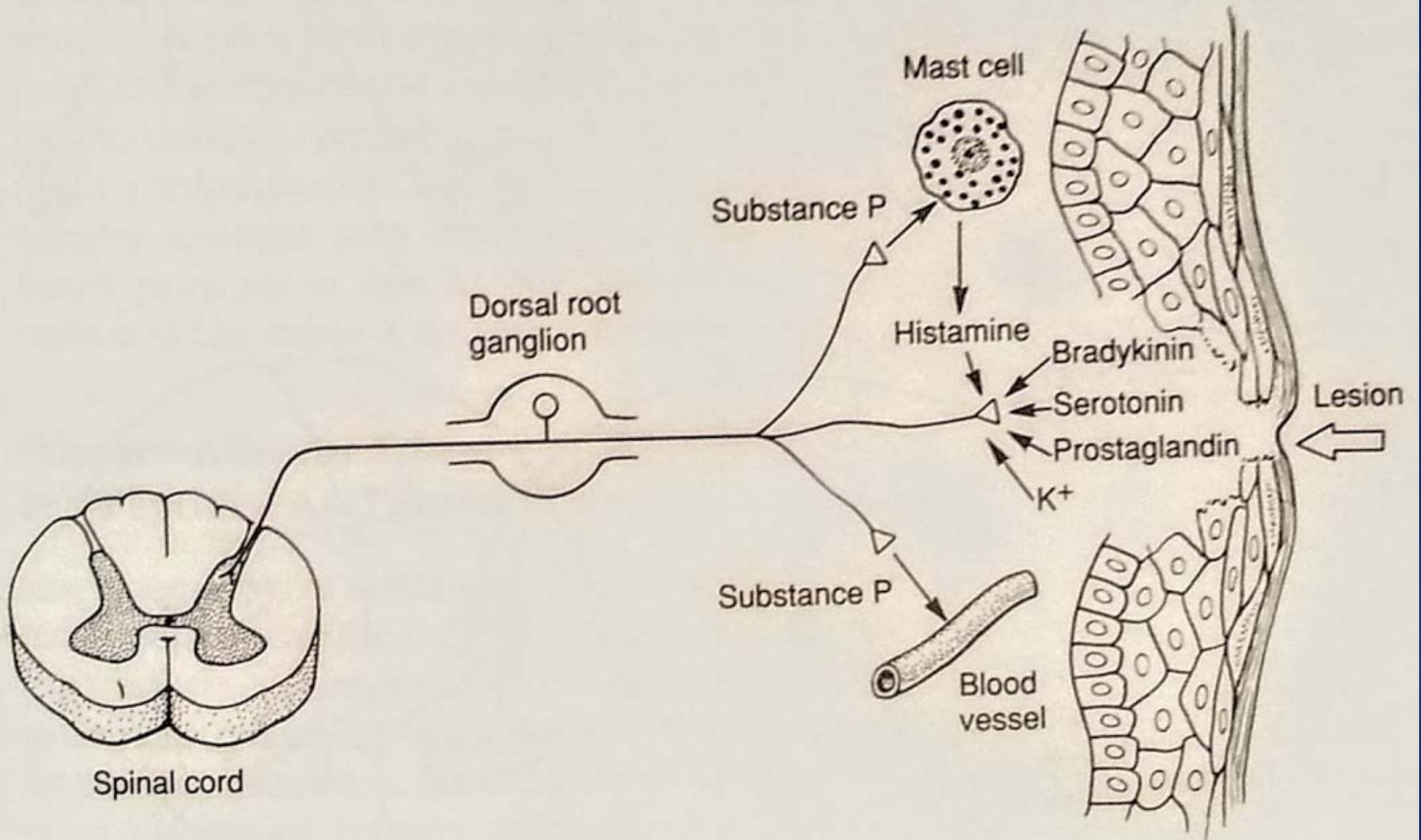
- ▶ Innervation that may affect local PCT to produce a Gonstead scope reading:
- ▶ Dermatomes vs Thermatomes
 - ▶ IVD and Facets
 - ▶ Nociceptive, proprioceptive and vasomotor associated with small vessels along the superficial annulus.
 - ▶ Sinuvertebral/recurrent meningeal n. and branches from segmental sensory nerve divisions and branches from the gray rami communicantes (sympathetic).

PCT Gonstead Reading Mechanisms?

- ▶ Different classes of nociceptors:
 - ▶ Thermal or mechanical are small, thinly myelinated (sharp, pricking pain);
 - ▶ Polymodal are activated by high-intensity mechanical, chemical and hot or cold stimuli-small, unmyelinated, slow.
 - ▶ Both are widely distributed in skin and deep tissues.
 - ▶ Harmful stimuli activate nociceptors whose cell bodies are in DRG.
- ▶ Axonal reflex stimulation of sinu-vertebral nerve.

PCT Gonstead Reading Mechanisms?

- ▶ Tissue damage can sensitize or activate nociceptors by chemical mediators (BK, PG, HA, ST, K, SP, ATP, AC).
- ▶ Nociceptors - Substance P which sensitize sensory endings.
 - ▶ Substance P (and other chemical mediators indirectly) contributes to edema by
 - ▶ vasodilation
 - ▶ and by releasing histamine from mast cells - also acts on the sensory n endings.
- ▶ Edema - further BK liberation (somewhat cyclic effect).
 - ▶ Increased metabolic activity and increased bodily fluids including blood;
 - ▶ likely increased temperature in the local region.



PCT Gonstead Reading Mechanisms?

- ▶ When this mechanism is operative, the level of the thermal asymmetry may theoretically be the same as the level of subluxation, or close to it.
 - ▶ How often?
- ▶ One sided?
 - ▶ Deep joint tissues involved bilaterally often.



Autonomic PCT Mechanisms



- ▶ Skin temps differ drastically from deep body temp.
 - ▶ Most obvious difference –
 - ▶ deep body temp is relatively constant,
 - ▶ skin temperatures vary greatly.
 - ▶ A full understanding of skin and temp dynamics is needed for clinical understanding of ΔPCT
 - ▶ *Romanovsky. Skin temperature: its role in thermoregulation. Acta Physiol 2014 Mar;210(3):498-507. (full text free)*
- 

Autonomic PCT Mechanisms



- ▶ Non-hairy ('glabrous') skin
 - ▶ Covers specialized organs (dense vascular w/arteriovenous anastomoses) and large surface to volume ratios.
 - ▶ Biological radiators can mount two opposite responses:
 - ▶ Rapid dumping of heat,
 - ▶ Abrupt cessation of heat loss.
- ▶ Temperature fluctuates greatly normally.
 - ▶ Finger can increase flow by 500% or decrease to near 0!

Autonomic PCT Mechanisms



- ▶ Hairy (non-glabrous) skin.
 - ▶ More proximal, lack of BV anastomoses, hair.
 - ▶ Better at thermal insulation vs radiation.
 - ▶ More thermally stable.
 - ▶ Deep temp feedback most control of autonomic thermoregulation.
 - ▶ Includes sweating and shivering along with blood changes.
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SYMPATHETIC NERVES:

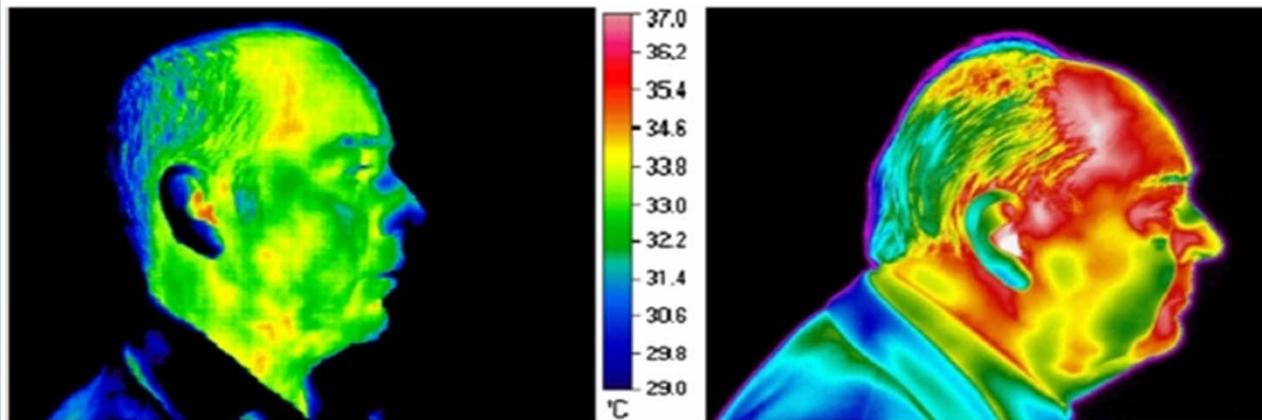
- ▶ Norepinephrine acting on **alpha receptors** causes vasoconstriction.
 - ▶ This effect is strong in the **skin, digestive tract** and **kidneys**.
 - ▶ In these organs, normal blood flow greatly surpasses that required to keep the tissues alive.
 - ▶ Instead, most of the blood flow serves specific physiological functions in the organs.
 - ▶ Skin: Thermoregulation

Early Chiropractic Computerized IRT

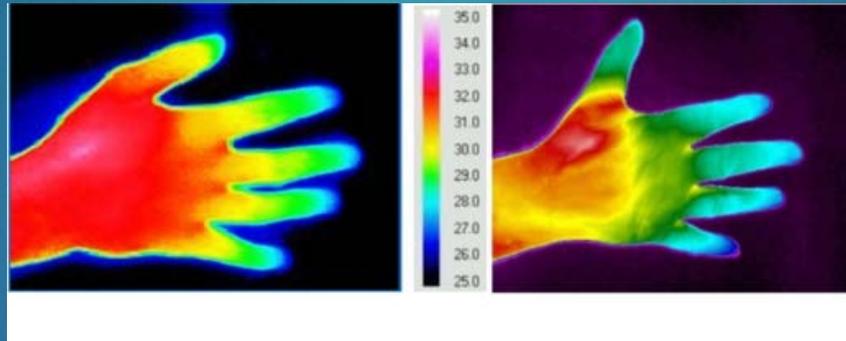
- ▶ Two phases are involved:
 - ▶ a) digital information from the IRT instrument, is standardized, stored and retrieved for comparisons with other graphs;
 - ▶ b) stored data is graphically displayed, statistically analyzed, and otherwise compared.
- ▶ Comparisons between graphs are plotted against one another.
- ▶ *Stewart MS, Riffle DW, Boone WR. Computer-aided pattern analysis of temperature differentials. JMPT 1989;12(5):345-352.*
- ▶ *Spector B. Dynamic thermography: a reliability study. JMPT 1981;4.*

Thermographic Technology Advances

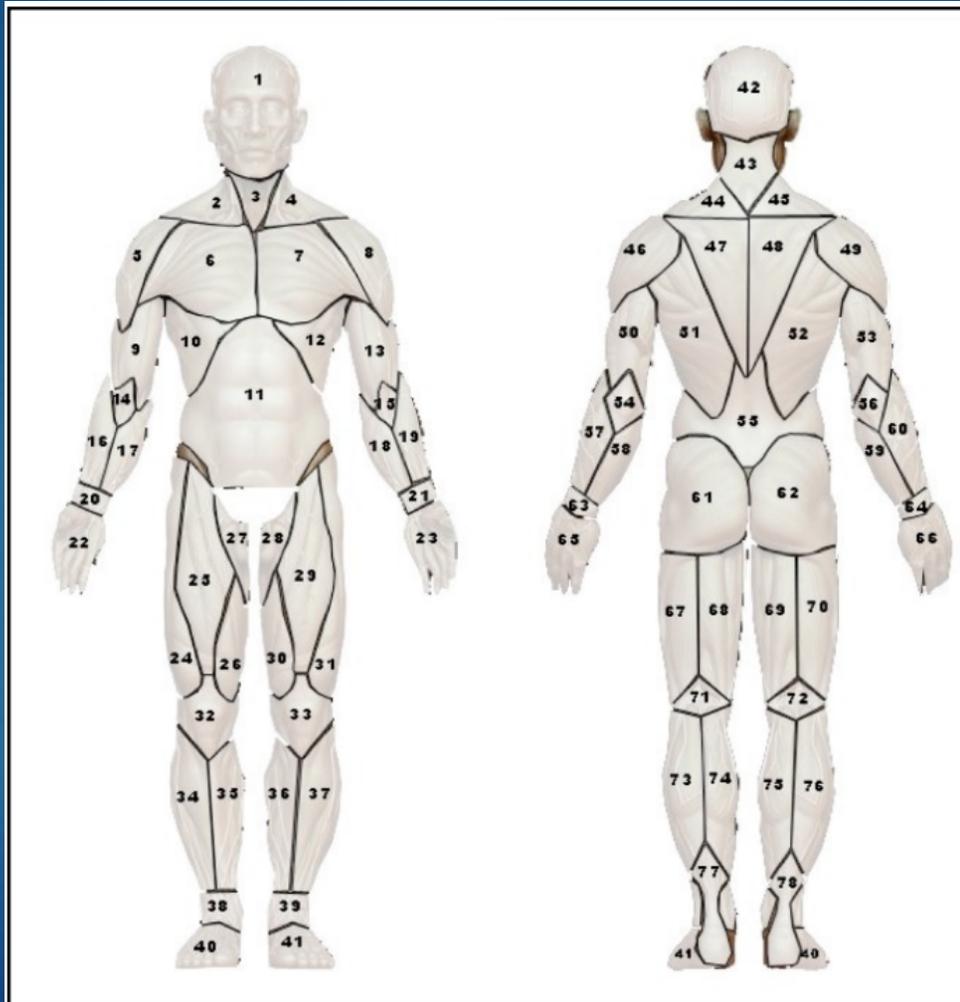
Figure 1 from Infrared thermal imaging in medicine
E F J Ring and K Ammer 2012 Physiol. Meas. 33 R33 doi:10.1088



1995 vs 2011



Regions of Interest



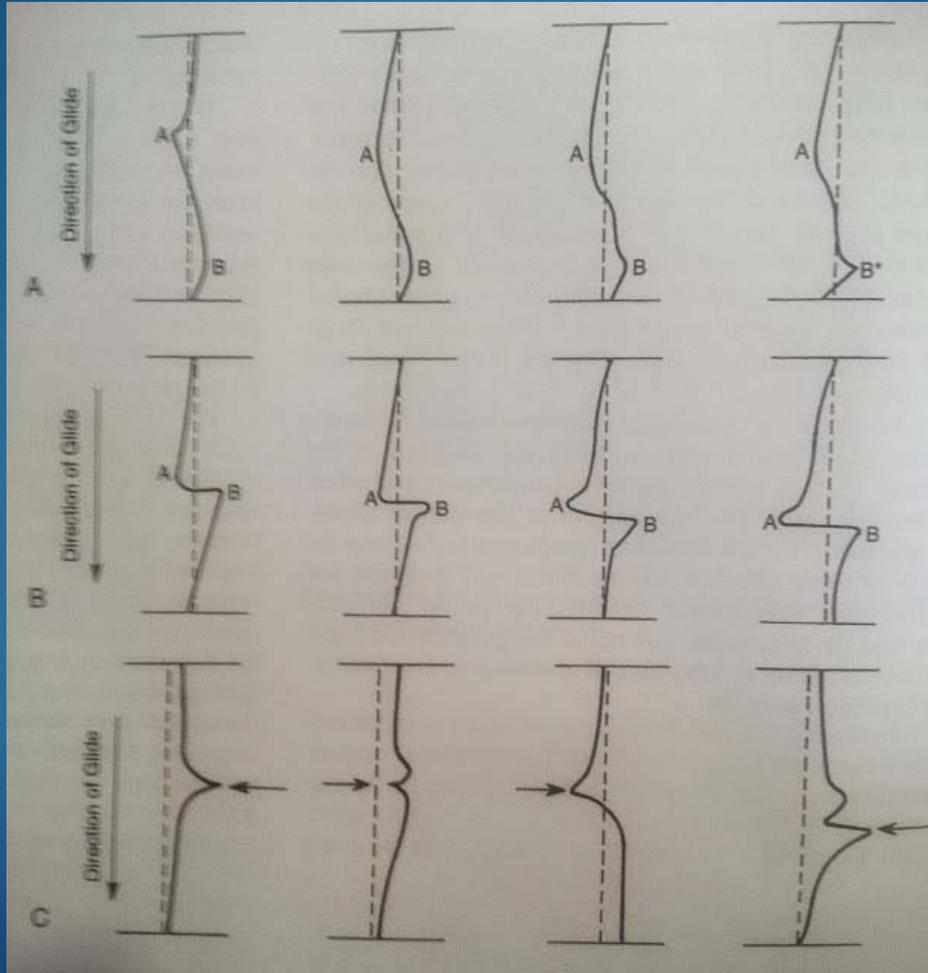
Status of Thermography

- ▶ Thermal imaging has been used mainly for research over the last 50 years.
 - ▶ Literature supports a number of diseases where skin temp reflects inflammation in underlying tissues, or increased or decreased blood flow due to a clinical abnormality.
 - ▶ Thermal imaging in health care either as a diagnostic test or as an outcome measure for clinical trials.
- ▶ *Ring. Infrared thermal imaging in medicine. Physiol Meas 2012;33(3):1-30.*

Nervoscope Reliability GCSS Study

- ▶ 19 chiropractic college students.
- ▶ 3 areas (C4-T2, T4-T8 and L2-L5) examined for concordance between two examiners.
- ▶ Concordance for a reading in particular area: Kappas: 0.034 to 0.6591 all statistically significant.
 - ▶ Slight to moderate reliability C4-T2, substantial agreement T4-T8, L2-5 could not be evaluated with Kappa due to limited variation.
- ▶ Given agreement for reading in an area -> evaluated for agreement with the ICC.
- ▶ 1st observation: fair inter-examiner agreement (ICC = 0.2756).
- ▶ 2nd observation: substantial agreement (ICC = 0.6402).
- ▶ Intraexaminer agreement was moderate for one examiner (ICC = 0.5078).
- ▶ The other examiner showed an excellent level of agreement (ICC = 0.8588, p less than 0.001) between observations.
- ▶ *Plaugher G, Lopes MA, Melch PE, Cremate EE. The inter and intra-examiner reliability of a paraspinal skin temperature differential instrument. JMPT 1991;14:361-7.*

Nervoscope Readings



Thermography and Nervoscope Trial

- ▶ Prospective, infrared thermography of 31 healthy students, then blinded Nervoscope exam (“two experts”).
- ▶ Attempt to generate description of thermal characteristics where a Nervoscope reading existed.
- ▶ In 5 subjects both Δ PCT methods found dysfunction at a particular level.
- ▶ Showed 0.3 to 1.1 C differential possibly related to subluxation.
- ▶ Data 3D graphs were made.
- ▶ *Ebrall. The thermal characteristics of spinal levels identified as having differential temperature by contact thermocouple measurement (Nervoscope). Chiroprac J Aust 1994;24:139-146.*

Neurocalometer Trial



- ▶ Most accurate in lumbar spine:
 - ▶ Of 12 subjects with other neurologic signs, 67% correlation with NCM.
- ▶ Thoracic spine:
 - ▶ Only 21% correlation with other physical signs.
- ▶ *Trott, Maitland. The neurocalometer: a survey to assess its value as a diagnostic instrument. Med J Aust 1:464, 1972.*

Δ PCT After L5 Manipulation

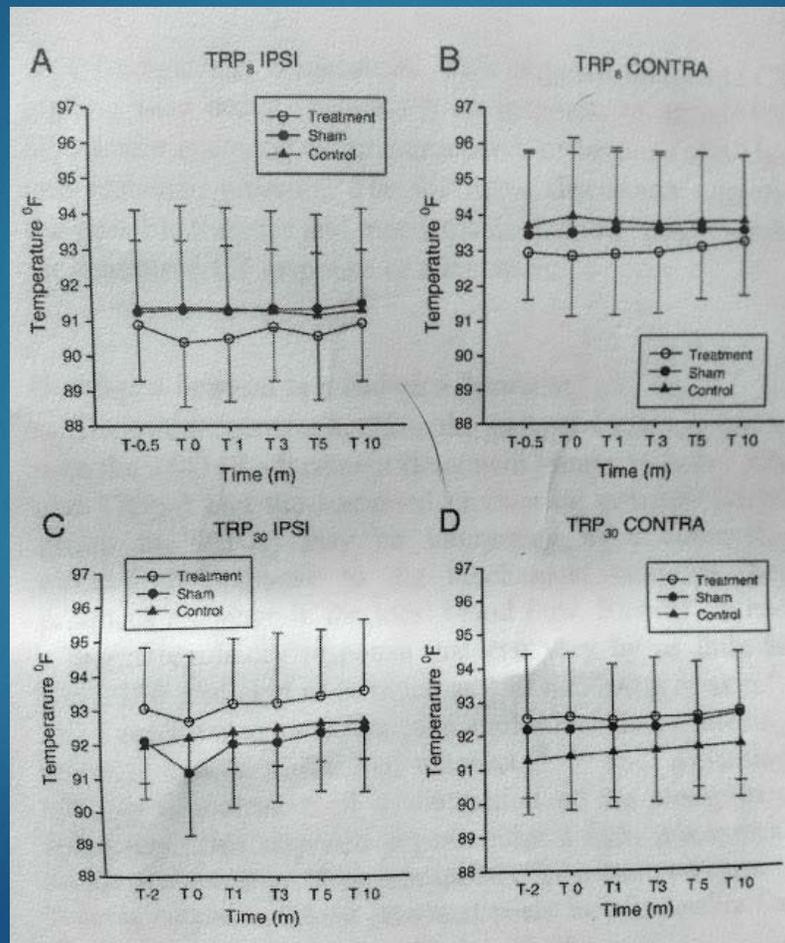
- ▶ 20 subjects with acute LBP randomized to tx or sham group (n = 10 per group).
 - ▶ 8-minute acclimatizing period.
 - ▶ Temp. was measured bilaterally with IR cameras at L5.
 - ▶ Tx: lumbar roll, pisiform on ipsilateral mammillary of L5.
 - ▶ Sham: same technique w/o thrust.
 - ▶ PCT taken 2 min before, immediately after, and at 1, 3, 5, and 10 mins post intervention.
 - ▶ At 1 min, PCT in the tx group on ipsilateral side warmed up by 0.2°F.
 - ▶ Sham group, no significant temperature modifications on either side.
 - ▶ At 10 min, PCT in the tx group on the tx side warmed 0.6°F, whereas the contralateral side cooled.
 - ▶ Tx group, significant differences were noted between sides.
 - ▶ Lumbar spine SMT appears noticeable by Δ PCT at L5.
- ▶ Roy RA. *Paraspinal cutaneous temperature modification after spinal manipulation at L5.* JMPT 2010 May;33(4):308-14.

Δ PCT L4 and L5 After Activator

- ▶ 66 healthy subjects, 11 each group (control, sham, tx), all maintenance care with films.
- ▶ Pre-selected to have L4 or L5 problem via Activator protocol.
- ▶ Insight 7000 Sub Station; TRT 8 min and 30 min; 0,1,3,5,10 min post.
- ▶ Tx-Activator L4 or L5 max force (45 lbs), sham-click no force but tissue pull pressure, control-nothing.
- ▶ Tx and sham: first cooler, then warmer ipsilat (whitening/reddening).
 - ▶ Normal axonal reflex to pressure.
- ▶ But tx alone had another cool/warm period and was different both sides throughout recording periods.

- ▶ *Roy RA. Effects of a manually assisted mechanical force on cutaneous temperature. JMPT 2008;31:230-236*

PCT Graph Activator Study



Hypotheses

- ▶ Initial whitening/reddening-normal reaxn to pressure.
 - ▶ 3 stages: whitening, reddening, edema (local axon reflex).
 - ▶ Antidromic relayed impulse to other sensory n. branches (Sub P, CGRP).
- ▶ Mechanical stimulation of endothelium affecting the vascular system locally.
 - ▶ Strong pressure or ms. spasm->vasoconstriction.
 - ▶ Pressure or spasm subsides->re-establish circulation.
- ▶ Segmental sympathetic stimulation possible (Sato, Budgell, Pickar).
- ▶ Prolonged warming might be from reduced symp tone or increased vasodilator metabolites.
- ▶ Relaxed ms. spasm after adjustment-release blood flow?
- ▶ Thalamic thermoregulation reflex?
 - ▶ Initial local response followed by higher center normalization?

PCT Tx Difference Pain or No Pain

- ▶ Tx and PCT for subjects with chronic LBP vs. no tx without chronic LBP.
 - ▶ Chronic LBP: n = 11, 7 males, 4 females.
 - ▶ Asymptomatic, no tx group: n = 10, 6 males, 4 females.
 - ▶ Outcomes: Oswestry and PCT prone position after 8-minute acclimation period.
 - ▶ Tx group: 9 instrument-based treatments over 2 weeks.
 - ▶ Reeval 2 weeks later for both groups.
 - ▶ Pre-tx Oswestry tx group: $29.8\% \pm 11.8\%$; asymptomatic group: $10.2\% \pm 10.6\%$.
 - ▶ Post-tx Oswestry tx group: $14.20\% \pm 11.5\%$.
 - ▶ Pre-tx PCT higher in the chronic LBP group than the asymptomatic group.
 - ▶ Asymptomatic group PCT was stable, varying from 0.01°C to 0.02°C .
 - ▶ LBP group PCT varied from 0.10°C to 0.18°C .
 - ▶ Tx group post-tx PCT increase after the 9 visits, but not to asymptomatic group levels.
- ▶ *Roy RA. Comparison of paraspinal cutaneous temperature measurements between subjects with and without chronic low back pain. JMPT. 2013 Jan;36(1):44-50.*

Thoraco-Lumbar IVD Disease

- ▶ 58 chondrodystrophic dogs with Type I TLIVDD and 14 chondrodystrophic dogs with no evidence of TLIVDD.
- ▶ Thermal images reached a rate of 90% successful differentiating normal dogs and 97% successful in localizing the site of IVD protrusion.
- ▶ *Grossbard BP, Loughin CA, Marino DJ , et al. Medical infrared imaging (thermography) of type i thoracolumbar disk disease in chondrodystrophic dogs. Veterinary Surgery. 2014;43:869–76.*

Lumbar Disc IRT

- ▶ Lesions of L4-5, L5-S1 study.
- ▶ Central L4-5 disc -> bilaterally in region between lower lumbar and sacral-iliac areas.
- ▶ Lateral L4-5 disc -> unilateral heat.
- ▶ Central L5-S1 disc -> heat in normally cool L/S region bilaterally.
- ▶ Lateral L5-S1 disc -> heat medial to sacro-iliac region.

- ▶ *Edeiken J. Thermography and herniated lumbar disc. Am J Roent Radiol Therapeu Nuclear Med 1968; 102:790.*

Trigger Point Thermology



- ▶ Studied whether active TP showed a hyper-radiation region along the referred pain area when compared to latent TP.
- ▶ Also a subgroup of 25 ptnts with jt dysfunction that could be the cause of the hyper-radiation in the same area of referred pain of the TP.
- ▶ When this subgroup was suppressed, the distinction between the active TP and the latent ones increased.
 - ▶ Of the remaining 104 patients, there was an increase in specificity of 70% to 82%, sensitivity remained constant at 74% and there was an increase of Cohen's Kappa from 0.44 to 0.54.

Trigger Point Thermology

- ▶ ∴ Jt dysfunction can be additional cause of hyper-radiating points.
 - ▶ In agreement with studies by Korr on facilitated segments.
- ▶ Skin temperature we see paraspinally may be due to jt dysfunction via some mechanism not yet certainly known or to active TP.
- ▶ *Diakow PR. Differentiation of active and latent trigger points by thermography. J Manipulative Physiol Ther 15(7):439-441, 1992.*

Pain and Thermal Images



- ▶ Areas of pain show thermal asymmetry between corresponding areas on opposite sides of the body.
 - ▶ Latent TP, not causing pain at time of IR imaging exhibit hyperradiant spots.
 - ▶ These latent TPs also have abnormal PPT.
 - ▶ There was alteration of skin temp after TP local anesthesia/dry needling showing immediate sympathetic response.
- ▶ *Brioschi ML. Documentation of myofascial pain syndrome with infrared imaging. ACTA FISIATR 2007; 14(1): 41 – 48.*

Thermography Research



- ▶ 0.6 °C difference in extremity temp distinguished RDS from non-RSD patients.
- ▶ *Breuhl. Validation of thermography in the diagnosis of reflex sympathetic dystrophy. Clin J Pain 1996;12:316-325.*

Thermography Research

- ▶ Compression of TPT led to an average decrease of mean temp at several thermal referral areas in the upper extremities.
- ▶ Compression of same areas in non TPT controls increased temp slightly.
- ▶ Decreased PPT at TPT areas.
- ▶ ∴ Myofascial TPTs probably have autonomic component vs. TPTs in fibromyalgia patients.

- ▶ *Kruse. Thermographic imaging of myofascial trigger points: a follow-up study. Arch Phys Med Rehabil 1993;73:819-823.*

Thermography Research

- ▶ Thrust vs non thrust methods, 5 patients, chronic CTP, 3 OMTs 1x/wk.
- ▶ Tenderness, tissue texture, ROM checked pre and post by two blinded examiners.
- ▶ Questionnaires pre and post tx each time
- ▶ Thermograms baseline, after each tx.
- ▶ Decreased pain, improved ROM, tissue texture, tenderness.
- ▶ All 5 patients therm asymmetry pre tx; post tx 4 normalized, 5 cooling CT
- ▶ *Walko. Effects of osteopathic manipulative treatment in patient with cervicothoracic pain: pilot study using thermography. J Am Osteopath Associ 1994;94:135-141.*

Thermography Research



- ▶ Can't generalize from this study
- ▶ Only 5 patients without controls.
- ▶ Validity/reliability of other exam procedures used.
- ▶ Blinded only to what type of tx, not whether received tx.
- ▶ Is thermographic change necessarily indicative of successful adjustment?

Thermography, Low Back Pain and Sciatica

- ▶ Temperature differences between the lower extremities using computerized thermography in 144 patients with low-back pain and sciatica.
- ▶ Highly significant thermal asymmetries, with the involved limb being cooler.
- ▶ When asymmetries exceeded 1 SD from the mean temperature of homologous regions measured in 90 normal control subjects, the positive predictive value of thermometry in detecting root impingement was 94.7% and the specificity was 87.5%.
- ▶ Temperature asymmetry is particularly effective in evaluating patient populations w/ LBP/sciatica
- ▶ Thermography can be performed to avoid more invasive and probably less revealing diagnostic or exploratory surgical procedures.
 - ▶ The chance of positive myelography or impaired root function is low. In these patients.
- ▶ *Uematsu S. Quantification of thermal asymmetry, Part 2: Application in low-back pain and sciatica. J Neurosurg October 1988;69(4):556-561.*

IRT vs Electrical Skin Resistance

- ▶ Skin temp and electrical skin resistance (GSR) to evaluate SNS dysfunction in ptnts w/ L disc herniation.
 - ▶ Affected dermatome was found; skin temp and GSR were measured for affected and opposite dermatome.
 - ▶ Mean skin temp of affected vs opposite: 32.13 C vs. 32.68 C.
 - ▶ Difference not significant.
 - ▶ But, GSR was 163.39 vs 147.05 k Ω .
 - ▶ Was statistically significant.
 - ▶ GSR is more sensitive and early in detecting SNS dysfunction in L disc patients than skin temp. Test is cheap and easy and helpful in follow up of these cases.
- ▶ *Tuzgen S. Electrical skin resistance and thermal findings in patients with lumbar disc herniation. J Clin Neurophys: 2010; 27(4):303-307.*

IRT & Unilat. Lumbar Radiculopathy

- ▶ Relationship of skin temperature changes to clinical, radiologic, and electrophysiological findings in unilateral lumbosacral radiculopathy and mechanisms involved.
- ▶ 101 ptnts w/ symptoms and signs of unilateral lumbosacral radiculopathy, plus 27 normal controls. Digital infrared thermographic imaging (DITI) of the back and lower extremities. Compared mean temperature differences (ΔT) in 30 ROIs; abnormal thermal patterns divided into 7 regions. MRI and electrophysiological tests were also done.
- ▶ Disc herniation on MRI: 86%; 43% of patients showed electrophysiological abnormalities. On DITI, 97% of the patients showed abnormal ΔT in at least one of the 30 ROIs, and 79% showed hypothermia on the involved side. 78% of ptnt also showed abnormal thermal patterns in at least 1 of 7 regions. Ptnts w/ motor weakness or lateral-type disc herniation: some correlations with abnormal DITI findings. Pain severity or other physical or electrophysiological findings weren't related to the DITI findings.
- ▶ Skin temp change following lumbosacral radiculopathy was related to some clinical and MRI findings, suggesting muscle atrophy. DITI, despite its limitations, might be useful as a complementary tool in the diagnosis of unilateral lumbosacral radiculopathy.
- ▶ *Ra JY. Skin temperature changes in patients with unilateral lumbosacral radiculopathy. Annals Rehab Med 2013; 37(3):355-363.*

Thermatomal Changes in CDH

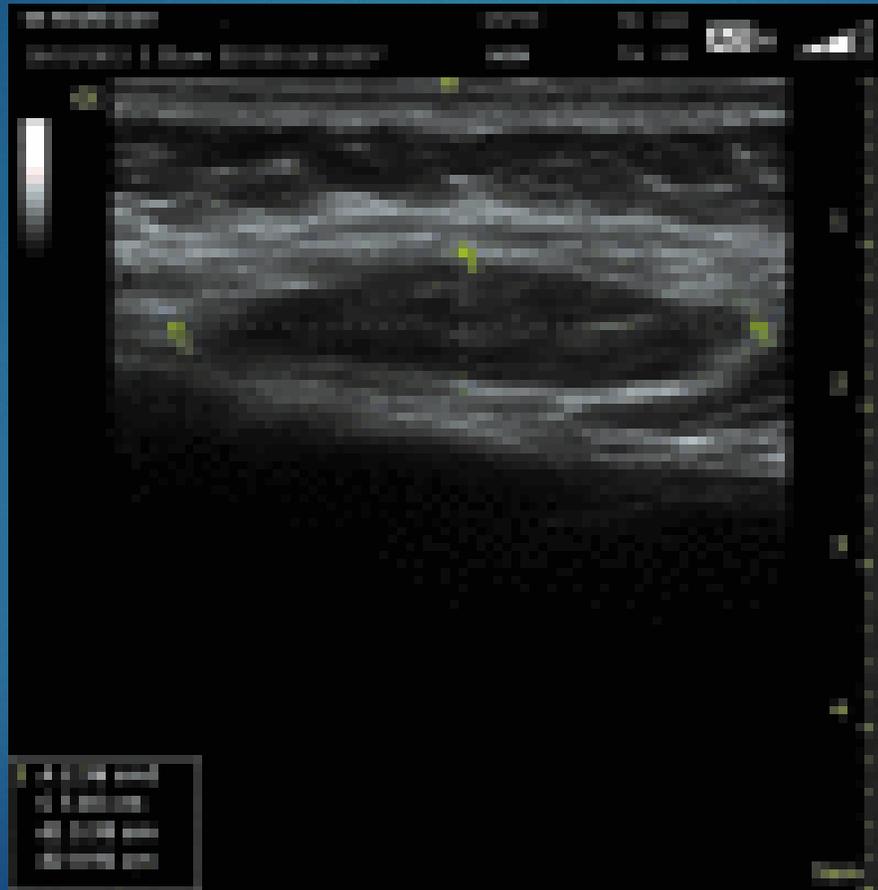
- ▶ DITI of 50 controls and 115 CDH ptnts - defined areas of thermatomal change in CDH C3/4, C4/5, C5/6, C6/7 and C7/T1.
- ▶ Minimal abnormal thermal diff. upper extremities: 0.1 C to 0.3 C, 99% confidence interval. If delta T was more than 0.1 C, the anterior middle shoulder sector was considered abnormal. If delta T was more than 0.3 C, the medial upper aspect of the forearm and dorsal aspect of the arm, some areas of the palm and anterior part of the fourth finger, and their opposite side sectors and all dorsal aspects of fingers were considered abnormal. Other areas were considered abnormal if delta T was more than 0.2 C.
- ▶ In $p < 0.05$,
 - ▶ C3/4: posterior upper back and shoulder and the anterior shoulder.
 - ▶ C4/5: middle and lateral aspect of the triceps muscle, proximal radial region, the posterior medial aspect of the forearm and distal lateral forearm.
 - ▶ C5/6: anterior aspects of the thenar, thumb and second finger and the anterior aspects of the radial region and posterior aspects of the pararadial region.
 - ▶ C6/7: posterior aspect of the ulnar and palmar region and the anterior aspects of the ulnar region and some fingers.
 - ▶ C7/T1: scapula and posterior medial aspect of the arm and the anterior medial aspect of the arm. The areas of thermal change in each CDH included wider sensory dermatome and sympathetic dermatome.
- ▶ There was a statistically significant change of temperature in the areas of thermal change in all CDH patients. In conclusion, the areas of thermal change in CDH can be helpful in diagnosing the level of disc protrusion and in detecting the symptomatic level in multiple CDH patients.
- ▶ Zhang HY. *Thermatomal changes in cervical disc herniations. Yonsei Med J* 1999, 40(5):401-412.

Thermography, Ultrasound, TPTs

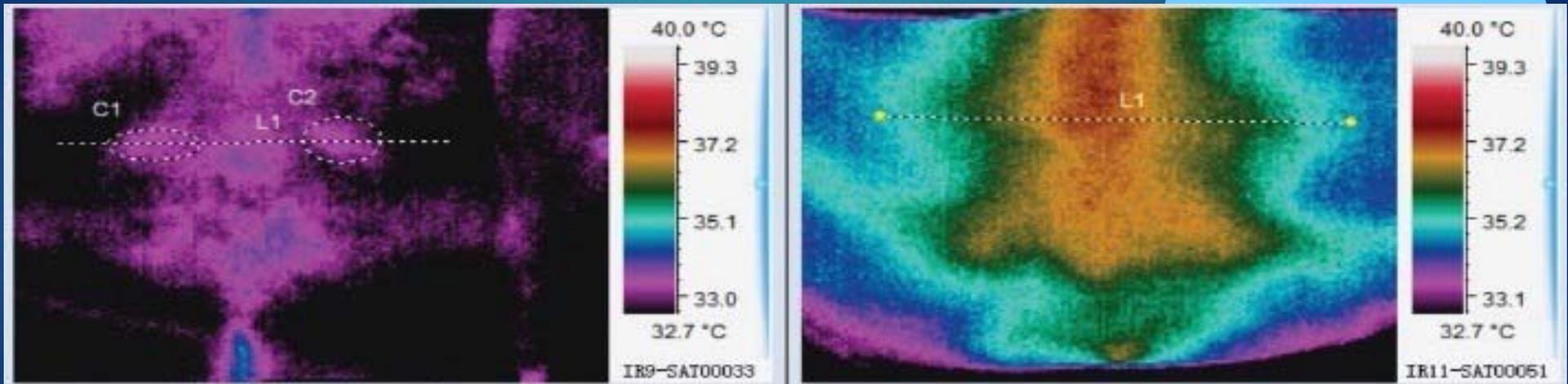


- ▶ 8 LBP patients, pilot.
- ▶ TPTs were clinically found, then thermography of low back to observe the thermal pattern of the area. The TPT was evaluated ultrasound.
- ▶ Ptnts received injection treatment then re-exam 5 days later.
- ▶ Trigger point has a distinct thermal pattern: a hotter area surrounded by a cooler area.
- ▶ Ultrasound showed an ellipsoidal hypoechogenic area in the muscle ranging from 1.18 cm² to 3.54 cm².
- ▶ *Cojocarú MC. Trigger points – ultrasound and thermal findings. J Med Life 2015, Jul-Sep;8(3): 315–318.*

Ultrasound of a Trigger Point



Thermal Image of TPT Pre-Post Injection



Author's Conclusions

- ▶ TPTs have higher temp because a ms contraction generates heat and the cooler area is observed because there is a deficit in the blood flow surrounding these points;
 - ▶ the exact mechanism for this phenomenon is not known but it can be caused by the metabolic disturbances in the area of a trigger point.
 - ▶ Prior doppler studies revealed a deficit in the blood flow in the area of the trigger point.
- ▶ Thermal imaging has limitations in practice-can't see more than the skin temp.
- ▶ Unreliable as a stand-alone DDx for TPTs.
 - ▶ Example, the same thermal pattern can be seen in a localized infection of the skin, so the clinical assessment is very important.

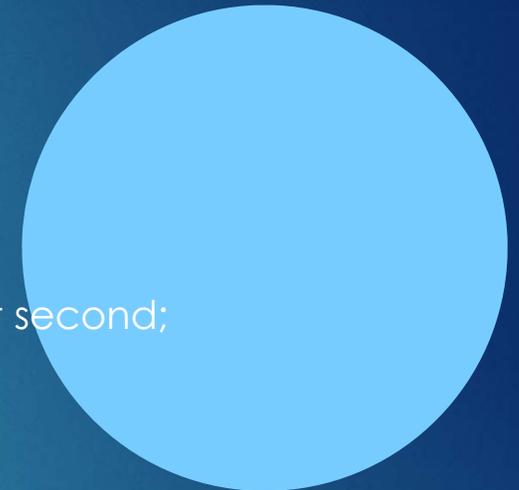
Interpreting Pattern Scans

- ▶ 1st study* on reliability of interpreting thermographic pattern scans as used in upper cervical techniques.
- ▶ Reliability of those designated as “pattern” (completely similar to a reference scan) was good.
- ▶ Reliability of those designated as “adaptation” (completely dissimilar to a reference scan) was fair.
- ▶ Poor agreement for scans with partial similarity.
- ▶ ∴ Other clinical findings should be relied upon to determine tx.
- ▶ Further research needed to understand if tx based on thermographic findings are related to clinical outcomes.

- ▶ *Mansholt BA. Inter-examiner reliability of the interpretation of paraspinal thermographic pattern analysis. JCCA. 2015* Jun; 59(2): 157-164.*

Nervoscope

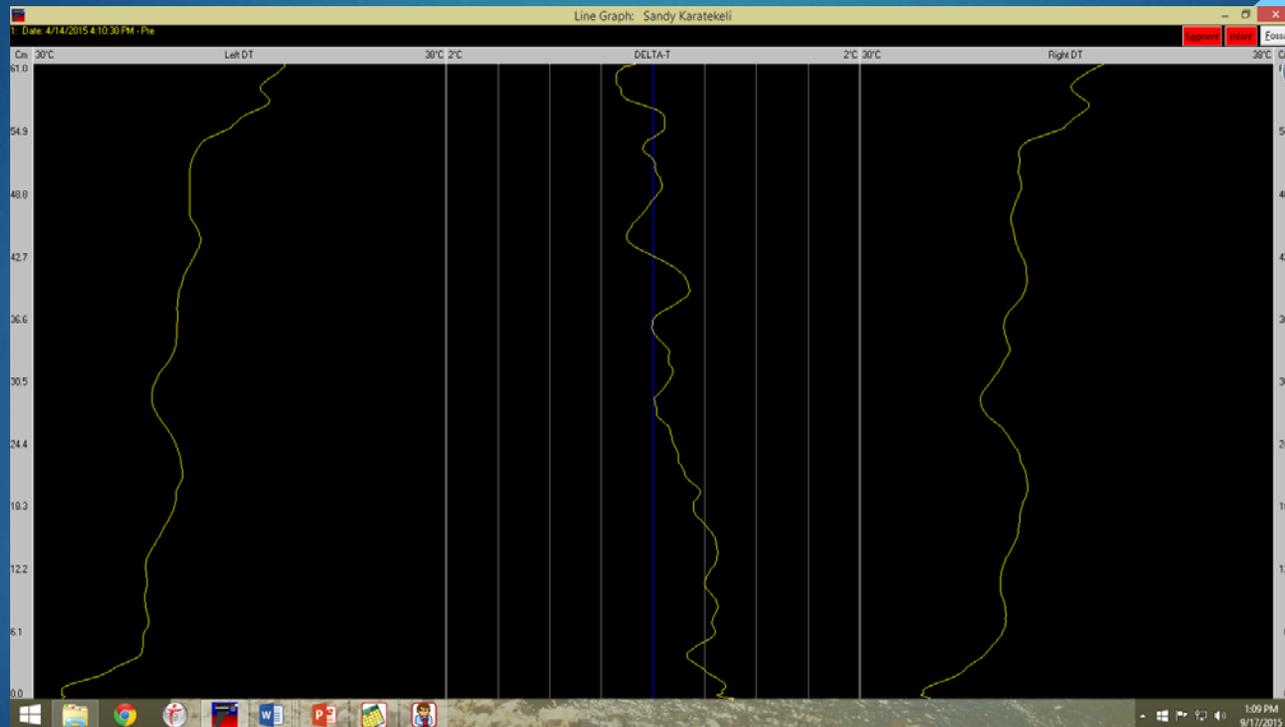
- ▶ Challenges, skills needed to operate properly:
 - ▶ Speed of glide;
 - ▶ Pressure and angle of scope;
 - ▶ Can't take your eyes off of it-must recognize reading in split second;
 - ▶ Air gaps at thermocouples;
 - ▶ Gradual drop of in sensitivity;
 - ▶ Contact interaction altering natural state;
 - ▶ Qualitative info only as opposed to Tytron or other IR measures.
 - ▶ Lack of research connecting it with anything significant.
 - ▶ Moderately reliable in skilled hands.



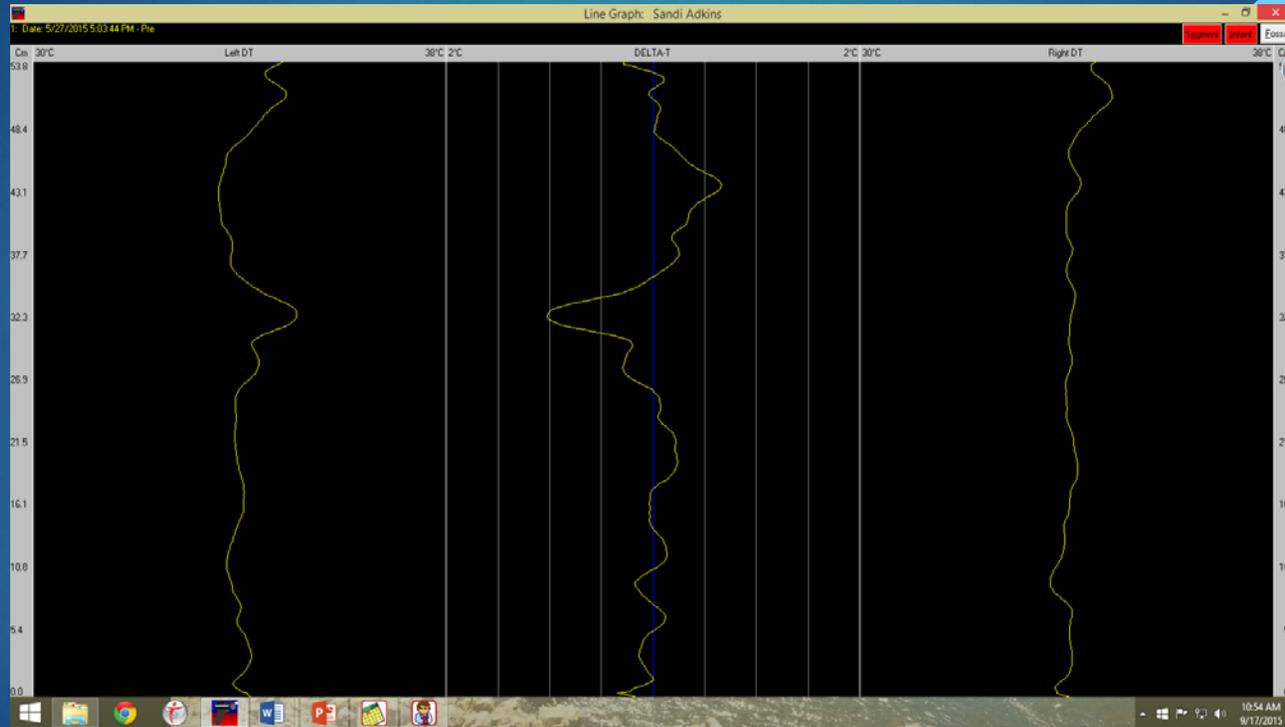
Nervoscope or Break Readings

- ▶ Recurrent meningeal N; mixed sensory and sympathetic components; pain or other sensory disturbance or thermal manifestations. Antidromic stimulation of DRG can raise skin temp (ref 59,60 Ch 4)
- ▶ Interconnection of contiguous spinal segments of C and L regions vs not in T sp (51); direct reading in T sp whereas maybe not in C or L.
- ▶ Cauda Equina region w/disc protrusion affecting NR exiting below it; Where's reading?
- ▶ Reading alone is not pathognomonic of subluxation.
- ▶ Temperature changes may be distal to PCT (limb, outer torso).
- ▶ What other physiologic measures do we have?

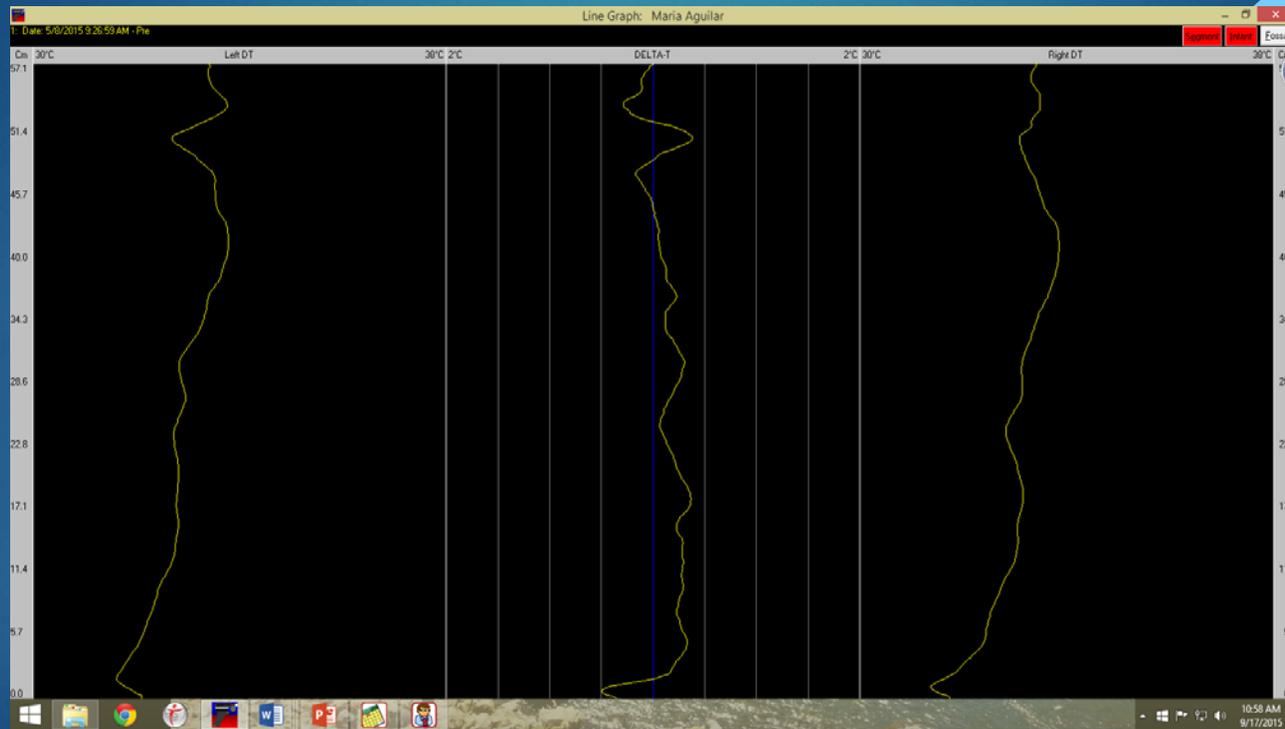
Tytron Graph w/o Asymmetry w/ Bilateral Decrease Temp.



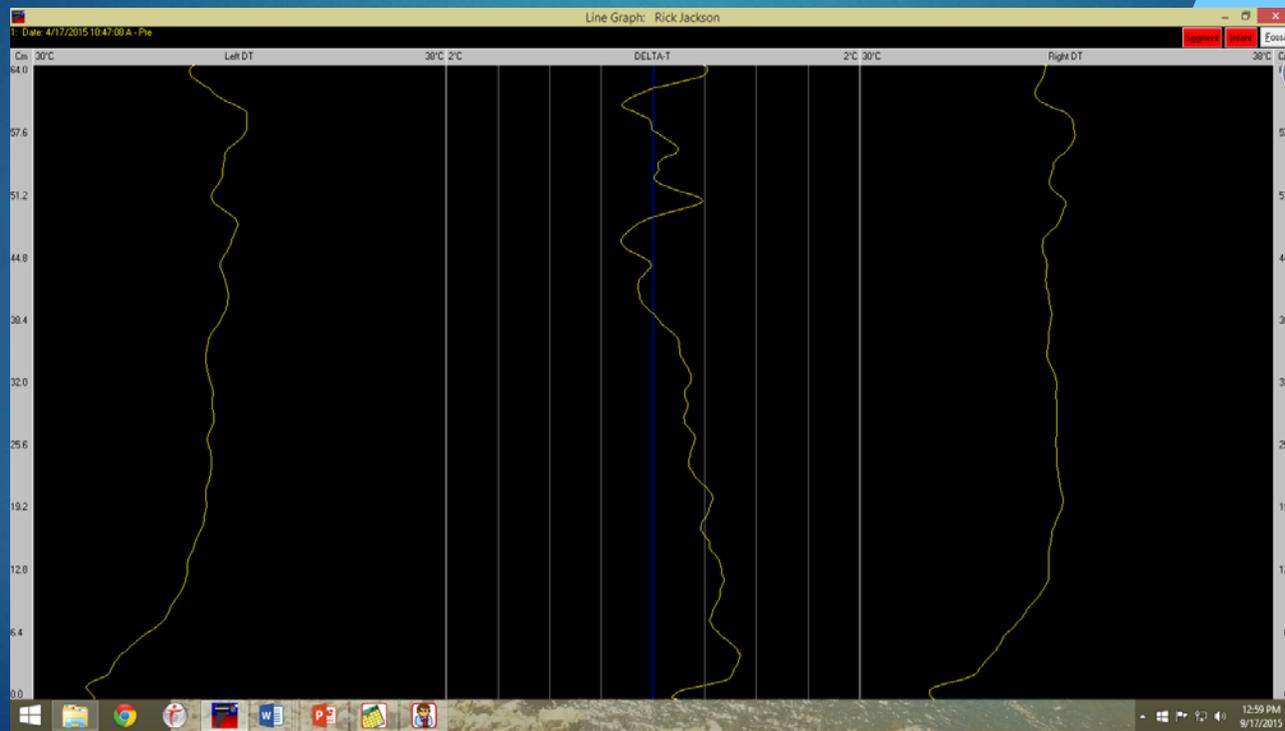
Unilateral PCT Variation (One Side Hotter)



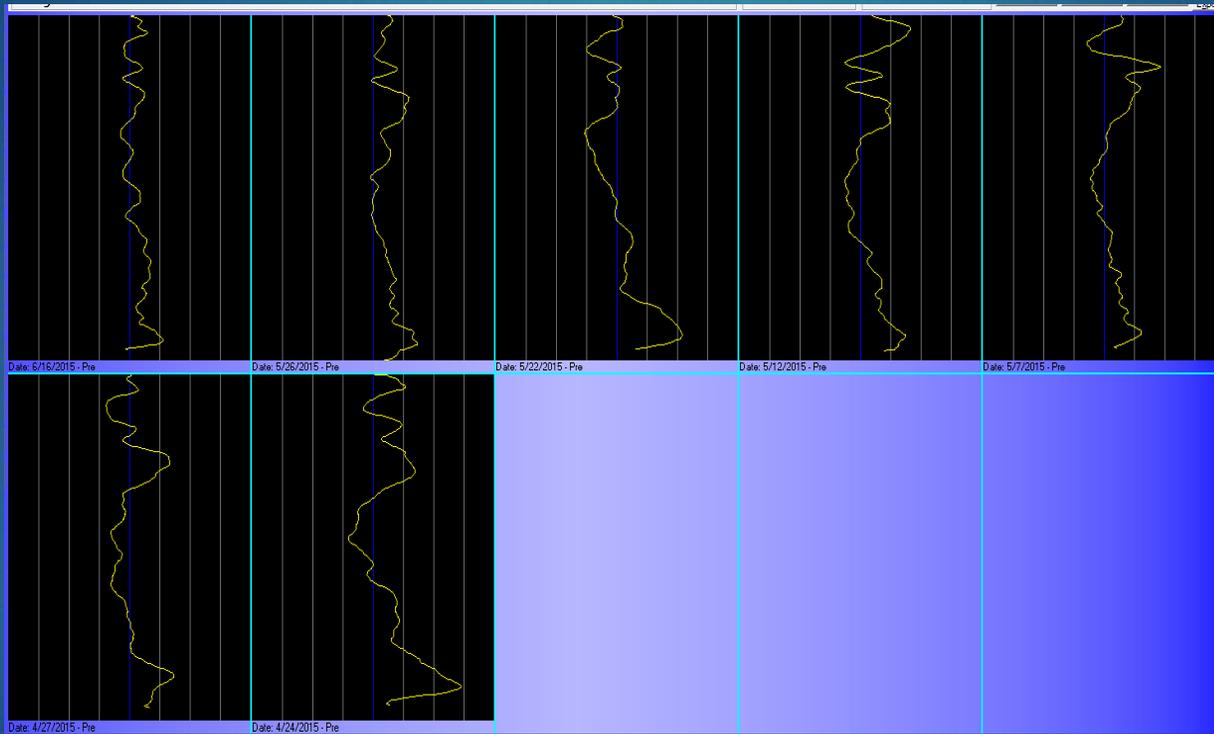
Unilateral PCT Variation (One Side Colder)



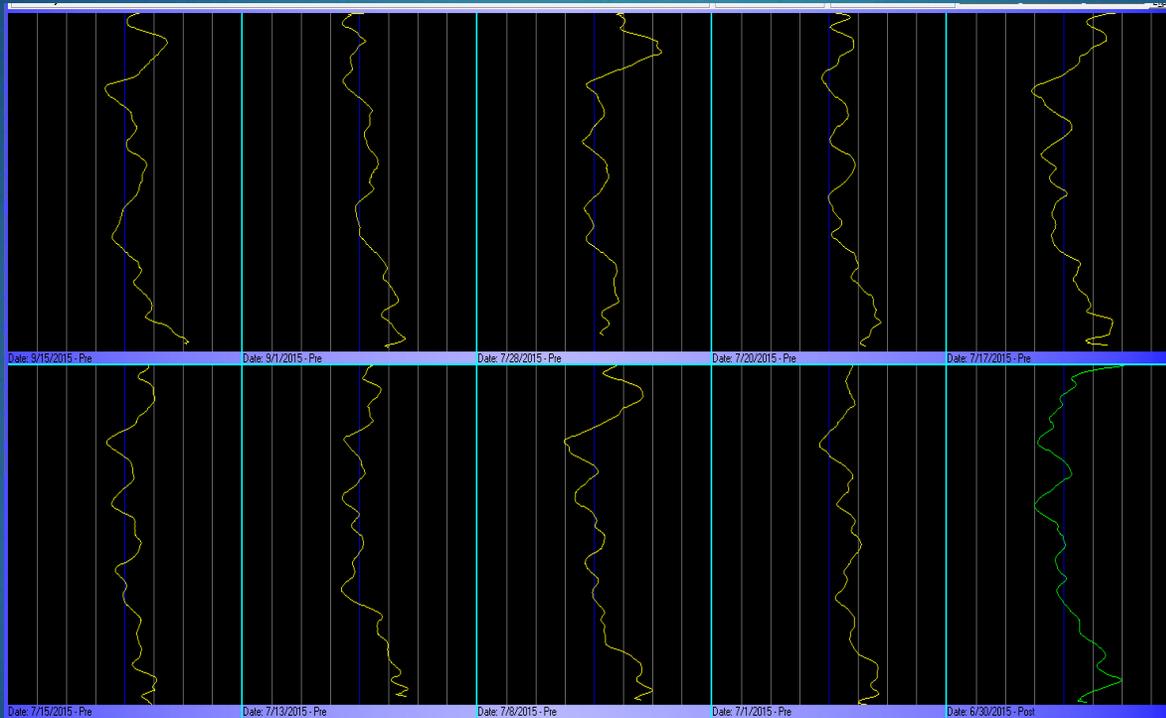
Slight Decrease Left/Slight Increase Right Equals Significant Break



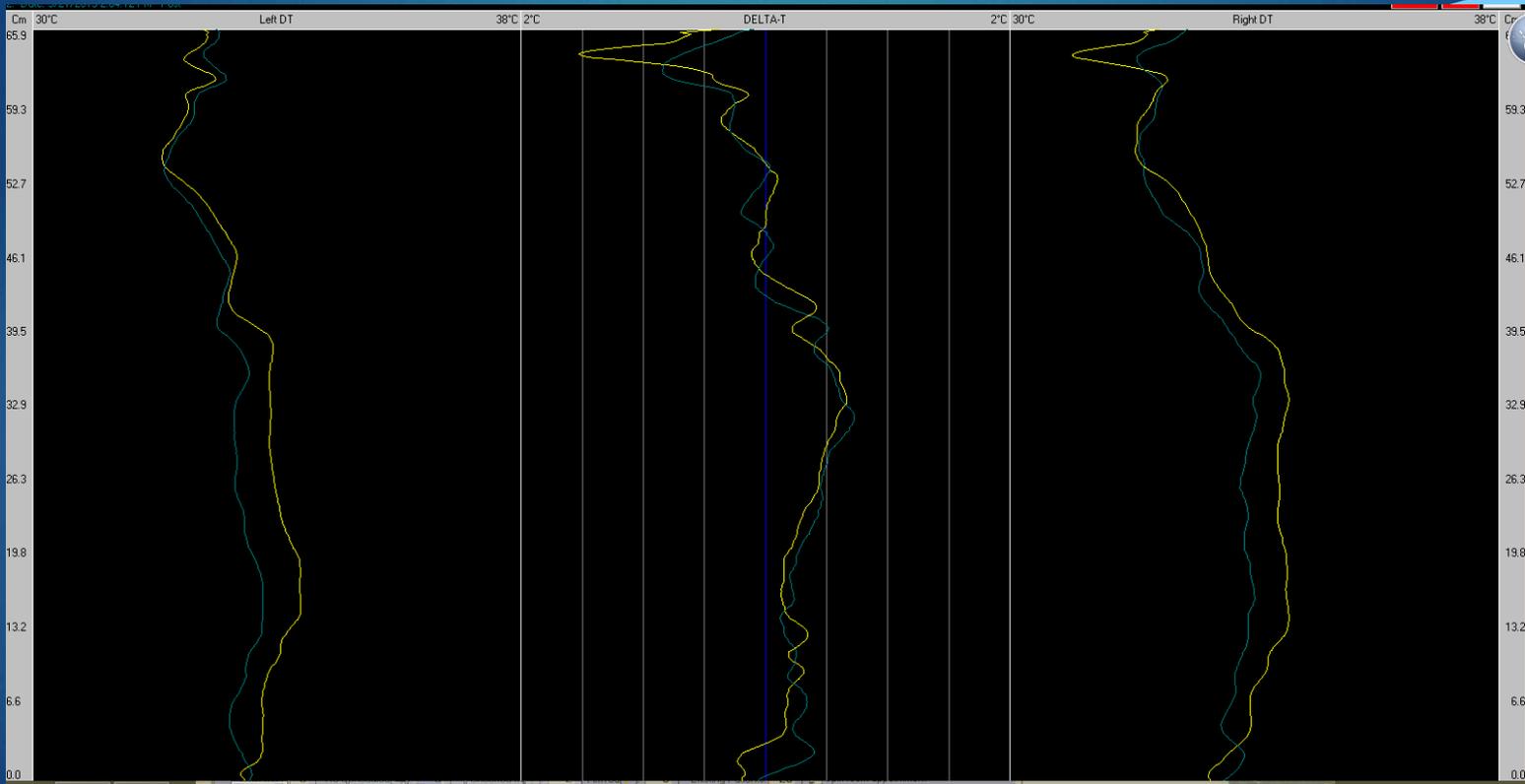
Gradual Improved Pattern and Patient S&S



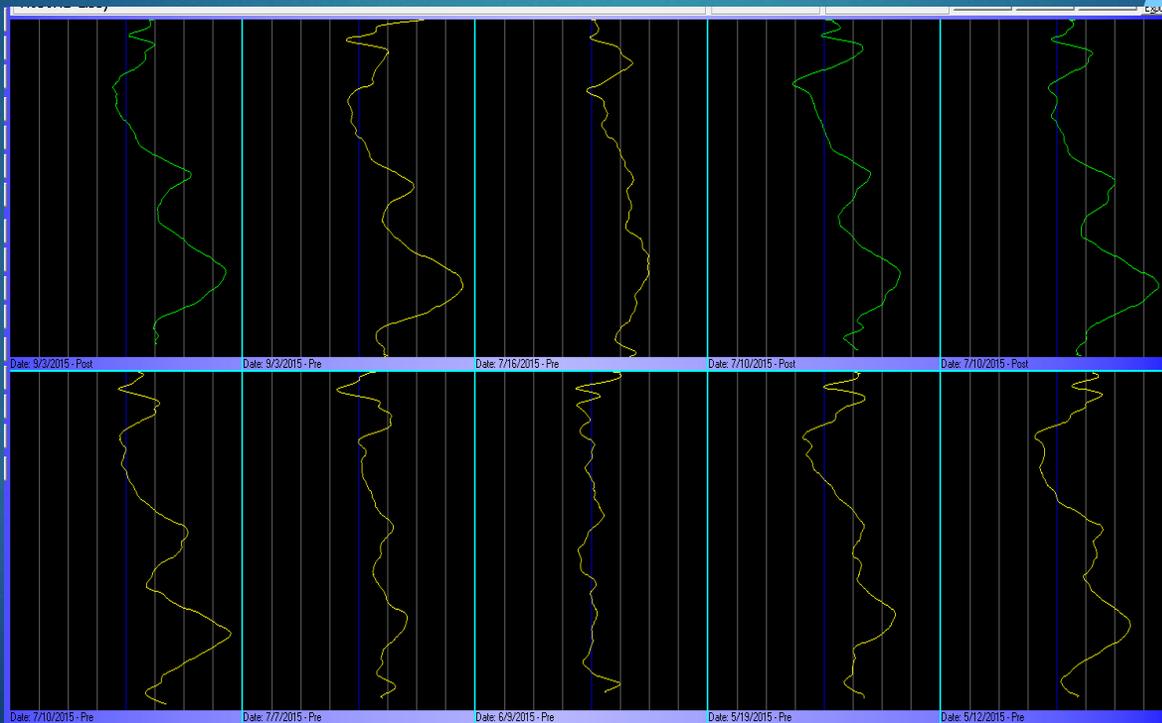
Series of Scans-Ptnt Improved-Substantial Value?



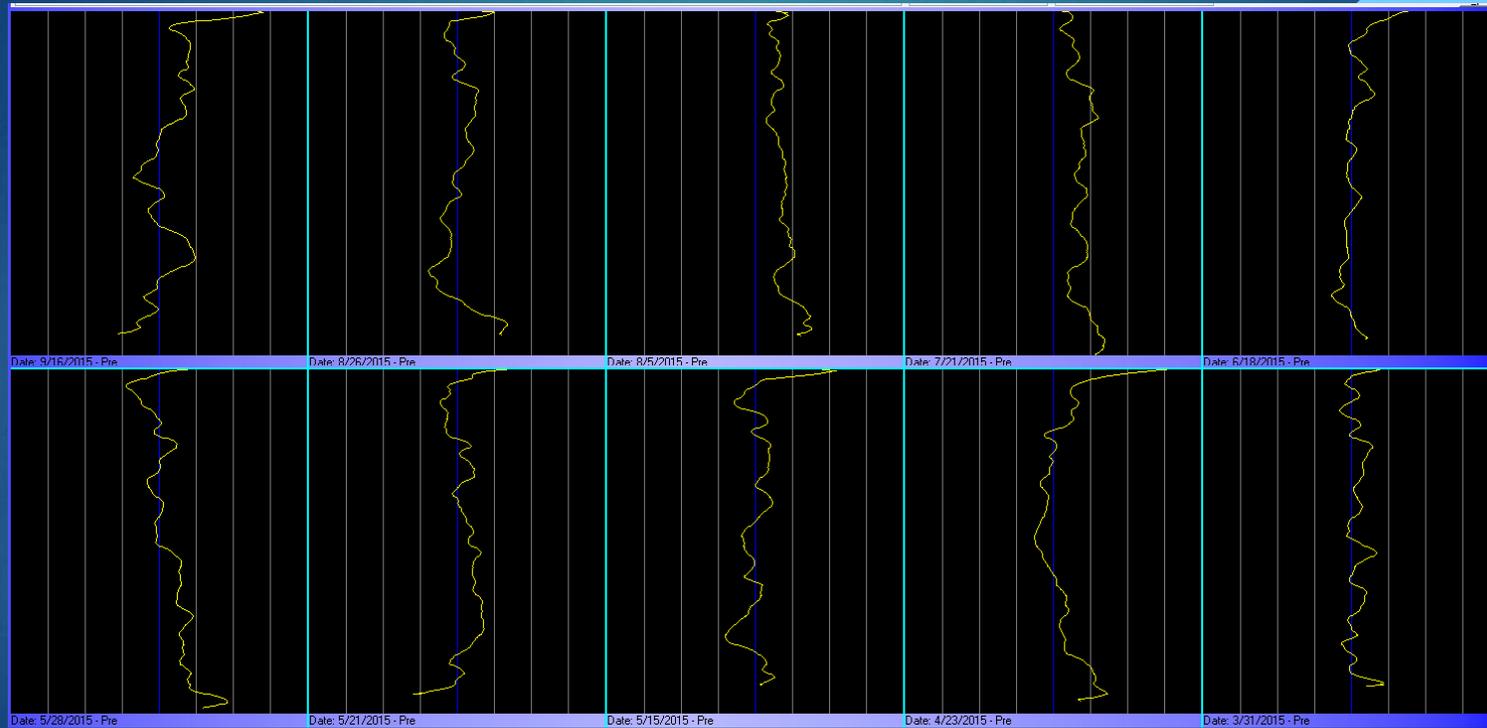
Pre- Post C2 PL Adjustment Seated



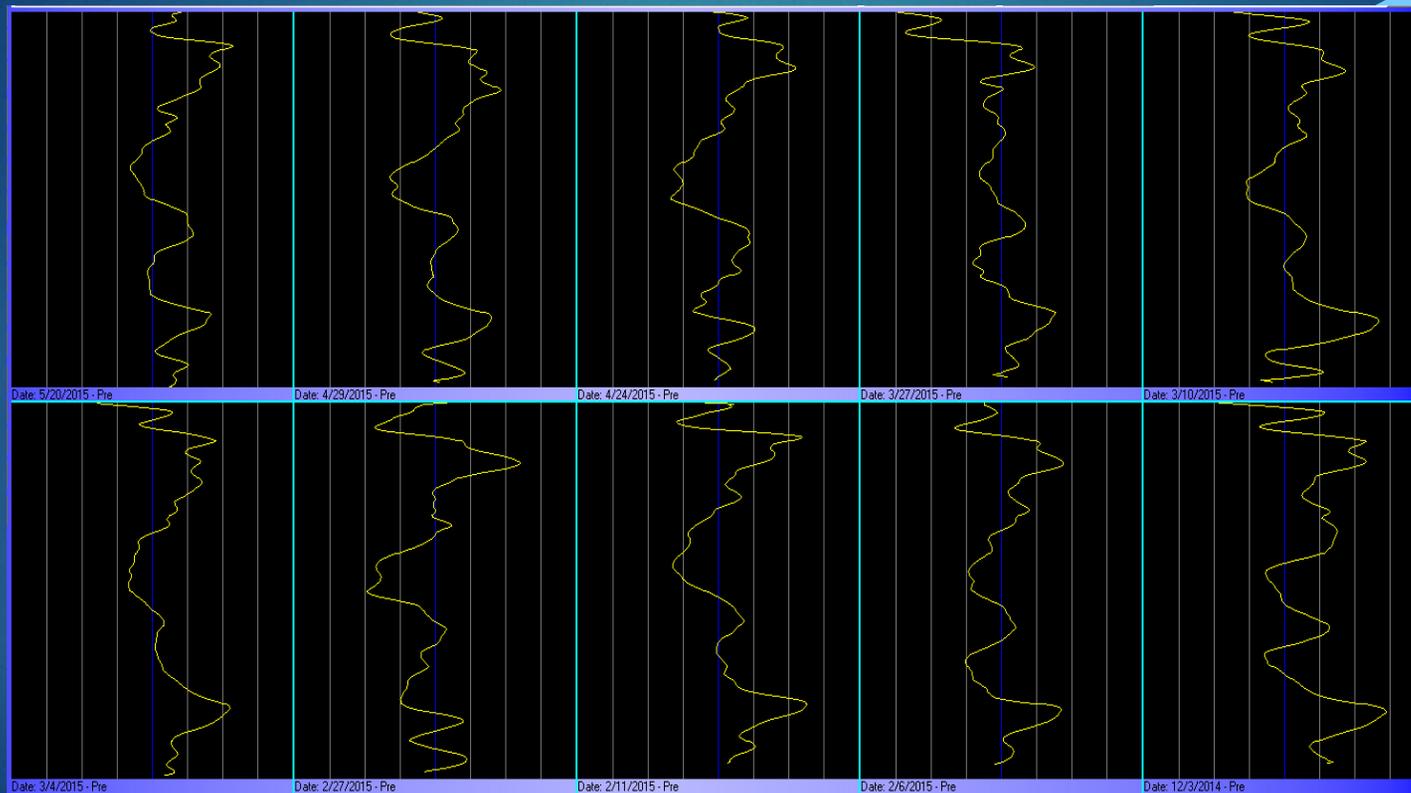
Break the Pattern, Return to Pattern-Recurrent Chronic Subluxations?



Potentially Healthy Variable PCT

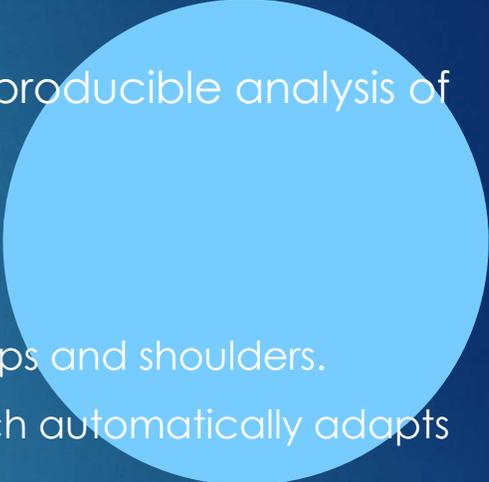


Likely Unhealthy Persistent Pattern



New Directions?



- ▶ New method of image analysis relates to automatic and reproducible analysis of temperature distribution on the patient's back:
 - ▶ (1) detection of the external contours of the human body.
 - ▶ (2) identification and recognition of the position of the arms, hips and shoulders.
 - ▶ (3) application of a mesh having a fixed number of fields (which automatically adapts to the size of the patient's back).
 - ▶ (4) analysis of the paraspinal muscles.
- 

New Directions?

- ▶ Based on a thermal image, this new fully automated algorithm enables to:
 - ▶ (1) evaluate temperature distribution in the paraspinal area
 - ▶ (2) pre-assess the degree of lateral spinal curvature in screening
 - ▶ (3) evaluate anomalies (deviations from the norm) in temperature distribution.
 - ▶ The algorithm was practically implemented in Matlab Image Processing Toolbox
- ▶ *Koprowski R. Automatic analysis of the trunk thermal images from healthy subjects and patients with faulty posture. Comput Biol Med. 2015 Jul 1;62:110-8.*

My Conclusions

- ▶ Sometimes Δ PCT does specifically relate to subluxation level.
 - ▶ But Δ PCT is not certain.
- ▶ Subluxations don't always involve disc protrusions or certain aspects of misalignment or certain nerves involved.
 - ▶ But they are still relevant and one should evaluate for them.
- ▶ Just as disc protrusions, misalignments, various nerve involvements are still relevant, so is Δ PCT