Evidence and applications of Instrument-assisted soft tissue mobilization in physical therapy

Shane McClinton, PT, DPT, OCS, FAAOMPT, CSCS

DES MOINES UNIVERSITY

Objectives

- List the level of evidence for conditions in which instrument-assisted soft tissue mobilization (IASTM) has been utilized in the published literature.
- Describe the histological changes associated with IASTM in animal studies.
- Describe potential mechanisms by which IASTM can produce a treatment effect.
- Discuss applications of IASTM in clinical practice.
- Identify limitations of IASTM theory and applications.
- Identify the clinical relevance of studies forming the basis for IASTM

Outline

- IASTM history, treatment theory, tools, & “brands”
- Histological basis of IASTM
- Review of published literature using IASTM as treatment
  - Hierarchy of evidence
  - Clinical relevance of treatment effects
  - Conditions studied
  - Treatment parameters
- Considerations & conclusions

IASTM – What is it?

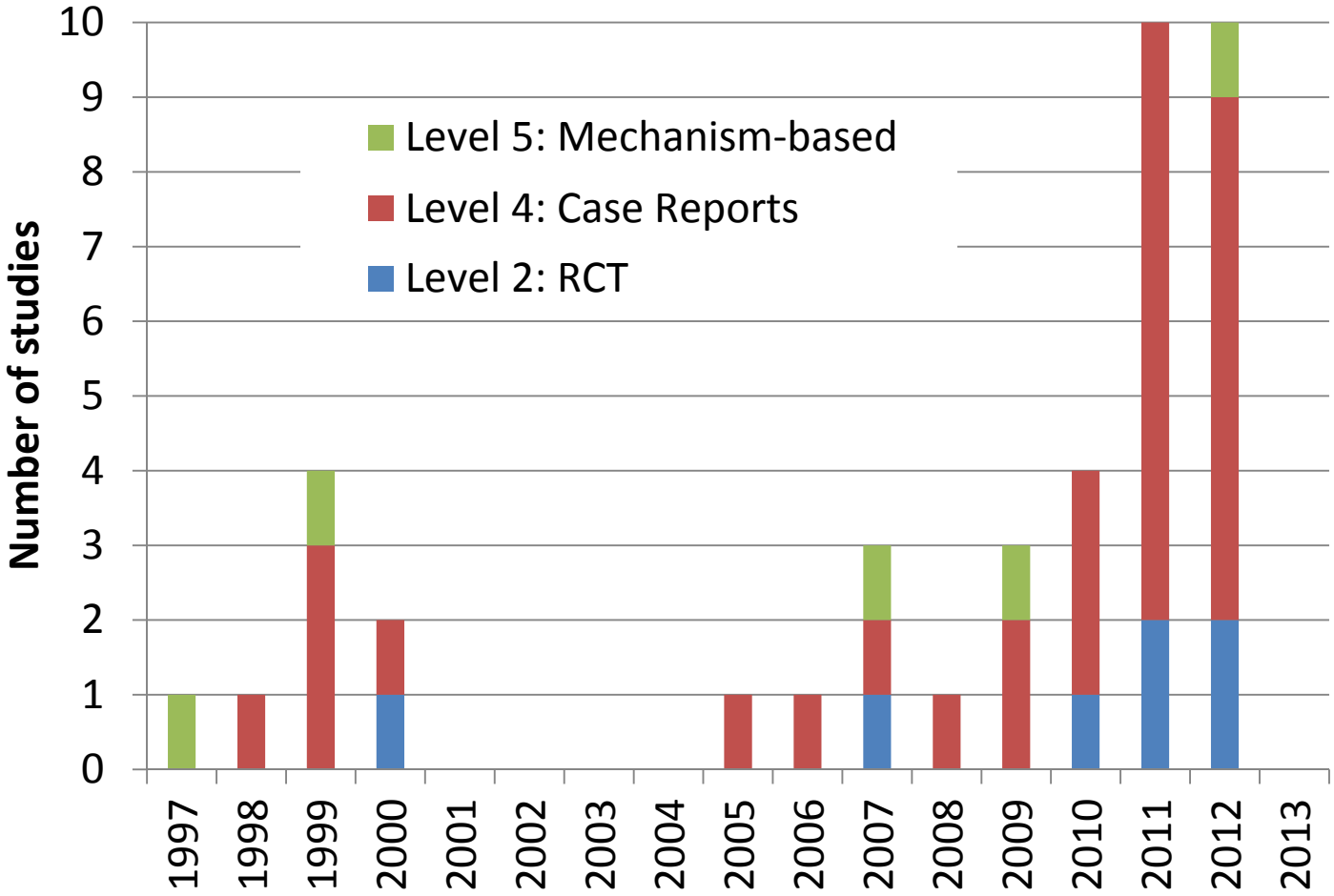
- Manual therapy technique: soft-tissue biased
- Involves the use of an instrument or tool

IASTM?

Instrumented Reiki?

Instrumented chair massage?

Number of studies including IASTM



History

- Stone massage - ?
- Ancient Greek Roman baths
  - Strigils
- Gua sha – 1300
  - spooning, coining, scraping
- Iron Bar Bob – 1930
- Evolution of the modern American IASTM brands - 1989

IASTM “Brands’

- Astym® (Performance Dynamics, www.astym.com)
- Graston (Therapy Care Resources Inc., www.grastontechnique.com)
- Gua Sha
- SASTM (Carpal Therapy Inc. www.sastm.com)

Disclosure


ASTYM
Restore • Revitalize • Recover
Medical Professionals | Patients
Find a Provider
Where It Hurts
News
Clinician Listing
ASTYM-Certified Clinicians at Des Moines University Clinic
[redacted]
[redacted]
Shane McClinton, DPT, OCS, FAAOMPT, CSCS
[redacted]
[redacted]

Battle of the “Brands” – What is IASTM

Astym®

Astym is regenerative soft tissue therapy which successfully resolves many difficult conditions, including chronic tendinopathies and movement restrictions/pain resulting from scar tissue. Astym is non-invasive, has a short treatment course, and it is reliable and safe. The effectiveness and quality of Astym treatment has been achieved through its groundbreaking scientific and clinical research, and the dedication of the Astym researchers, clinical partners, and staff.

Astym treatment safely, effectively and efficiently stimulates scar tissue to be resorbed by the body and regenerates damaged soft tissues. It is clearly superior in chronic conditions such as plantar fasciopathy, lateral epicondylopathy, chronic hamstring or groin injuries, tendinopathies and post-traumatic/post-surgical scarring — even when nothing else seems to work. It is also very effective on sprains, strains, and other acute and sub-acute soft tissue injuries. Some of the more common diagnoses that have demonstrated excellent clinical results when treated with the Astym approach are:

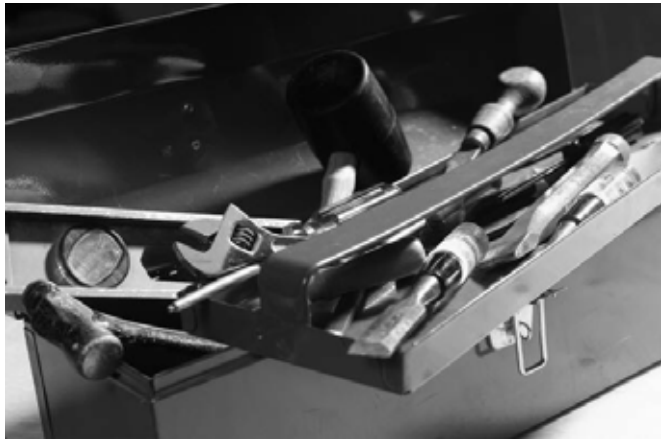
http://www.astym.com/Medical/About

Graston

IASTM has two main functions: to break up abnormal densities in tissue, such as scar tissue, and to reinitiate first-stage healing in the body. “When a body is injured, it sends blood, specifically the healing substances found in white blood cells, to the wounded area to begin laying down new collagen tissues and repairing the injury—building scar tissue,” says Dr. Heller. “IASTM is like a mild injury to the tissue which starts this process over again and helps the body to heal itself,” he adds. Tough scar tissue is essentially a “patch” at the site of an injury, helping it to heal, it is much less flexible than normal tissue. In the long run, scar tissue can cause restricted motion, which leads to pain when, for example, a patient with a sprained ankle tries to return to running. Typically, patients with soft-tissue injuries do not seek out a DC until the injuries have become chronic, usually months post-injury. By this point, the body has completed most of its self-healing process—scar tissue has built up, restricting motion—and it’s necessary for the DC to restart the curative process.

Lukacs. ACAnews. Sept. 2013.

IASTM Tools



- Astym® (Performance Dynamics, www.astym.com)
- Fibroblaster (Fibroblaster LLC, www.fibroblaster.com)
  - Jack
- Fuzion (Soft tissue therapy tools Inc., http://fuziontherapytools.com/)
- Graston (Therapy Care Resources Inc.,www.grastontechnique.com)
- Gua Sha
- SASTM (Carpal Therapy Inc. www.sastm.com)
- STARR Tool (www.starrtool.com)
- The Edge (http://www.themanualtherapist.com/p/for-sale-is-300-grade-stainless-steel.html)
- Hawk Grips (http://hawkgrips.com/)

Examples of IASTM tools

http://guashatools.com*

www.sastm.com*

the-edgetool.com*

www.starrtool.com*

Container lid

*with permissions

Aims of IASTM

- Assessment
  - Detect irregularities in the soft tissue texture through the undulation of the gliding tools. (Sevier TL, et al. *Sports Medicine.* 1999.)
- Treatment Effects
  - Biomechanical
  - Neurophysiological
  - Psychological

Proposed IASTM Treatment Effects

BioMechanical effects

- Stimulates healing and strengthens new collagen (www.astym.com)
- Break down scar tissue (including collagen cross links) and fascial restrictions (www.graston.com)
- Controlled microtrauma, increased fibroblasts (Davidson et al. *Med Sci Sports Exerc.* 1997.; Gehlsen et al. *Med Sci Sports Exerc.*1999.)
- Removal of blood and metabolic waste, promotes normal circulation and metabolic processes (Chiu et al. *J Nurs Research.* 2010.)

Observed responses to treatment

Bruising

petechiae

Petechiae

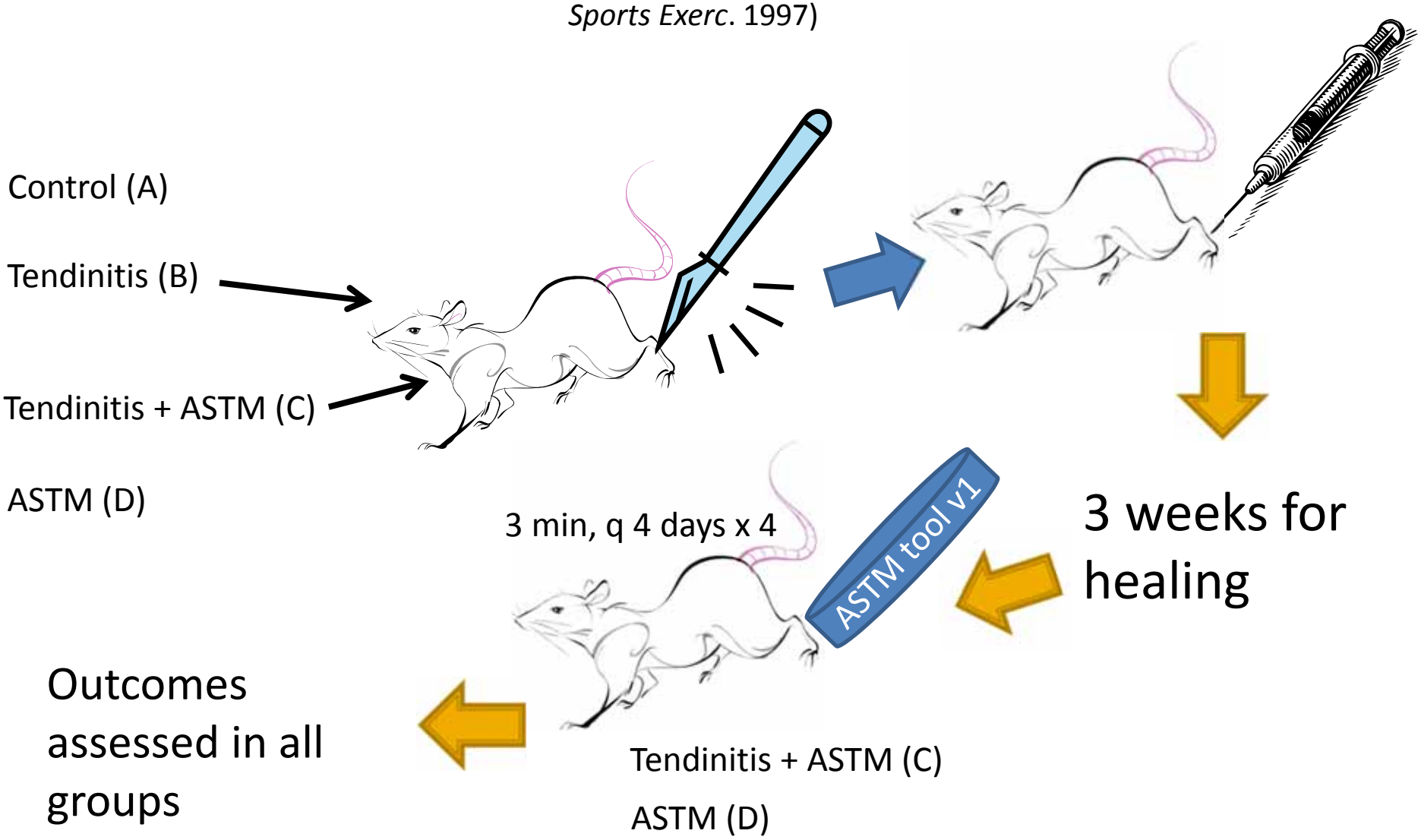
Lauche et al. *Am J Chin Med*. 2012

Biomechanical response to IASTM

- Rat tendon morphologic and functional changes resulting from soft tissue mobilization (Davidson et al. *Med Sci Sports Exerc*. 1997)
- Fibroblast response to variation in soft tissue mobilization pressure (Gehlsen et al. *Med Sci Sports Exerc*. 1999)
- Instrument assisted cross-fiber massage accelerates knee ligament healing (Loghmani & Warden. *J Orthop Sports Phys Ther*. 2009)

Rat tendon morphologic and functional changes resulting from soft tissue mobilization

(Davidson et al. *Med Sci Sports Exerc*. 1997)



Rat tendon morphologic and functional changes resulting from soft tissue mobilization (Davidson et al. *Med Sci Sports Exerc*. 1997)

- Increased fibroblast proliferation with ASTM in rats

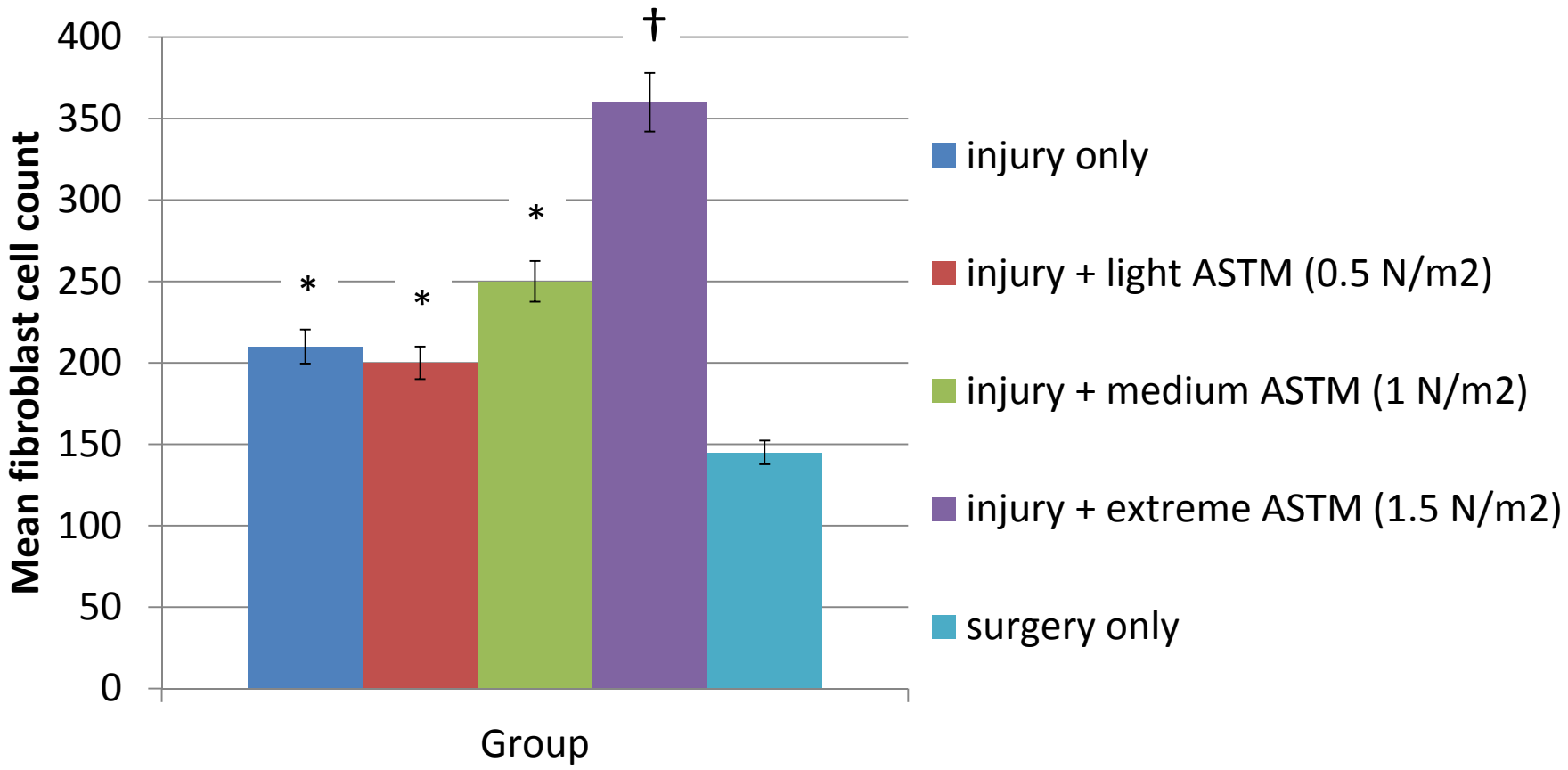
	Group	Fibroblast count
A	No injury + no ASTM	3±3
B	Injury + no ASTM	10±7*
C	Injury + ASTM	15±11*
D	No injury + ASTM	4±2

* Significant difference between injury + ASTM and all other groups….and injury + no ASTM and all other groups

- Increased stride length/decreased stride frequency

Fibroblast response to variation in soft tissue mobilization pressure (Gehlsen et al. *Med Sci Sports Exerc*. 1999)

ASTM= 3 strokes up, 3 down, q 4 days x 6



1 week after last rx: ~ 5-6 weeks post start of rx, 8-9 weeks after surgical injury

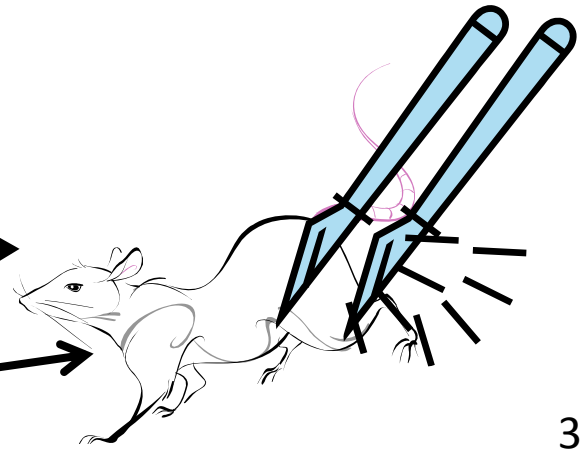
*Significantly different from group surgery only
†Significantly different from all other groups

Instrument assisted cross-fiber massage accelerates knee ligament healing (Loghmani & Warden. *J Orthop Sport Phys Ther*. 2009)

Non-injured Control

Injury + no Rx

Injury + IACFM



1 week for healing

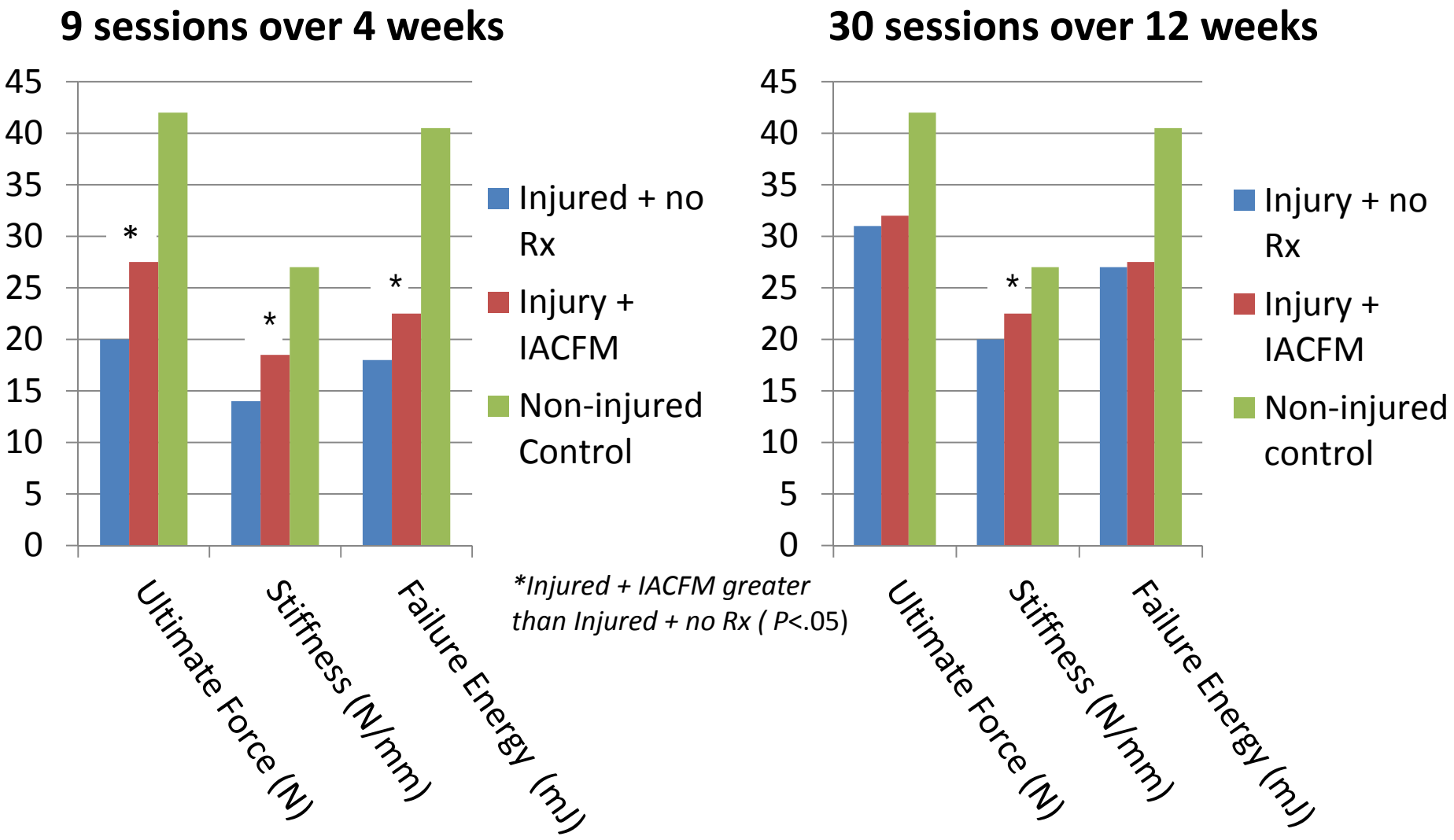
31: 1 min, 3x/wk x 3 wks
20: 1 min, 3x/wk x 10 wks

Injury + IACFM

Outcomes assessed in all groups

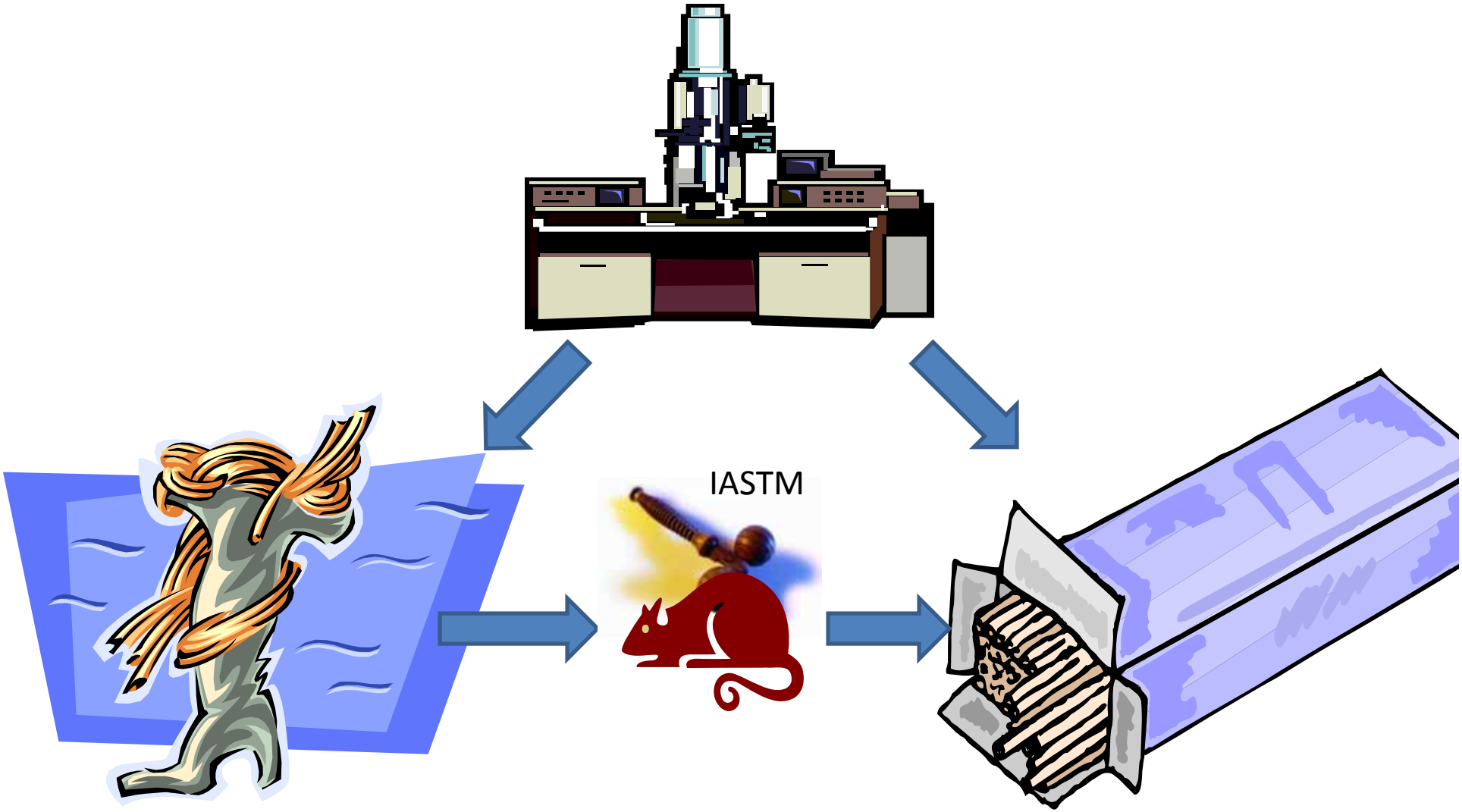
- 31: 4 wks post surgical injury
- 20: 12 wks post surgical injury

Instrument assisted cross-fiber massage accelerates knee ligament healing (Loghmani & Warden. *J Orthop Sport Phys Ther*. 2009)



**Injured + IACFM greater than Injured + no Rx (P<.05)*

Instrument assisted cross-fiber massage accelerates knee ligament healing (Loghmani & Warden. *J Orthop Sport Phys Ther*. 2009)



From the bench to the plinth

Can you alter healing of my injured Achilles/MCL using IASTM?

Yes, studies show….

Does that mean you can alter healing of my Achilles/MCL injury?

Chronic ankle pain and fibrosis successfully treated with ASTYM (Melham, et al. *Med Sci Sports Exerc*. 1998.)

- Rx: ASTYM (2x/wk x 7 weeks), ice stretching and a HEP
- Outcomes
  - ROM - improved in all directions
  - Pain – reduced from 6/10 to 0/10 with activity
  - NSAIDS – stopped use after treatment
  - MRI: baseline, 4 and 6 weeks post-treatment
    - Extensive scar formation – no change with treatment.
  - Photographs: before and after treatment
    - Scar maturation and reduced soft tissue

Proposed IASTM Treatment Effects

Neuropysiological effects

- Alteration of the pain experience - hypoalgesia
- Sympathetic response: blood flow, skin temperature
- Peripheral inflammatory mediators
- Muscle reflexogenic

Bialosky et al. *Man Ther.* 2009.

Proposed IASTM Treatment Effects

Psychological effects

- Neuropsychological
  - Desire for pain relief
  - Pt. expectations (Bialosky et al. *BMC Musculoskelet Disord.* 2008)
  - Psychosocial context of treatment (context bias)
  - Fear, avoidance, catastrophization, kinesiophobia?
- Placebo effect (George and Robinson, *J Orthop Sports Phys Ther.* 2010)
  - Complex and dynamic
    - neurophysiological
    - neuropsychological
  - Study design with 3 arms (active treatment, placebo, control)

Contraindications

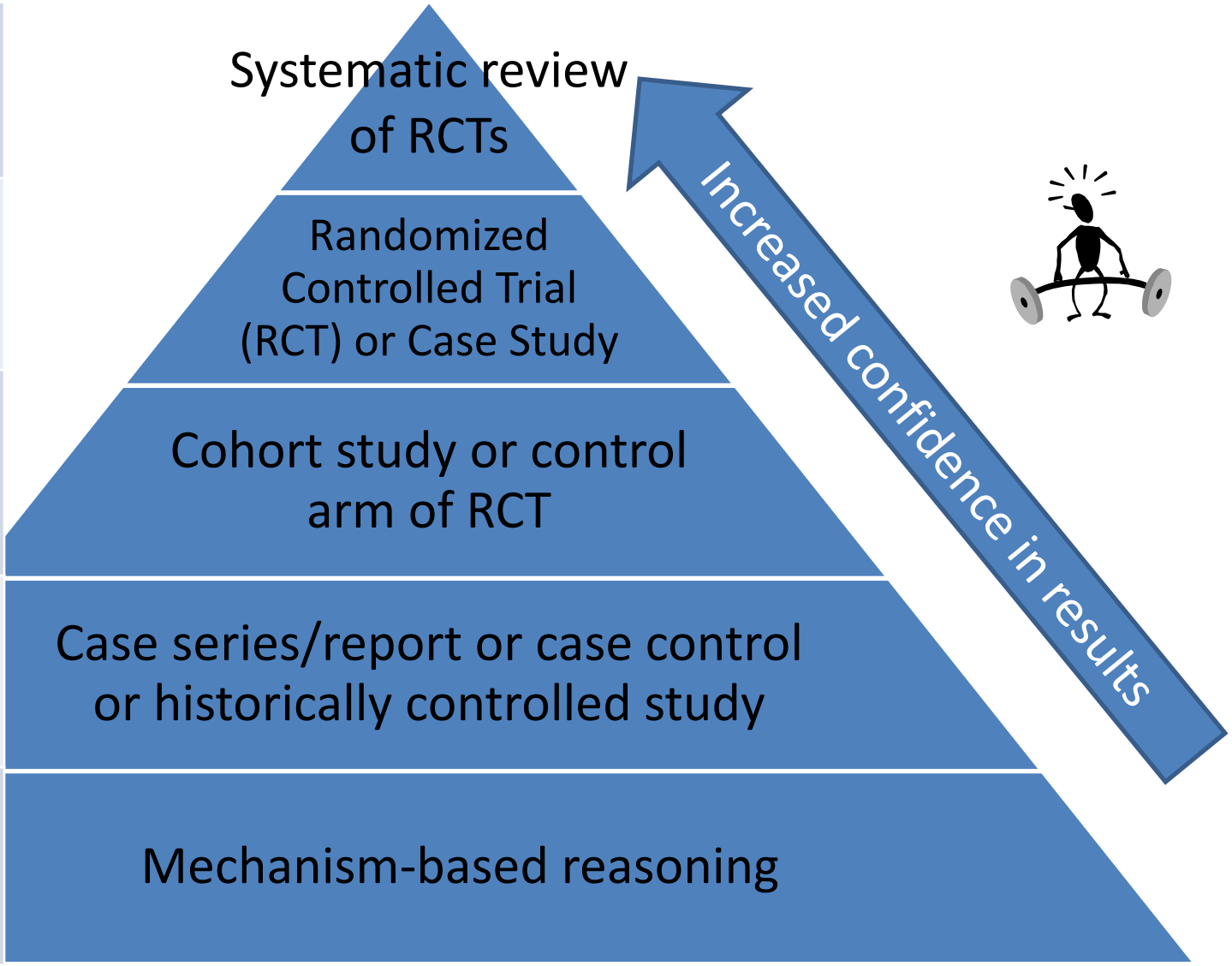
- Compromised tissue integrity (open wound, infection, tumor)
- Active implants (pacemaker, internal defibrillator, picc/pump lines)
- DVT
- Cervical carotid sinus

Precautions

- Bleeding disorders
- Inflammatory/irritable conditions (RA, lupus, Fibromyalgia, Complex Regional Pain Syndrome
- Cancer
- Pregnancy
- Psychological state

Hierarchy of Evidence:

Number of IASTM studies *	
Level 1: L1	0
Level 2: L 2	8
Level 3: L 3	0
Level 4: L 4	31
Level 5: L 5	5-?



*as of September 2013

www.cebm.net

Studies per condition using IASTM

	Total	RCT/n=1	Case Series	Case Report
Lateral/Medial epicondylalgia	4	1		3
Plantar heel pain/PTTD	4		1	3
Carpal tunnel syndrome	2	1		1
Patellar tendinopathy/ TKA/ACLR	7	2	1	4
Mastectomy/Breast engorgement	2	1	1	
Neck Pain	2	2		
Chronic ankle sprain/pain	3	1		2
Acute PTTD	1			1
Costochondropathy/Pec strain	2			2
LBP	3	1		2
Trigger thumb/Dupuytren's	3			3
Proximal HS tendinopathy	2		1	1
Achilles tendinopathy/Calf pain	5			5
Shoulder tendinopathy	1			1

Effectiveness of traditional Chinese Gua sha therapy in patients with chronic neck pain: a randomized controlled trial (Braun et al. *Pain Medicine*. 2011.)

L 2

48 volunteers with neck pain >30mm VAS and reported cervical restriction x 3 mo without surgery, neuro signs, excessive med use, treatment in the last mo or ever had Gua Sha or Ginger heat pad treatment

Container lid

Randomized

Gua sha to upper back and entire neck (N=24)

Heat pad for 15-20 minwith Ginger and education that Ginger shows promising effects in chronic neck pain (N=24)

1 week outcomes: Avg neck pain in past week and related to movement (VAS), NDI, SF-36

21 completed, 24 analyzed

23 completed, 24 analyzed

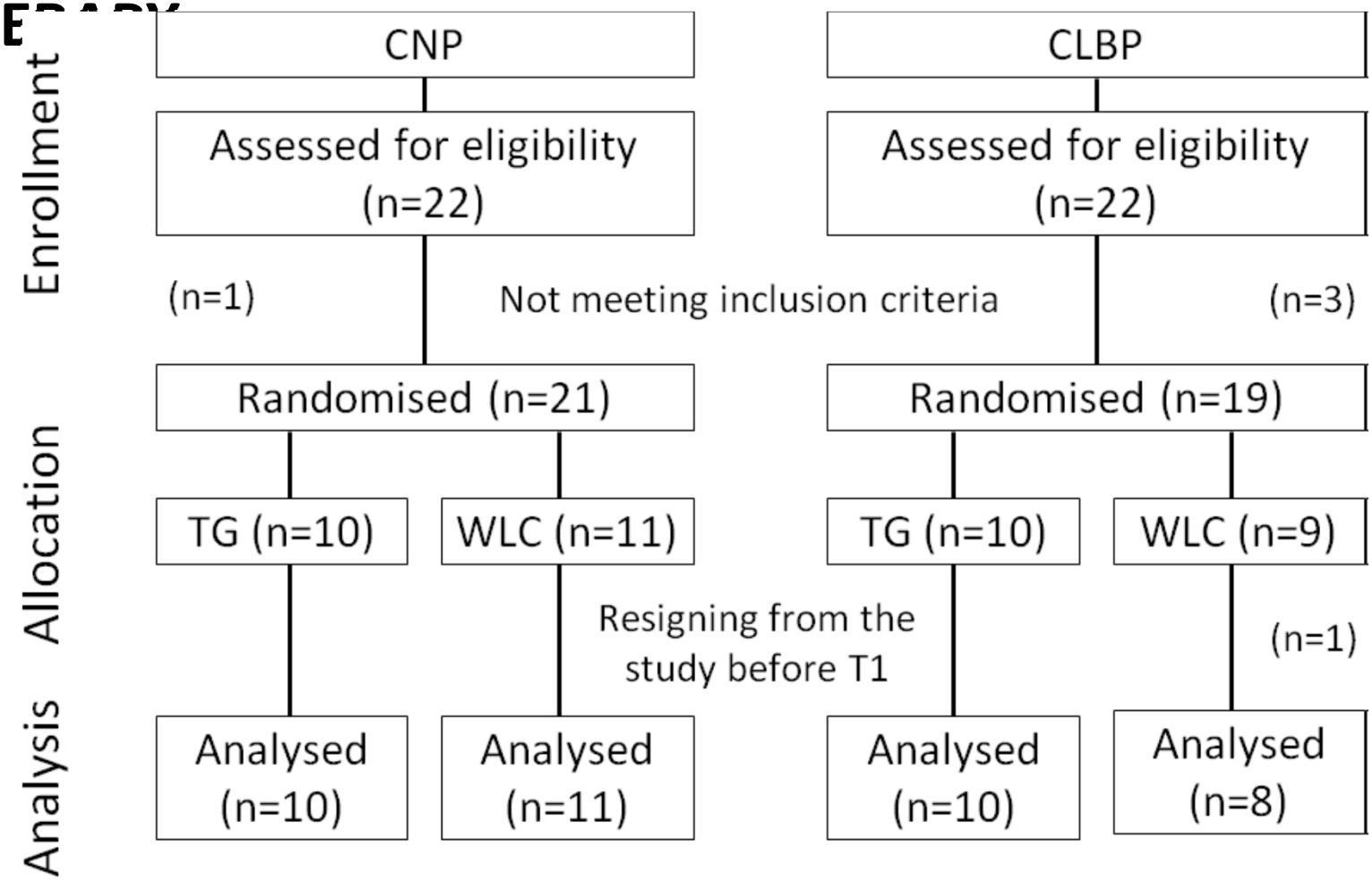
Effectiveness of traditional Chinese Gua sha therapy in patients with chronic neck pain: a randomized controlled trial (Braun et al. *Pain Medicine*. 2011.)

	NDI		Mean pain with motion		Max pain with motion	
	Gua sha	Thermal	Gua sha	Thermal	Gua sha	Thermal
Baseline	32.8	35.6	50.6	51.0	67.8	68.3
Post-Rx	-	-	29.2	45.7	44.1	60.1
7d post-Rx	21.8	32.8	24.7	47.1	36.4	60.3
Group diff baseline to 7d post-Rx	-8.5 (-13.6, -3.5)*		-23.5 (-34.5, -12.5)*		-19.1 (-31.7, -6.6)*	

*p<.003). NDI MCID = 10 points (Young et al. *Spine*. 2009). VAS MCID: If baseline 50-65 mm, then 19-27 mm. If baseline >65 mm, then 29-37 mm (Stauffer, *Inj J Inflam.* 2011).

- SF-36: Gua sha resulted in greater physical function by 4.2 pts (95% CI 7.1, 1.4) and social function by 6.5 (95% CI 12.4, 0.7). No difference in vitality, general health perception and mental health.
- Greater satisfaction with Gua sha
- Higher outcome expectation not associated with outcome

RANDOMIZED CONTROLLED PILOT STUDY: PAIN INTENSITY AND PRESSURE PAIN THRESHOLDS IN PATIENTS WITH NECK AND LOW BACK PAIN BEFORE AND AFTER TRADITIONAL EAST ASIAN "GUA SHA" THERAPY



Results

- Measures taken 1 week later

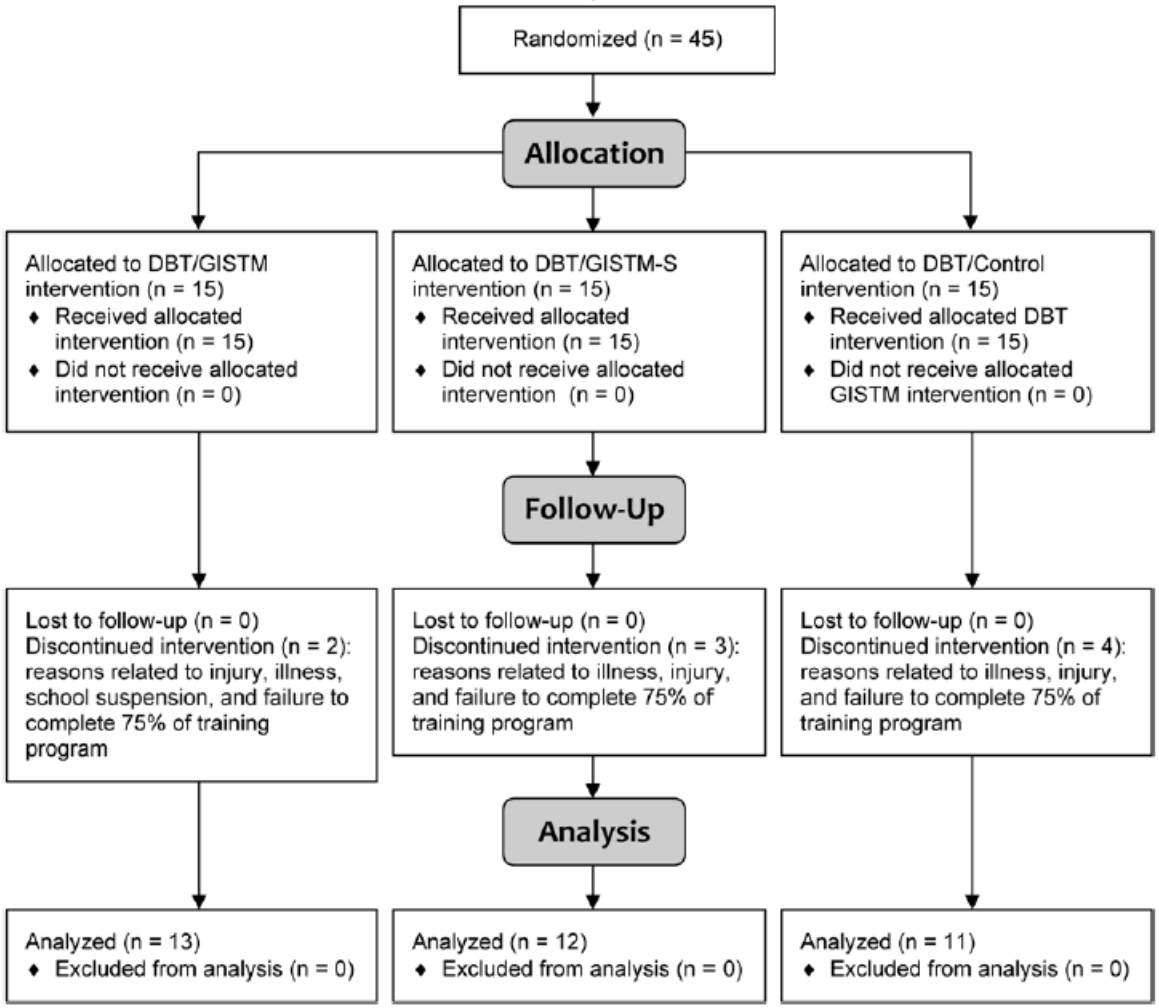
Table 2. Outcome Measures and Estimated Group Differences from ANCOVA at T2 for Each Group

	CNP					
	TG		WLC		Group Difference* at T2 (95% CI)	*p*
	T1	T2	T1	T2		
Pain at Rest (VAS)	4.3 ± 1.7	3.0 ± 2.2	5.2 ± 1.6	5.1 ± 1.4	−1.6 (−3.0 to −0.1)	0.045
PPT at Pain-Maximum	2.38 ± 0.26	2.46 ± 0.13	2.40 ± 0.19	2.34 ± 0.16	0.13 (0.04 to 0.22)	0.01
PPT at Pain-Adjacent	2.41 ± 0.23	2.50 ± 0.09	2.43 ± 0.17	2.36 ± 0.17	0.15 (0.06 to 0.24)	0.01

Note: *Group differences and *p* values from an ANCOVA model with two groups and baseline values as covariate.

	CLBP					
	TG		WLC		Group Difference* at T2 (95% CI)	*p*
	T1	T2	T1	T2		
	3.4 ± 2.4	2.1 ± 1.9	3.3 ± 2.1	3.1 ± 2.4	−1.1 (−2.0 to −0.2)	0.03
	2.56 ± 0.16	2.56 ± 0.15	2.52 ± 0.26	2.50 ± 0.28	0.02 (−0.08 to 0.12)	0.64
	2.52 ± 0.17	2.52 ± 0.17	2.55 ± 0.19	2.48 ± 0.22	0.07 (−0.01 to 0.15)	0.11

EFFECTS OF A 4-WEEK DYNAMIC-BALANCE-TRAINING PROGRAM SUPPLEMENTED WITH GRASTON INSTRUMENT-ASSISTED SOFT-TISSUE MOBILIZATION FOR CHRONIC ANKLE INSTABILITY (SCHAEFER & SANDREY. J SPORT REHABIL. 2012)



GISTM Treatment

Table 1 Graston Instrument-Assisted Soft-Tissue Mobilization

Graston-technique instrument	Patient position	Strokes and anatomical area
GT4, GT5, knob of GT2 or GT3 (Figure 4)	Prone, foot over end of table. Add active plantar flexion and dorsiflexion range of motion. Release restrictions if found.	Sweep plantar fascia and gastrocnemius/soleus. Sweep heel pad, metatarsals, calcaneal insertion. Localize restrictions within gastrocnemius/soleus and Achilles. Mobilize soft tissue on medial and lateral side between Achilles and fibula. Mobilize fascia from calcaneus → metatarsal head and back.
GT4, GT5, knob of GT2 or GT3 (Figure 5)	Supine, foot over end of table. Add passive ankle and first toe range of motion. Release restrictions if found.	Sweep dorsum of foot→ anterior tibialis → sweep between toes. Sweep dorsum of foot and anterior tibialis to isolate restrictions. Frame medial and lateral malleoli. Sweep first and fifth metatarsals. Mobilize soft tissue of talocrural and distal tibia/fibula joint. Sweep up and down medial and lateral aspect of tibia.
GT2, GT3, GT4	Side-lying with pillow between knees.	Sweep peroneals. If restrictions found, use strum, fan, or J-stroke as needed.

Results – No B/w group differences

L 2

Table 3 Mean Difference and MCID/MDC Values for All Dependent Variables

Outcome	DBT/Control group mean difference	DBT/GISTM-S group mean difference	DBT/GISTM group mean difference	MCID/MDC
FAAM %	11.2[a]	10.5[a]	9.5[a]	8.0
FAAM Sport %	13.6[a]	23.7[a]	22.4[a]	9.0
Visual analog scale	1.9	1.8	1.4	2.0
Range of motion, °				
dorsiflexion	2.8[b]	2.2[b]	4.2[b]	2.0
plantar flexion	1.2	4.4	6.9[b]	5.6
inversion	0.5	0.5	3.8[b]	2.3
eversion	1.3[b]	1.5[b]	1.2[b]	1.0
SEBT				
anterior	5.5[b]	7.9[b]	12.8[b]	4.9
posteromedial	5.5[b]	3.8	10.2[b]	5.2
posterolateral	7.1[b]	8.3[b]	7.2[b]	5.4

Key: MCID, minimal clinically important difference; MDC, minimal detectable change; DBT, dynamic-balance training; GISTM, Graston instrument-assisted soft-tissue mobilization; FAAM, Foot and Ankle Ability Measure; SEBT, Star Excursion Balance Test (normalized reach distances).

[a] Exceeded MCID. [b] Exceeded MDC.

Study underpowered – Type II error – 300 subjects needed

Augmented soft tissue mobilization vs natural history in the treatment of lateral epicondylitis: a pilot study

(Blanchette & Normand. *J Manipulative Physiol Ther*. 2011)

L 2

30 volunteers with unilateral LE and without CTS, radiculopathy, or injection w/i 30 d

Randomized

GISTM 2x/wk x 5 wks
N=15

Control: Education about pathology, ergonomics; wrist flex/ext stretchs 6x/d; medication. 1 time session + handout
N=15

6 week outcomes (examiner not blinded): PRTEE, VAS, PFG

12 analyzed

15 analyzed (*avg onset of LE 43 mo vs 22)

Augmented soft tissue mobilization vs natural history in the treatment of lateral epicondylitis: a pilot study

(Blanchette & Normand. *J Manipulative Physiol Ther*. 2011)

- No statistically significant differences between groups in PRTEE, VAS, and PFG
- Sample estimation for power= 0.8, 58 in each group

	PRTEE		VAS		PFG	
	GISTM	Control	GISTM	Control	GISTM	Control
Baseline	37	30	46	39	25	26
6 wk	15*	25	16*	21	27*	28†
3 mo	16*	17†	17*	21†	-	-

* † p<.05 compared to baseline for the respective group

Underpowered – Type II error

A PILOT STUDY COMPARING TWO MANUAL THERAPY INTERVENTIONS FOR CARPAL TUNNEL SYNDROME (Burke et al. *J Man Manip Ther*. 2007)

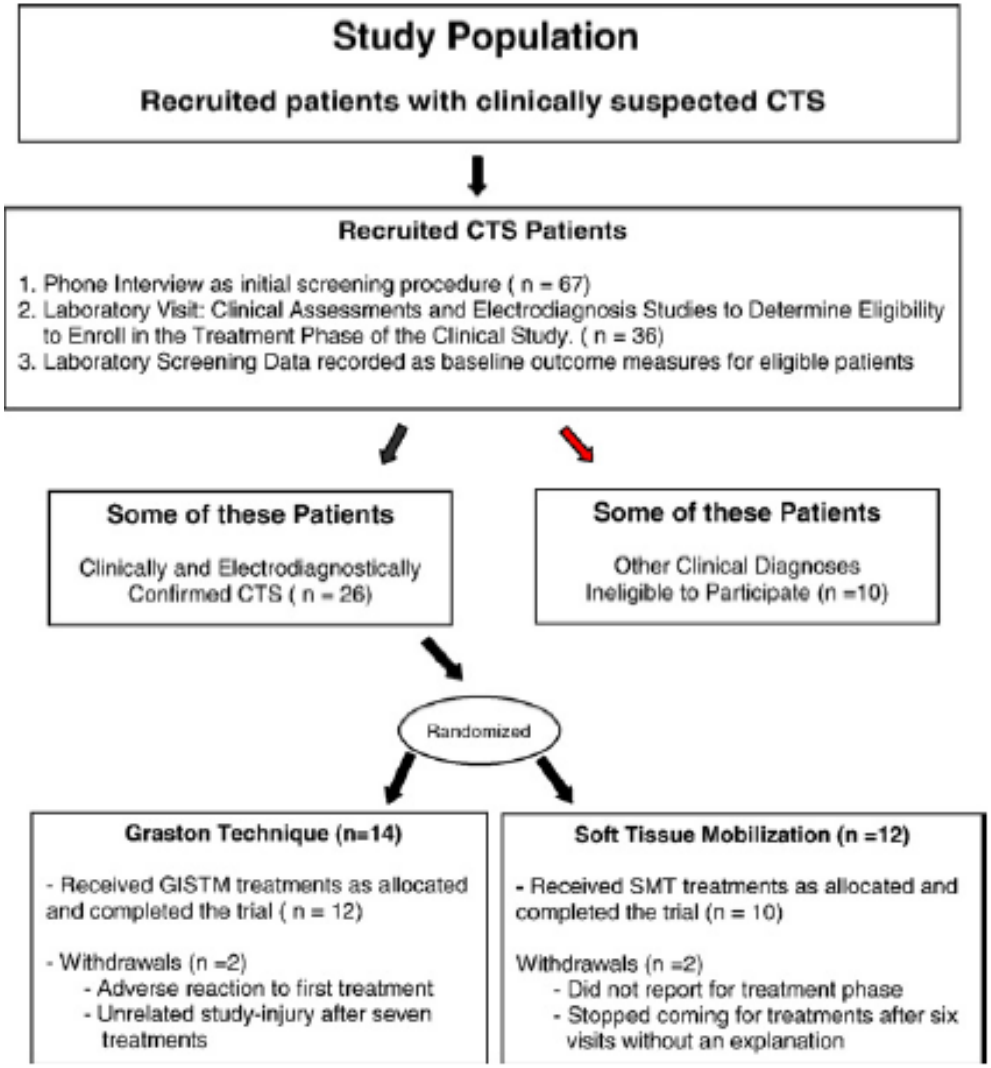
Warm up

GISTM or STM

Stretch

Strengthen

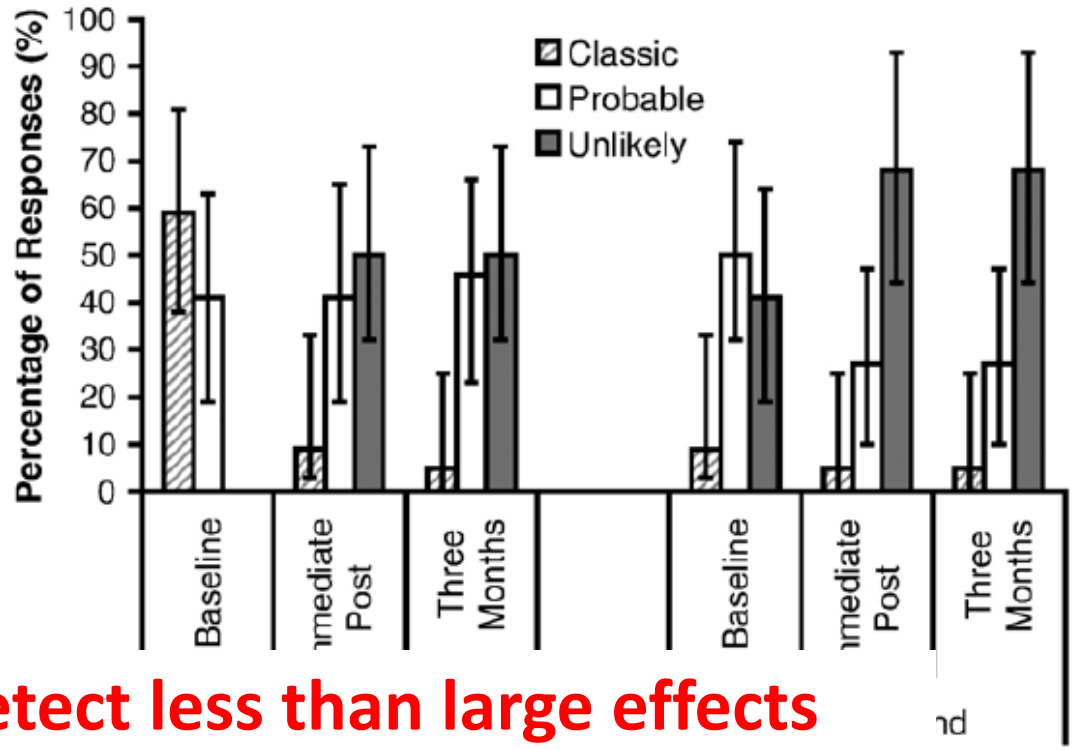
Ice



Outcome Measures

- Median nn sensory and motor NCT
- Self-reported
  - Pain
  - Function
  - Severity
- Phys exam signs

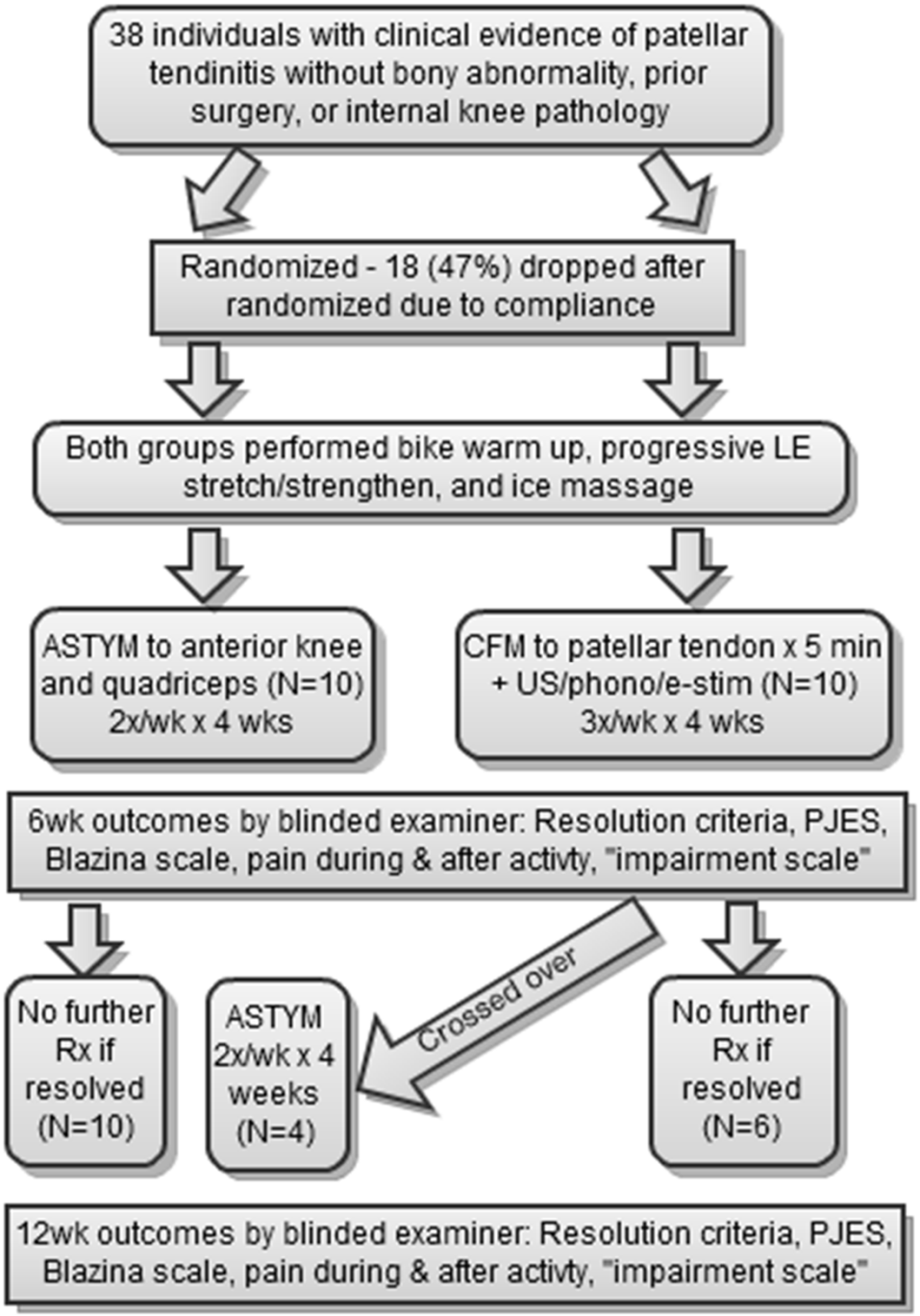
Both groups improved in the Katz diagram indicating patterns of symptoms likely to be associated with CTS



Not powered to detect less than large effects

Outcome Measure	Differences b/w groups (statistical or clinically-meaningful)?
Distal motor latency	No
Distal sensory latency	No
VAS pain (0-100 mm)	Yes, GISTM -24.5 (95% CI -5.7, -43.26)*
Wrist ROM	No
Grip or Pinch Strength	No

*VAS MCID: If baseline 50-65 mm, then 19-27 mm. If baseline >65 mm, then 29-37 mm (Stauffer, *Inj J Inflam.* 2011).



Comparison of rehabilitation methods in the treatment of patellar tendinitis

(Wilson et al. *J Sport Rehabil*. 2000)

L 2

L 2

Comparison of rehabilitation methods in the treatment of patellar tendinitis (Wilson et al. *J Sport Rehabil*. 2000)

	ASTYM (N=10 + 4 crossover)			"Traditional" (N=10)		
	Baseline	6 wks	12 wks	Baseline	6 wks	12 wks
Resolution*	-	10	10 (2/4 crossover)	-	6	6
PJES (x/100)	74	85	91	61	89	90
Blazina	2.0	1.1	1.0 (2.3 crossover)	2.4	2.4	1.0

- Greater percentage improvement in "impairment scale" in ASTYM group (p=.04)
- Pain values not provided: ASTYM group improved from baseline to 6 & 12 weeks (p<.05), traditional group not significant

Underpowered

*Resolution criteria: 1) no swelling, 2) no pain with palpation, 3) <3/10 pain with single leg hop, squat to thigh parallel, eccentric step down

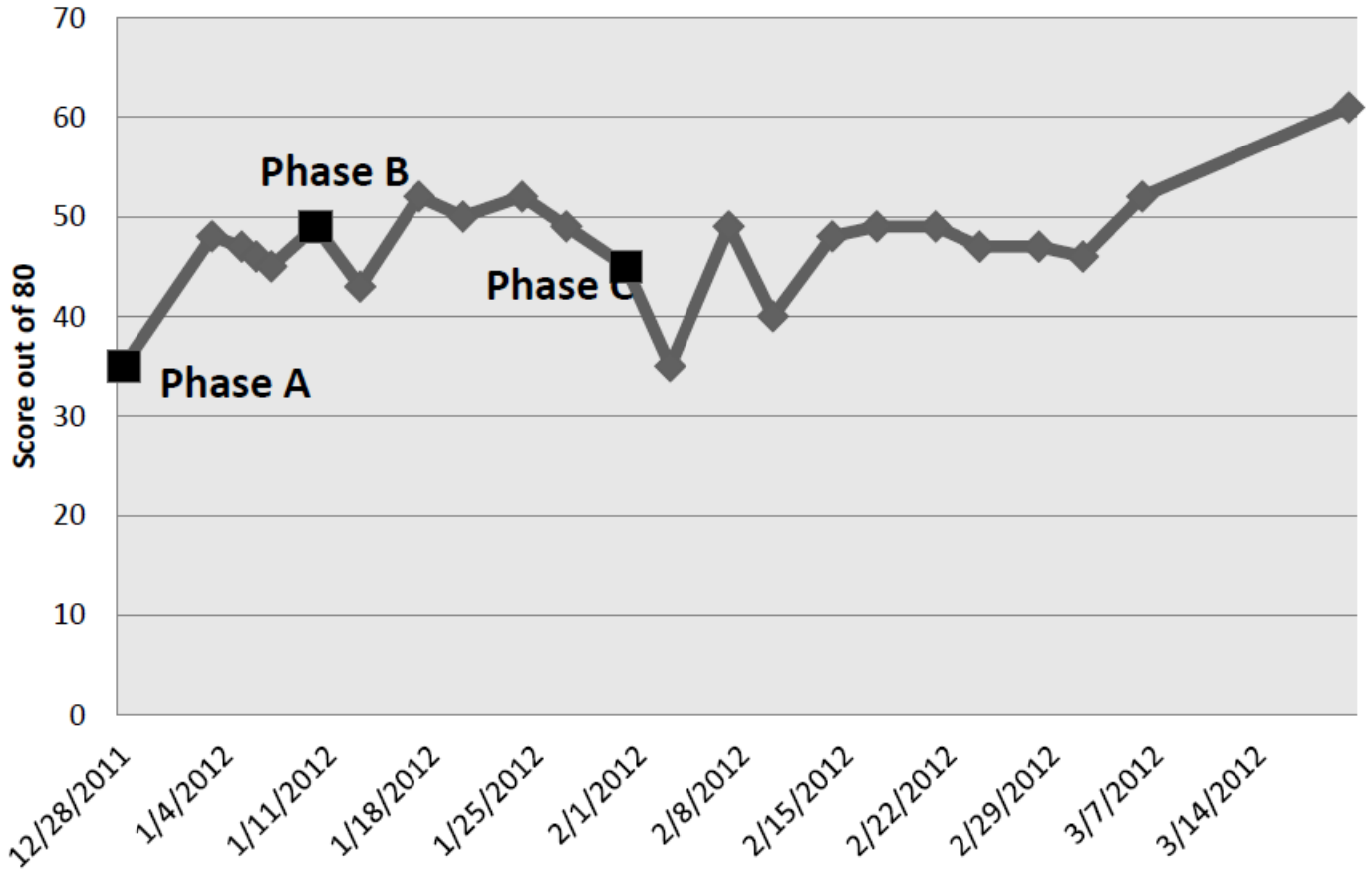
The Role of the Astym® Process in the Management of Osteoarthritis of the Knee: A Single-Subject Research Design (Tyler & Slaven. *J Stud Phys Ther Res*. 2013)

L 2

- 61 y/o male with knee OA and pain x 18 mo
- Outcome Measures: 10 m walk test, LEFS, VAS

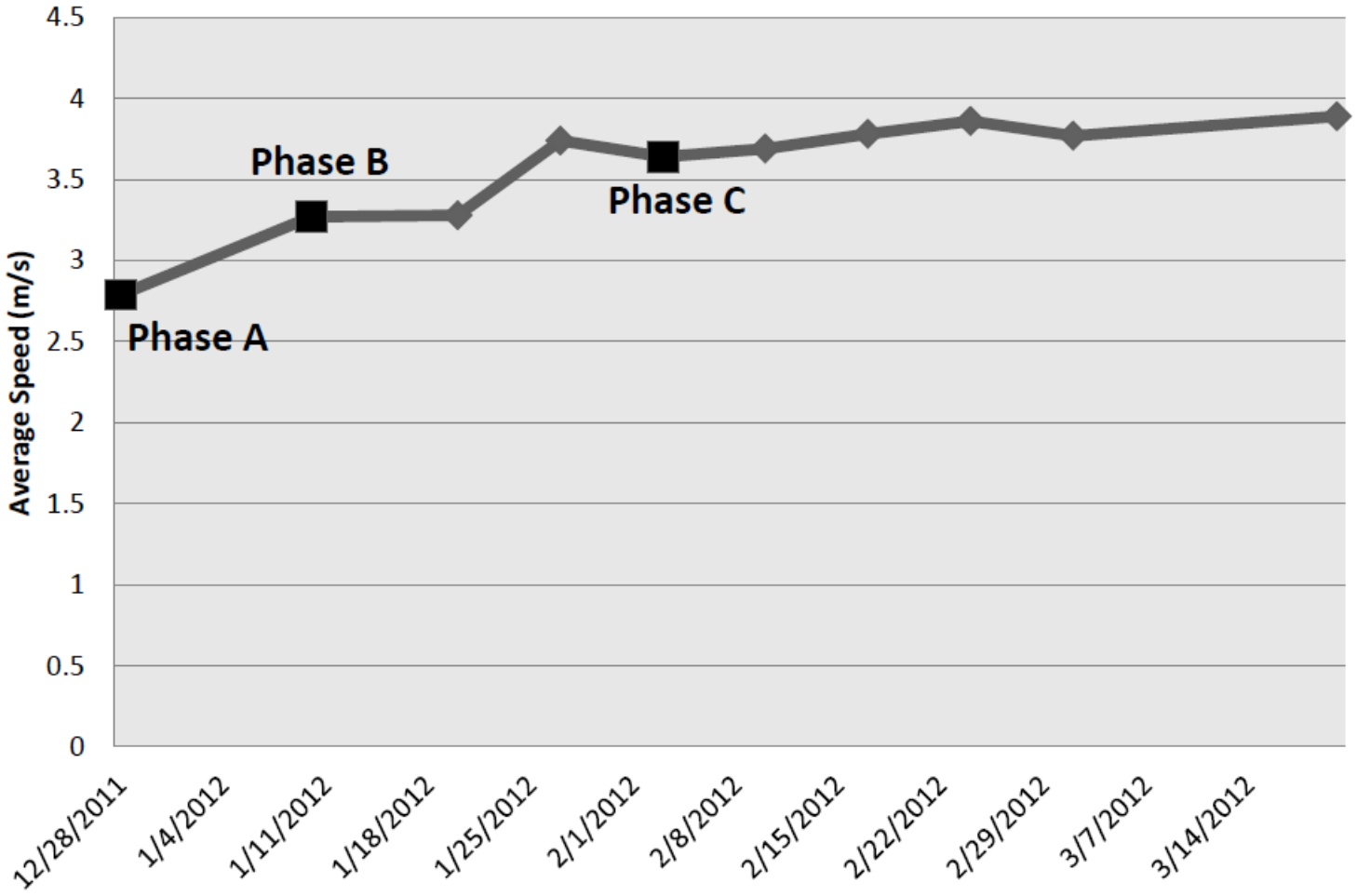
Results - LEFS

Figure 3. Participant responses on the Lower Extremity Functional Scale (LEFS).



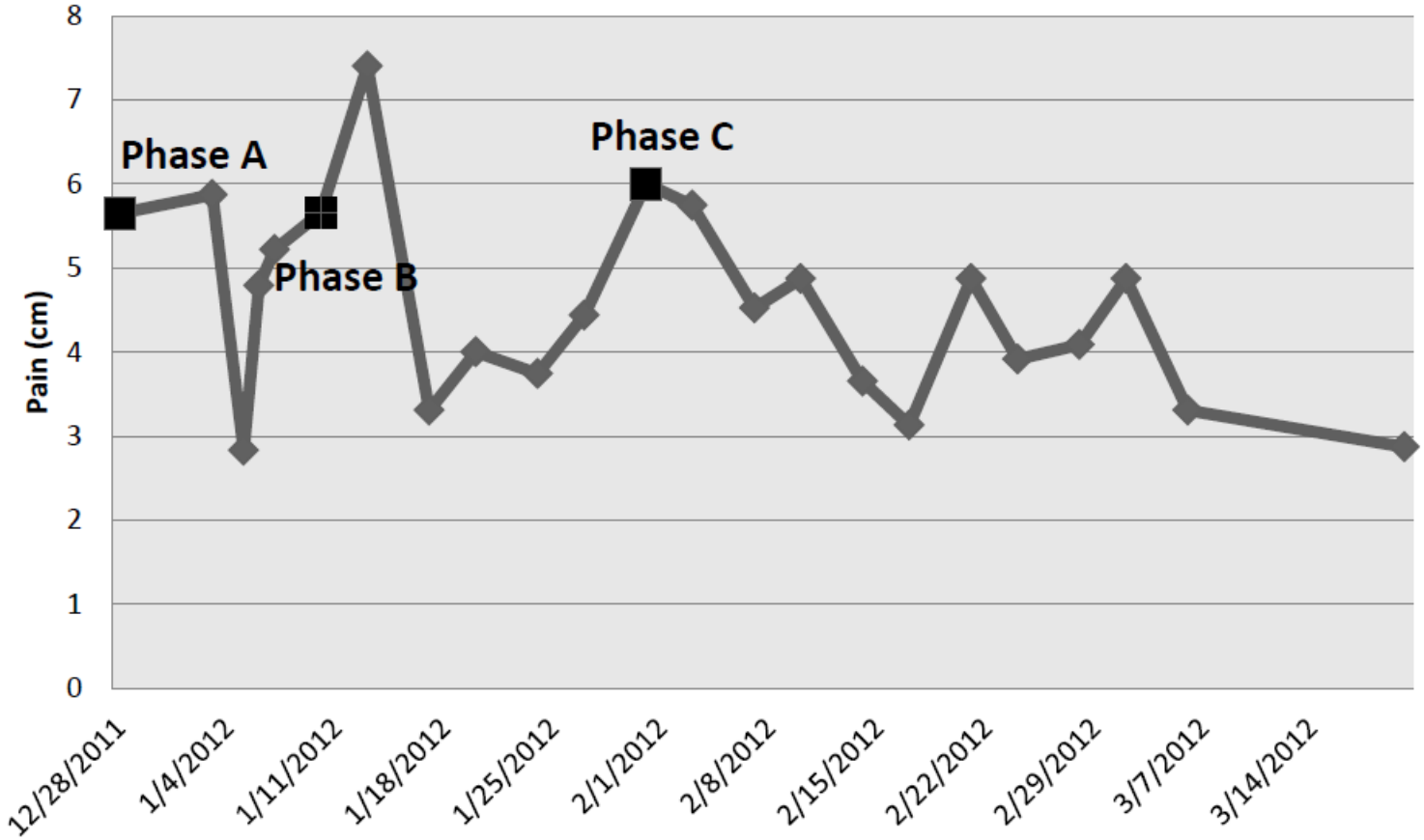
Results – 10 m walk test

Figure 4. Participant's walking speed measured by the 10-Minute Walk Test (10MWT) – Fast.



Results - VAS

Figure 5. Participant's pain rating per Visual Analog Scale (VAS).



Is there more evidence out there?

- Other studies lacking details (e.g. tool/instrument usage)
  - "aggressive soft tissue mobilization" (Cleland, et al. *J Orthop Sports Phys Ther.* 2009)
  - "transverse friction massage" (Mayer et al. *Br J Sports Med*. 2007)
- Language/terminology problem?

More to come…

Comparison Study of Two Chiropractic Treatment Protocols for Knee Pain Due to Patellofemoral Pain Syndrome

Condition: Patellofemoral Pain Syndrome

Interventions: Procedure: chiropractic manipulative therapy; Procedure: knee exercises; Procedure: Graston Instrument Soft Tissue Mobilization (GISTM)

Astym® Compared Eccentric Exercise for Chronic Mid-substance Achilles Tendinopathy

Condition: Achilles Tendon Pain

Intervention: Procedure: Astym

Does the Addition of Manual Therapy Techniques Increase Gastrocnemius/Soleus Length More Than Stretching Alone?

Condition: Muscle Tightness

Interventions: Procedure: Instrument Assisted Soft Tissue Mobilization; Procedure: Rearfoot joint mobilization; Other: Static stretching/ROM exercises

Treatment Parameters

	RCT	Case Series	Case Studies
Number of visits	1-10	3-15	5-16
Treatment frequency & duration	2x/wk x 4-5 wks; 1x/wk x additional 2 wks	1-2x/wk, 2-32 wks	1x/wk – 3 x/wk, 3–8 wks
IASTM Intervention duration	?, 2-30 min	1-2 min/area, 15 min total	30-60 s bouts, 5-10 minutes
Concurrent treatment	None - exercise (stretch/strengthen); ice	Exercise, ice, MLD, HVLA	Exercise, ice, heat jt. mob, HVLA, e-stim, US, ART, kinesiotape

Conclusions

- IASTM use is trending
- Evidence in infancy (8 RCTs, mostly lower quality)
  - Lots of case reports
  - Effects of IASTM (from RCTs)
    - 1 session of Gua Sha may decrease pain and function ≥ MCID for neck pain compared to moist heat or no treatment
    - Limited studies demonstrating clinically meaningful changes due to IASTM
      - Poor quality or **low power** in most studies
    - More comparative effectiveness trials needed
  - IASTM may affect soft tissue healing (fibroblast counts, tissue strength) in the short term
- Interdependence
  - Intervention
  - Regional
- Additional considerations: Clinician's experience & Patient's preferences

Questions

- Tool vs. no-tool?
- Does the type of tool matter?
- Who is most likely to benefit?
- Does the intent (i.e. treatment paradigm) matter?
- How much pressure?
  - Different pathology (MLD vs tendinopathy)
- Recurrence/retention/histology?
- Patient preference/expectations?

Thank you!

References

- Aspegren, D., Hyde, T., & Miller, M. (2007). Conservative treatment of a female collegiate volleyball player with costochondritis. *J Manipulative Physiol Ther, 30*(4), 321-325. doi: S0161-4754(07)00075-9 [pii]
- Baker, D., & Wilson, J. (1999). Bilateral carpal tunnel syndrome in a piano teacher. P*hysical Therapy Case Reports, 2(*2), 73-76.
- Bialosky, J.E., Bishop, M.D., Price, D.D., Robinson, M.E., George, S.Z. (2008). The mechanisms of manual therapy in the treatment of musculoskeletal pain: a comprehensive model. *Man Ther*, 14(5), 531-538.
- Bialosky, J.E., Bishop, M.D., Robinson, M.E., Barabas, J.A., George, S.Z. (2008). The influence of expectation on spinal manipulation induced hypoalgesia: an experiemental study in normal subjects. *BMC Musculoskelet Disord,* 11, 9-19.
- Black, D. W. (2010). Treatment of knee arthrofibrosis and quadriceps insufficiency after patellar tendon repair: a case report including use of the graston technique. I*nt J Ther Massage Bodywork, 3(*2), 14-21.
- Blanchette, M. A., & Normand, M. C. (2011). Augmented soft tissue mobilization vs natural history in the treatment of lateral epicondylitis: a pilot study. *J Manipulative Physiol Ther, 34(*2), 123-130. doi: S0161-4754(10)00332-5 [pii]
- Braun, M., Schwickert, M., Nielsen, A., Brunnhuber, S., Dobos, G., Musial, F., Michalsen, A. (2011). Effectiveness of traditional Chinese "gua sha" therapy in patients with chronic neck pain: a randomized controlled trial. Pa*in Med, 12(3*), 362-369. doi: 10.1111/j.1526-4637.2011.01053.x
- Burke, J., Buchberger, D. J., Carey-Loghmani, M. T., Dougherty, P. E., Greco, D. S., & Dishman, J. D. (2007). A pilot study comparing two manual therapy interventions for carpal tunnel syndrome. *J Manipulative Physiol Ther, 30(1*), 50-61. doi: S0161-4754(06)00313-7 [pii]
- Chiu, J. Y., Gau, M. L., Kuo, S. Y., Chang, Y. H., Kuo, S. C., & Tu, H. C. (2010). Effects of Gua-Sha therapy on breast engorgement: a randomized controlled trial. *J Nurs Res, 18(1)*, 1-10. doi: 00134372-201003000-00003 [pii]
- Cleland, J.A., Abbott, J.H., Kidd, M.O., Stockwell, S., Cheney, S., Gerrard, D.F., Flynn, T.W. (2009). Manual physical therapy and exercise versus electrophysical agents and exercise in the management of plantar heel pain: a multicenter randomized clinical trial. *J Orthop Sports Phys Ther,* 39(8):673-585.
- Davidson, C. J., Ganion, L. R., Gehlsen, G. M., Verhoestra, B., Roepke, J. E., & Sevier, T. L. (1997). Rat tendon morphologic and functional changes resulting from soft tissue mobilization. Med *Sci Sports Exerc, 29(3),* 313-319.
- Davies, C., & Brockopp, D. (2010). Use of ASTYM treatment on scar tissue following surgical treatment for breast

References (cont.)

- Gehlsen, G. M., Ganion, L. R., & Helfst, R. (1999). Fibroblast responses to variation in soft tissue mobilization pressure. Med *Sci Sports Exerc, 31(4),* 531-535.
- George, S.Z., & Robinson, M.E. (2010). Dynamic nature of the placebo response. *J Orthop Sports Phys Ther.* 40(8), 452-454.
- Haller, K., Helfst, R., Wilson JK, & TL, S. (1999). Treatment of chronic elbow pain. Phys*ical Therapy Case Reports, 2(5),* 195-200.
- Hammer, W. I., & Pfefer, M. T. (2005). Treatment of a case of subacute lumbar compartment syndrome using the Graston technique. J Ma*nipulative Physiol Ther, 28(3),* 199-204. doi: S0161475405000540 [pii]
- Henry, P., Panitz, B., & Wilson, J. (2000). Rehabilitation of a post-surgical patella fracure: a case study. Physi*otherapy, 86(3),* 139-142.
- Henry, P., Panwitz, B., & Wilson, J. (1999). Treatment of a bilateral total knee replacement using ASTYM. Physi*cal Therapy Case Reports, 2(1),* 27-30.
- Howitt, S., Jung, S., & Hammonds, N. (2009). Conservative treatment of a tibialis posterior strain in a novice triathlete: a case report. J Can *Chiropr Assoc, 53(1),* 23-31.
- Howitt, S., Wong, J., & Zabukovec, S. (2006). The conservative treatment of Trigger thumb using Graston Techniques and Active Release Techniques. J Can *Chiropr Assoc, 50(4),* 249-254.
- Loghmani, M. T., & Warden, S. J. (2009). Instrument-assisted cross-fiber massage accelerates knee ligament healing. J Ort*hop Sports Phys Ther, 39(7),* 506-514. doi: 2308 [pii]
- Looney, B., Srokose, T., Fernández-de-las-Peñas, C., & Cleland, J. A. (2011). Graston instrument soft tissue mobilization and home stretching for the management of plantar heel pain: a case series. *J Manipulative Physiol Ther, 34(2), 1*38-142. doi: S0161-4754(10)00334-9 [pii]
- Mayer, F., Hirschmuller, A., Schuberth, M. Baur, H. (2007) Effects of short-term treatment strategies over 4 weeks in Achilles tendinopathy. *Br J Sports Med*, 41(7):e6.
- McCrea, E., & George, S. (2010). Outcomes following augmented soft tissue mobilization for patients with knee pain: a case series. *Orthop Phys Ther Pract, 22(2), 69*-74.

References (cont.)

- Melham, T. J., Sevier, T. L., Malnofski, M. J., Wilson, J. K., & Helfst, R. H. (1998). Chronic ankle pain and fibrosis successfully treated with a new noninvasive augmented soft tissue mobilization technique (ASTM): a case report. Med Sci *Sports Exerc, 30(6), 80*1-804.
- Mintken, P. E., DeRosa, C., Little, T., Smith, B., & American Academy of Orthopaedic Manual Physical, T. (2008). AAOMPT clinical guidelines: A model for standardizing manipulation terminology in physical therapy practice. J Ort*hop Sports Phys Ther, 38(3), A1*-6.
- Sevier T.L., Wilson, J.K. (1999). Treating lateral epicondylitis. *Sports Med,* 28(5), 375-380.
- Slaven, E., & J, M. (2011). Management of chronic ankle pain using joint mobilization and ASTYM treatment: a case report. J *Man Manip Ther, 19(2), 10*8-112.
- Stauffer, M.E., Taylor, S.D., Watson, D.J., Peloso, P.M., Morrison. A. (2011). Definition of nonresponse to analgesic treatment of arthritic pain: an analytical literature review of the smallest detectable difference, the minimal detectable change, and the minimal clinically important difference on the pain visual analog scale. Int J Inflam, doi:10.4061/2011/231926
- Wilson, J., Sevier, T., Helfst, R., Honing, E., & Thomann, A. (2000). Comparison of rehabilitation methods in the treatment of patellar tendinitis. *J Sports Rehabil, 9(4), 30*4-314.
- White, K. (2011). High hamstring tendinopathy in 3 femal long distance runners. *J Chiropr Med*, 10(2), 93-99.
- Young, B.A., Walker, M.J., Strunce, J.B., Boyles, R.E., Whitman, J.W., Childs, J.D. (2009). Responsiveness of the Neck Disability Index in patients with mechanical neck disorders. *Spine J*, 10,802-808.