Dosing and designing shoulder exercises for local circulation and tissue repair.

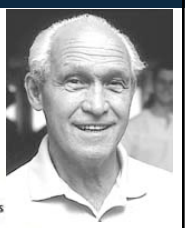
Jim Rivard PT, MOMT, DMT, OCS, FAAOMPT

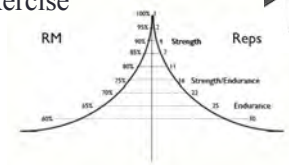
The Ola Grimsby Institute
www.olagrimsby.com

MT: More than Manipulation

STEP origins:

Oddvar Holten
Holten Curve
Physiologically dosed exercise





MT: More than Manipulation

Medical Exercise Therapy Norway — 1960's



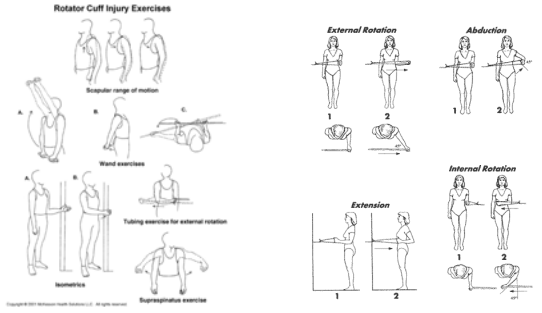
MT: More than Manipulation

STEP

Scientific
Therapeutic
Exercise
Progressions

MT: More than Manipulation

Are You Better than the Internet?



MT: More than Manipulation

Conceptual Framework

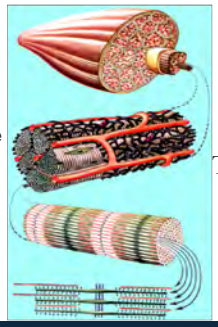
Diagnosis
Equipment
Exercises
Impairment



MT: More than Manipulation

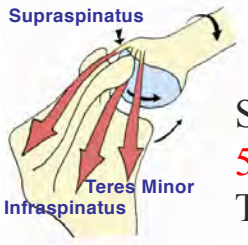
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No Nociception for Muscle



Fascia - 10% of Total Tissue Mass

Arthrokinematic Muscles



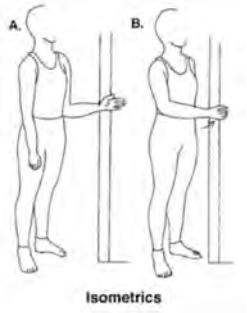
Supraspinatus from 56.73% — 63.97% Type I Fibers

(Kim, Lunn et al. 2013)

Types of Work Options

- Pure Concentric work
- Isometric Work
- Pure Eccentric Work
- Concentric / Eccentric (CW Bias)
- Eccentric / Concentric (EW Bias)

Is this What the Tissue Needs?





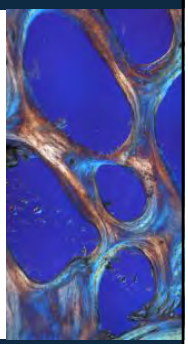
Tissue Repair

Mechanotransduction (McElhaney et al. 1968)

Optimal Stimulus for Regeneration /Repair to promote protein synthesis in tissue (MET/STEP—1960's).

Physical Stress Theory (Mueller and Maluf 2002).

Mechanotherapy (Khan and Scott 2009).



Microtransduction

The physiological process where cells sense and respond to mechanical loads—

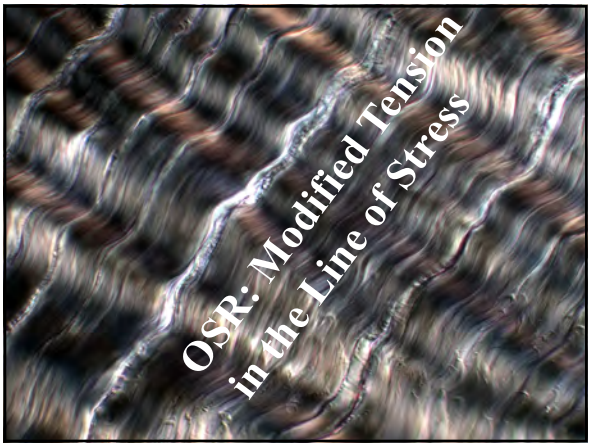
The Cellular response promotes structural change.

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3 Steps

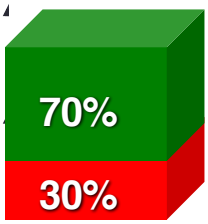
1. ***Mechanocoupling***: physical load (tensile, shear or compression) causing a physical perturbation to cells (Khan and Scott 2009).
2. ***Cell-to-Cell Communication***: chemical signalling to cells in areas of tissue that did not receive mechanical stimulus (Wall 2005).
3. ***Cell Response:*** produce fiber & GAG

MT: More than Manipulation



Daily Requirement vs. Reserve



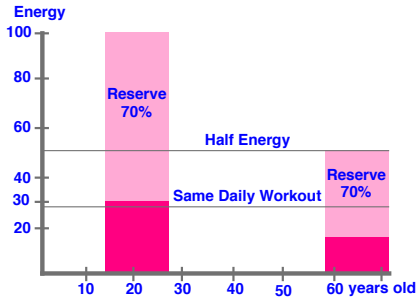


Reserve

Work Capacity Demand

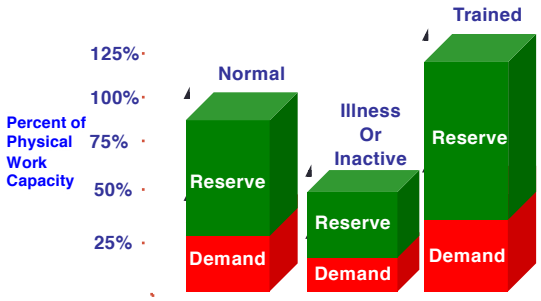
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Stress Effects



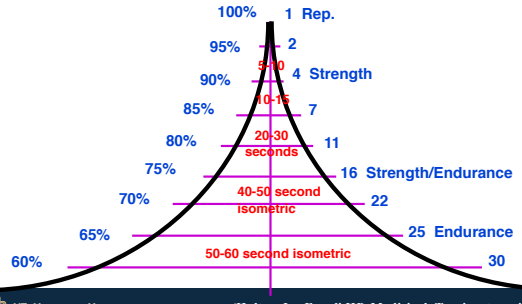
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Energy Reserve Changes



MT: More than Manipulation

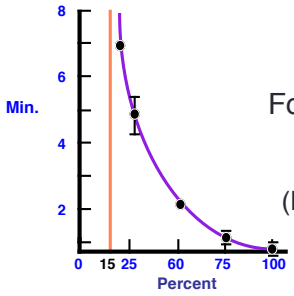
Concentric Curve (Holten)



MT: More than Manipulation

(Holten–In: Faugli HP. Medisinsk Treningsterapi 1996).

Isometric Contraction and Endurance



Maximal work time versus Force in isometric work

(Percentage of maximal isometric strength).

(Rohmert 1960)

Dosage and Blood Flow

28-30 Reps: maximal aerobic power and time increase (Campos et al. 2002).

16-24% 1RM: 22–30% increased blood flow lasting for over 2 minutes (Amundsen et al. 2002).

Blood flow severely limited during the concentric work phase (Amundsen et al. 2002).

Crossover effect: blood flow to non-working limb, both upper and lower quarter (Tanaka et al 2006).

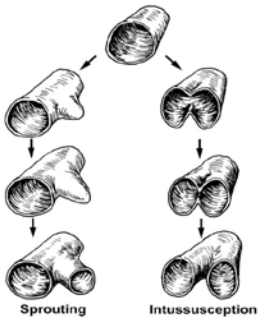
Training for Endurance

Arteriogenesis: enlargement of existing arterial vessels.

Angiogenesis: formation of new capillaries from existing capillaries

Intussusception

Refers to a single capillary splitting into two capillaries by the forming of a pillarlike structure or longitudinal divide on the luminal side of the capillary.



Intussusception

More efficient process of capillary multiplication, requiring less endothelial cell proliferation and offering a greater simplicity in extracellular matrix remodeling, compared with sprouting angiogenesis (Djonov, Baum et al. 2003).

Shear forces: friction experienced by endothelial cells as blood flow along its surface; initiates signals to enlarge vessel (Prior et al. 2004), preferentially increase capillarity through intussusception (Rivilis, Milkiewicz et al. 2002).

VASCULAR STUDY

James Rivard , Richard Kring and Chad Cook with the Ola Grimsby Institute

In coordination with the Cleveland Clinic Heart and Vascular Institute

Cleveland Clinic

mti physical therapy
PROVIDING ONE TO ONE CARE

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The Question:

Research Question: What Dosage of Resistance Provides the Greatest Vascular Response

STEP Question: Does **60%** of 1 Repetition Maximum Truly Provide the Greatest Local Vascular Response?



10 Healthy Volunteers from 25-62 years old.

Day One: Assessing true 1RM
24 hour rest before testing

Measures

- Calculation of 40%, 60%, and 80% of 1RM
- Speed of motion set by metronome
- Warm-up 1.5kg x 20
- 2 hour break between sessions and levels



Training Sessions



40% = 45 reps **60% = 30 reps**
80% = 15 reps

5 Minute Doppler Measures



1) immediately prior
2) immediately following
3) 15 minutes after

Statistical Mumbo Jumbo

Tests and 95% confidence intervals for *mean perfusion change* were based on a random-effects ANOVA model and incorporate an adjustment for multiple testing, which is based on the approximate multivariate distribution of parameter estimates.

Testing was two-sided and assumes an overall 5% significance level.

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Average Changes

%RM	Average % Increase in Blood Flow
40	25.09%
60	46.87%
80	-3.74%

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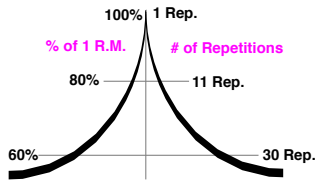
The Break Down

%RM	N	Mean /SD	95% CI	p-value
40%	10	$26.1^{+/-}43.8$	-4.9 - 57.1	0.11
60%	10	$46.9^{+/-}28.7$	15.9 - 77.9	0.003
80%	10	$-3.7^{+/-}38.5$	-34.7 - 27.2	0.98

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How to Calculate Weight from %RM

If the patient obtains 11 repetitions with 2lb., then 60% of 1 R.M. =



STEP 1: X / 60% = 2 lb. / 80%

STEP 2: X = 120 / 80

STEP 3: X =. 3 / 2

X = 1.5 lb.

60% of 1 R.M. = 1.5 lb.

MT: More than Manipulation

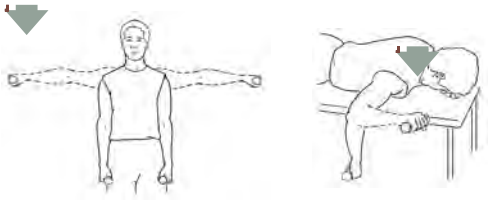
Why the Painful Arc?



MT: More than Manipulation

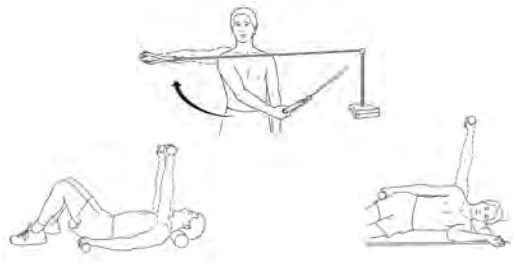
Perpendicular to Gravity

(Lever) Arm is Perpendicular to Gravity



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Adjusting Gravity



MT: More than Manipulation

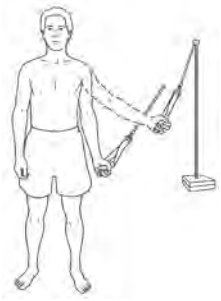
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Training Coordination

Coordination is often lost as the *resistance is too high*

Must reduce load, or weight of the head, limb or trunk.

Early training is more associated with neurological adaptation than hypertrophy.



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Loads as low as 6% of MVC limit flow

(Robergs et al. 1997).



MT: More than Manipulation

Muscle Pump: Circulation

4–5% of 1 RM: muscle blood flow greater than recovery phase, suggesting a muscle pump-induced enhancement



30–40% 1RM: net effect of the muscle pump was neutral

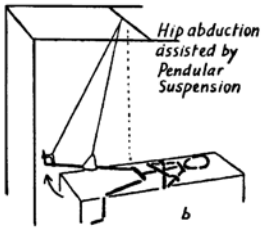
60–75% 1RM: At the heavier work rates the increased impedance to flow with increased contraction force was not fully compensated for by any enhanced flow during relaxation.



MT: More than Manipulation

(Lutjemeier et al. 2005)

M.D. Gardiner. *The Principles of Exercise Therapy* (1954)



Examples of a sling exercises for gravity eliminated exercises to the hip.

MT: More than Manipulation

Old School Slings



Axis of the sling is placed over the axis of the joint

Limb moves in a plane perpendicular to gravity

MT: More than Manipulation

Pure CW versus Pure EW

CW = vascularization



CW / CW Exercise:
- CW/CW: 27% increase in hypertrophy Type II
- CW only 0% hypertrophy
- **Increased Capillary Density for both CW and CW/CW**

EW = hypertrophy / collagen repair



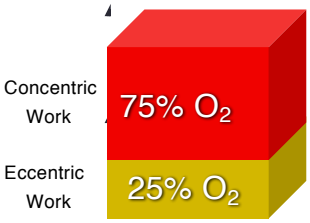
CW / EW Exercise:
- Increase **hypertrophy** Type I (14%) and Type II (32%).
- No capillary Density change

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(Hather et al. 1991)

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Ecc Training for Tendinopathy



Eccentric training for collagen repair and load tolerance was first published by Curwin (1984).

EW is 25% of the oxygen cost, compared to 75% during CW.

EW provides high collagen strain for cellular activity - GAG and fiber.

Goal: **Thicker and more elastic tendon**

MT: More than Manipulation

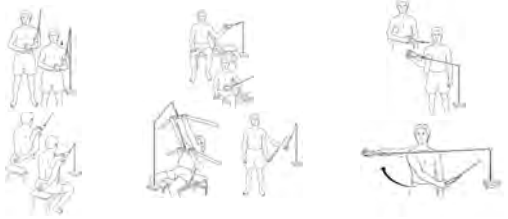
Knuttgen and Klausen 1971)

Training Sequencing: Tendinopathy

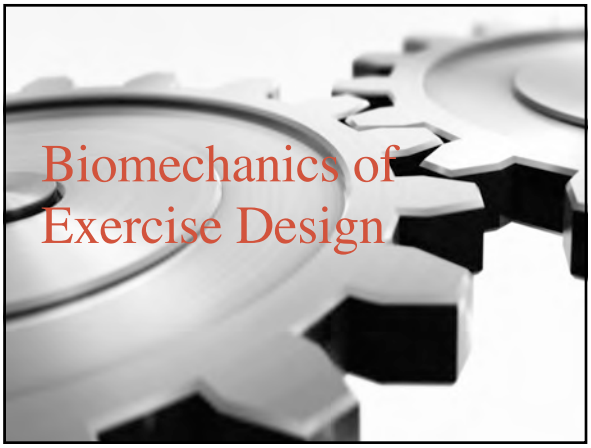
Cervical and/or Scapular Stabilization: **Coordination**

Guarded Pattern: **Vascularity**

Pure Eccentrics: Collagen Repair

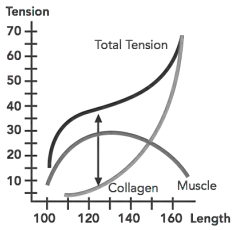


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Length Tension

Length Tension Curve

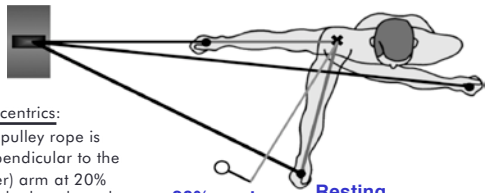


The diagram shows the relationship between "passive tension" and "total tension." When the passive curve is deducted from the total, one will get the actual active tension.

Greatest tension can be achieved at 20% increase in fiber length measured from resting position.

MT: More than Manipulation

Pulley Resistance for Length Tension



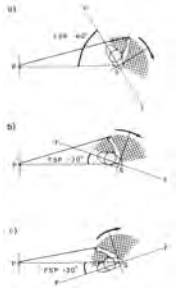
Concentrics:
The pulley rope is perpendicular to the (lever) arm at 20% into the lengthened range of the muscle group.

20% past Resting Position

Resting Position

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Length Tension Variations



A) perpendicular in *lengthened* range

B) perpendicular 20% lengthened

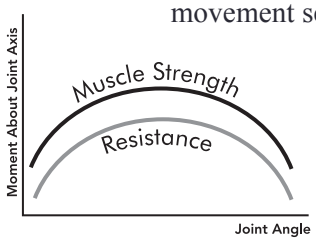
C) perpendicular in *shortened* range

MT: More than Manipulation

(Harms-Ringdahl **et al.** 1985)

Optimal Adaptation

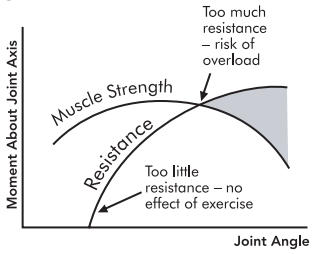
Optimal adaptation between resistance and strength in the whole movement sector



MT: More than Manipulation (Harms-Ringdahl 1993)

Poor Adaptation

Poor adaptation between resistance and strength in the movement sector



MT: More than Manipulation (Harms-Ringdahl 1993)

Elastic Resistance

Advantages

- Low Cost
- Easy to set up
- Varying types of exercise
- Requires a minimal level of education

Disadvantages

- Does not follow length tension curve
- Unknown, (less known), level of resistance
- Poor Eccentric training
- Resistance changes with distance from fixation

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Elastic Resistance



Elastic resistance, compared to normal weight training, does *not* produce significant changes in muscle oxidative capacity or fiber size (Hostler et. al 2001).

Less optimal for early rehabilitation training goals.

MT: More than Manipulation

What is Different: Band vs Pulley?

Matters	Doesn't Matter
1. -	1. -
2. -	2. -
3. -	3. -
4. -	4. -
5. -	5. -
6. -	6. -

MT: More than Manipulation

What is Different: Band vs Pulley?

Matters	Doesn't Matter
1. Long lever arm	1. Short lever arm
2. Vascular training	2. Strength training
3. Endurance	3. Hypertrophy
4. Coordination training	4. No other options
5. Large ROM	5. Benefit of end stage stabilization training
6. Eccentric strain	6. Isometrics

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UQ Evidence EW

Elbow Tendinopathy	Shoulder Tendinopathy
Svernlov et al. 2001	Bernhardsson et al. 2011
Martinez-Silvestrini et al. 2005	Samani et al. 2009
Croisier et al. 2006	Johsson et al. 2006
Stasinopoulos et al. 2006	Lombardi et al. 2008
Tyler et al. 2010	Maenhout et al. 2013
Peterson et al. 2014	Holmgren et al. 2012
Viswas et al. 2012	Struyf et al. 2013
Soderberg et al. 2012	
Wen et al. 2011	
Nagrale et al. 2009	



MT: More than Manipulation

MET/STEP for Overuse Tendinopathy

- Avoid initial training of involved muscle
- Train surrounding muscles for vascularity
- Avoid stretching
- Eccentrics to involved collagen (tendon)
- Clear spinal issues of facilitated segments

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Basic Tendinopathy Rehab Concepts

Concentric work: Initially CW emphasis for vascularity for all motions except primary motion of tendon (3 sets of 24 at 60% of 1RM)

Eccentric work: 1 set of 10-15 repetitions, as heavy as possible with coordinated and no pain. Multiple sets performed with 2 plus hours between.

Progress EW: ROM/lengthening, then weight, then speed

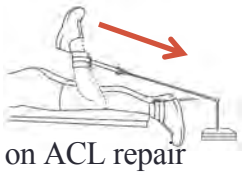
Avoid: rest, stretching, NSAIDs, corticosteroids, heating with ultrasound.

Manual Therapy: local joints and associated spinal levels

MT: More than Manipulation

EW for All Collagen Training

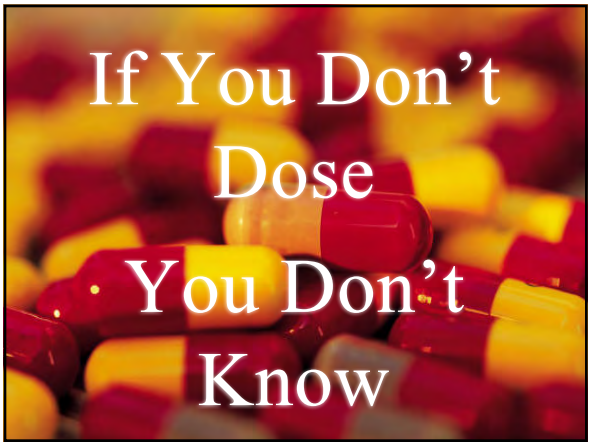
- Tendinopathy
- Tendon repair post-op
- Flexibility
- Post surgical hamstring on ACL repair
- Scar tissue
- Used to strengthen any condition of tendon weakness



MT: More than Manipulation

Condition/Impairment	Dosage/Training Concepts
Over Use: Myositis	Endurance: Vascular Training
Impingement: Bio	Manual Therapy
Impingement: Secondary to Motor Control	Coordination scapula and Cs Endurance: Vascular Training Eccentrics
Trauma: Crush Injury Inflammatory	Venous Pump Endurance: Vascular Training Eccentrics
Trauma: Strain	Endurance: Vascular Training Eccentrics
TENEX Debridement	Vascular Eccentrics
Post Op Repair	Venous Pump Endurance: Vascular Training

MT: More than Manipulation



Bibliography

Croisier, J. L., et al. (2007). "An isokinetic eccentric programme for the management of chronic lateral epicondylar tendinopathy." Br J Sports Med **41**(4): 269-275.

Curwin S, Stanish W. Tendinitis: Its etiology and treatment. Lexington, MA, DC health & Co., Toronto, 1984.

Djonov, V., O. Baum and P. H. Burri (2003). "Vascular remodeling by intussusceptive angiogenesis." Cell Tissue Res **314**(1): 107-117.

Ekholm J, Arborelius UP, Hillered L, Ortqvist A. Shoulder muscle EMG and resisting moment during diagonal exercise movements resisted by weight and pulley-circuit. Scand J Rehab Med 10(4):179–185, 1978.

Gardiner MD. The Principles of Exercise Therapy. G. Bell and Sons, LTD, 1954.

Grimbsy O, Rivard J. *Science, Theory and Clinical Application in Orthopaedic Manual Physical Therapy: Applied Science and Theory*. The Academy of Graduate Physical Therapy, Inc., 2008. (www.lulu.com).

Harms-Ringdahl K, Arborelius UP, Ekholm J, Nemeth G, and Schuldt K. Shoulder externally rotating exercises with pulley apparatus. Joint load and EMG. Scand J Rehabil Med 17:129–140, 1985.

Harms-Ringdahl K, Ekholm J, Arborelius UP, Nemeth G, and Schuldt K. Load moment, muscle strength and level of muscular activity during internal rotation training of the shoulder. Scand J Rehabil Med Suppl 9:125-135, 1983.

Harms-Ringdahl K. Muscle Strength: International perspectives in physical therapy. Vol 8. W.B. Saunders Company, 1993.

Hather BM, Tesch PA, Buchanan P, Dudley G. Influence of eccentric actions on skeletal muscle adaptations to resistance training. Acta Physiol Scand 143(2):177–185, Oct, 1991.

Holmgren, T., et al. (2012). "Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study." BMJ **344**: e787.

Holten O, Grimsby O. *Medical Exercise Therapy: A Course Workbook*. The Holten Institute for Medisinsk Treningsterapi, 1986.

Hostler D, Schwirian CI, Campos G, Toma K, Crill MT, Hagerman GR, Hagerman FC, Staron RS. Skeletal muscle adaptations in elastic resistance-trained your men and women. Eur J Appl Physiol 86(2):112–118, Dec, 2001.

Khan, K. M. and A. Scott (2009). "Mechanotherapy: how physical therapists' prescription of exercise promotes tissue repair." Br J Sports Med **43**(4): 247-252.

Kim, S. Y., D. D. Lunn, D. R. J., L. J. Kirkpatrick and B. W. C. Rosser (2013). "Fiber type composition of the architecturally distinct regions of human supraspinatus muscle: A cadaveric study." Histol Histopathol **28**: 1021-1028.

Knuttgen, H. G. and K. Klausen (1971). "Oxygen debt in short-term exercise with concentric and eccentric muscle contractions." J Appl Physiol **30**(5): 632-635.

Lutjemeier, B. J., A. Miura, et al. (2005). "Muscle contractionblood flow interactions during upright knee extension exercise in humans." J Appl Physiol 98(4): 1575-1583.

Maenhout, A. G., et al. (2013). "Does adding heavy load eccentric training to rehabilitation of patients with unilateral subacromial impingement result in better outcome? A randomized, clinical trial." Knee Surg Sports Traumatol Arthrosc **21**(5): 1158-1167.

Martinez-Silvestrini, J. A., et al. (2005). "Chronic lateral epicondylitis: comparative effectiveness of a home exercise program including stretching alone versus stretching supplemented with eccentric or concentric strengthening." J Hand Ther **18**(4): 411-419, quiz 420.

McElhaney, J. H., et al. (1968). "Electric fields and bone loss of disuse." J Biomech **1**(1): 47-52. [study related to bone loss with change in electrical fields]

Mueller, M. J. M., K. S. (2002). "Tissue Adaptation to Physical Stress: A Proposed ''Physical Stress Theory'' to Guide Physical Therapist Practice, Education, and Research." Phys Ther **82**: 383-403

Nagrale, A. H., D. Ganvir, S. Ramteke, G. (2009). "Cyriax Physiotherapy versus Phonophoresis with supervised exercise in subjects with Lateral epicondylalgia: A Randomized Clinical trial." J Man Manip Ther **17**: 171-178.

Peterson, M., et al. (2014). "A randomized controlled trial of eccentric vs. concentric graded exercise in chronic tennis elbow (lateral elbow tendinopathy)." Clin Rehabil **28**(9): 862-872.

Prior, B. M., H. T. Yang and R. L. Terjung (2004). "What makes vessels grow with exercise training?" J Appl Physiol **97**: 1119–1128.

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Rivard J, Grimsby O. Volume 2: *Scientific Therapeutic Exercise Progressions (STEP): The Neck and Upper Extremity*, The Academy of Graduate Physical Therapy, Inc., 2008 (www.lulu.com).

Rivard J, Grimsby O. Volume 3: *Scientific Therapeutic Exercise Progressions (STEP): The Back and Lower Extremity*, The Academy of Graduate Physical Therapy, Inc., 2009 (www.lulu.com).

Rivilis, I., M. Milkiewicz, P. Boyd, J. Goldstein, M. D. Brown, S. Egginton, F. M. Hansen, O. Hudlicka and T. L. Haas (2002). "Differential involvement of MMP-2 and VEGF during muscle stretch- versus shear stress-induced angiogenesis." Am J Physiol Heart Circ Physiol **283**(4): H1430-1438.

Robergs, R. A., M. V. Icenogle, et al. (1997). "Temporal inhomogeneity in brachial artery blood flow during forearm exercise." Med Sci Sports Exerc 29(8): 1021-1027.

Robergs, R. A., M. V. Icenogle, et al. (1997). "Temporal inhomogeneity in brachial artery blood flow during forearm exercise." Med Sci Sports Exerc 29(8): 1021-1027.

Rohmert, W. (1960). "[Determination of the recovery pause for static work of man]." Int Z Angew Physiol **18**: 123-164.

Soderberg, J., et al. (2012). "Effects of eccentric training on hand strength in subjects with lateral epicondylalgia: a randomized-controlled trial." Scand J Med Sci Sports **22**(6): 797-803.

Stasinopoulos, D. S., I. (2006). "Comparison of effects of Cyriax physiotherapy, a supervised exercise programme and polarized polychromatic non-coherent light (Bioptron light) for the treatment of lateral epicondylitis." Clin Rehabil **20**: 12-23.

Struyf, F., et al. (2013). "Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial." Clin Rheumatol **32**(1): 73-85.Lombardi, I., Jr., et al. (2008). "Progressive resistance training in patients with shoulder impingement syndrome: a randomized controlled trial." Arthritis Rheum **59**(5): 615-622.

Svernlov, B. A., L. (2001). "Non-operative treatment regime including eccentric training for lateral humeral epicondylalgia." Scand J Med Sci Sports **11**: 328–334.

Tanaka, H., et al. (2006). "Increases in blood flow and shear stress to nonworking limbs during incremental exercise." Med Sci Sports Exerc **38**(1): 81-85.

Tyler, T. F., et al. (2010). "Addition of isolated wrist extensor eccentric exercise to standard treatment for chronic lateral epicondylosis: a prospective randomized trial." J Shoulder Elbow Surg **19**(6): 917-922.

Viswas, R., et al. (2012). "Comparison of effectiveness of supervised exercise program and Cyriax physiotherapy in patients with tennis elbow (lateral epicondylitis): a randomized clinical trial." ScientificWorldJournal **2012**

Wall, M. E. and A. J. Banes (2005). "Early responses to mechanical load in tendon: role for calcium signaling, gap junctions and intercellular communication." J Musculoskelet Neuronal Interact **5**(1): 70-84.

Wen, D. Y., et al. (2011). "Eccentric strengthening for chronic lateral epicondylosis: a prospective randomized study." Sports Health **3**(6): 500-503.

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