Muscle Energy

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This is intended to be an informational outline of the most current available research on muscle energy techniques (MET). Literature was compiled from multiple articles databases, books, and non-peer reviewed websites. Due to the broad range of MET application to the entire body, this review focused only on techniques affecting musculature that attaches to the pelvis.

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History of Muscle Energy Techniques

- Dr. TJ Ruddy: was the first osteopathic doctor to use muscle energy in the 1940's and 1950's, he referred to it as resistive duction, which he defined as a series of muscle contractions against resistance; used techniques mainly in the C-spine[1]

- Dr. Fred Mitchell, Sr.: has been titled the Father of muscle energy, he took Dr. Ruddy's principles and incorporated them into manual medicine to any body region/articulation; he believed the pelvis was the key to the musculoskeletal system[1]
  - His first seminars were 2 days long in the 1950's and 1960's
  - He died in 1974 at which point his students continued his work by developing three courses for the American Academy of Osteopathy
  - His son, Fred Mitchell, Jr., continued his work with The Muscle Energy Manual, which was three volumes in length (http://www.shortdwarf.com/main/mitchell_muscle_energy_manual.PDF)
  - Defined muscle energy as when the patient uses his/her muscles on request from a precisely controlled position in specific direction against distinctly executed counterforce[2]
- Dr. Phillip Greenman: believed that any articulation which can be moved by voluntary muscle action can be influenced by muscle energy techniques (MET); MET can be used for: lengthening strengthening, decreasing local edema[2]
- Dr. Sandra Yale: stated that MET was safe enough for use with fragile and severely ill, or on a spasm from fall[2]

There are two main effects when performing muscle energy, physiologic and neurologic.

Physiological Reasoning

Definition of Muscle Energy:

- Procedure that involves voluntary contraction of a patients muscle in a precisely controlled direction, at varying levels of intensity.[1]

Uses of Muscle Energy:

- Muscle energy is used to lengthen a shorted, contractured or spastic muscle, to strengthen a physiologically weakened muscle or group of muscles, to reduce localized edema and relieve passive congestion, to mobilize an articulation with restricted mobility, trigger points, and myofascial states.

Muscle make-up:

- Muscles are made up of extrafusual and intrafusual fibers
  - Extrafusual fibers: during rest, some contract while others rest so whole muscle does not contract
  - Intrafusual fibers: same as muscle spindles
    - Function is to monitor length and tone of muscle; sensitive to change in length and rate of change
    - Innervated by gamma fibers: set length and tone of spindle

- It has been suggested and theorized that all muscles have combination of slow and fast twitch fibers; composition is important in determining tonic and phasic functions
  - Dysfunctional postural muscles become hypertonic, short and tight
  - Dysfunctional phasic muscles become weak and inhibited
- Golgi Tendon apparatus
  - Lies with extrafusual fibers; Sensitive to muscle tension
  - As the muscle contracts or is passively stretched, the tension build-up in the Golgi Tendon apparatus inhibits alpha motor neuron output (by afferent information to cord through 1B fibers)- causes muscle to relax

Two types of muscle energy techniques:

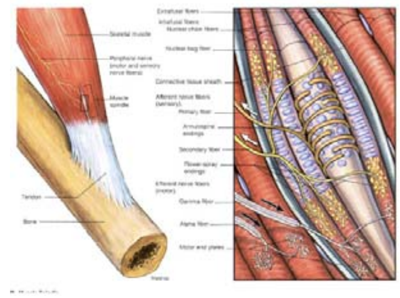
- Isometric muscle energy techniques
  - Primary effect: reduce tone in a hypertonic muscle and reestablish normal resting length
    - Gamma efferents return to intrafusual fibers resetting their resting length, which changes the resting length of the extrafusual fibers of the muscle
- Isotonic muscle energy techniques
  - Reciprocal Innervations/Inhibition[1-2]
    - When the agonist muscle contracts and shortens, its antagonist must relax and lengthen so the motion can be carried out under the influence of the agonist muscle
    - Contraction of the agonist reciprocally inhibits its antagonist: allows smooth motion; the harder the agonist contracts, the more inhibition occurs, and the more the antagonist muscle relaxes

Surrounding tissue:

- Muscle energy techniques also influence surrounding fasciae, connective tissue and interstitial fluids. This alters the muscle physiology by reflex mechanisms
- When a muscle contracts, the length and tone is altered, which influences biomechanical, biochemical and immunologic functions: muscle contraction requires energy and the metabolic process results in carbon dioxide, lactic acid and other metabolic waste products that must be transported and metabolized. This is why patients may experience muscle soreness within the first 12-36 hours after the technique

*Although these theories have been used by multiple sources there is no published proof or evidence to support these theories.

Neurological Properties



http://fig.cox.miami.edu/~lfarmer/BIL265/locomotion5.jpg

Muscle Spindles[3-5]

Located throughout the muscle and provide **continuous** feedback that enables the CNS to control the activity of the muscles. Gives the status of the muscle at **every instant**.

-Sensitive to length change

-Rate of length change

-Change in tension

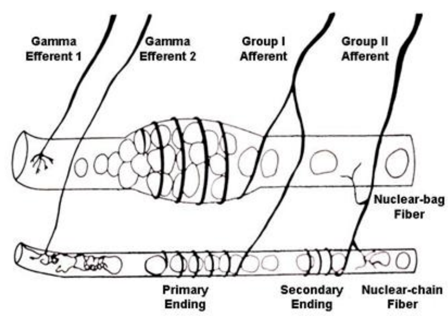
Stretching increases the rate of impulse (positive impulses) that are sent to the CNS. Whereas shortening decreases the rate of impulse (negative impulses) that are sent.

Made up of **extrafusal** muscle fibers and **intrafusal** muscle fibers (3-12 fibers within each spindle)

-Intrafusal are then broken down into[3](Guyton):

- Nuclear Bag fibers (1-3 in each spindle)
- Nuclear Chain fibers (3-9 in each spindle)

Nervous supply consists of both **afferent** and **efferent** nerve fibers:



http://www.mindmodulations.com/resources/images/dent4.jpg

-Afferents[3-5]:

- Primary Afferent: Type Ia
  - -Innervate both the Nuclear Bag fibers and the Nuclear Chain fibers
- Secondary Afferent: Type II
  - -Innervate the Nuclear Chain fiber

-Efferents[3-5]:

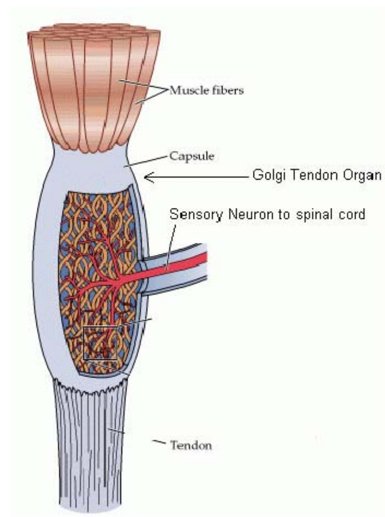
- Alpha (α) Motor Neurons- innervates extrafusal muscle fibers
  - -Originate in the Anterior Horn of the gray matter within the spinal cord
  - -Ranging from 9-20 microns in diameter
  - -Excites as few as 3 and up to several hundred skeletal muscle fibers (this is what makes up a motor unit)
- Gamma (γ) Motor Neurons- innervates intrafusal muscle fibers
  - -Originate in the Anterior Horn of the gray matter within the spinal cord
  - -Makes up 31% of all motor neuron fibers in muscle
  - -Smaller in diameter about 5 microns

"Static" Response[3]: Involves both *Primary* and *Secondary* afferents.

-As muscle is stretch slowly both transmit a signal proportional to the stretch

-Lasts as long as the stretch is applied
-Nuclear Chain (innervated by both) is thought to be responsible

"Dynamic" Response[3]: Involves only the *Primary* afferent.
-Responds powerfully to a rapid rate in length change
-Sensitive to only a fraction of a micro in length change within in a fraction of a second
-Last only while length is increasing, once it is stopped it returns almost back to normal
-Nuclear Bag fiber (innervated only by Ia) is thought to be responsible



http://www.arn.org/docs/glicksman/040105%20fig3.jpg

Golgi Tendon Organs[4-5]

Located within the tendon of muscle. On average 10-15 muscle fibers connect in series with each GTO. Provides **constant** feedback to the CNS[4].
-Sensitive and stimulated by the tension developed by muscle fibers
-Opposite of Muscle Spindle as it prevents muscles from developing too much tension
-If tension is too great can cause relaxation of entire muscle
-Type II fibers of Muscle Spindles are thought to assist
-Prevents tearing of muscle or avulsion: **Lengthening Reaction**

Nervous supply consists of **afferent** fiber[4-5]:
-Afferent: Type Ib
- Moderate diameter: 16 microns
- Excites inhibitory interneurons that inhibit anterior alpha motor neurons
- Inhibits individual muscle without affecting adjacent muscles

"Dynamic" Response[5]: Sensitive to quick change
"Static" Response[5]: Sensitive to slower, steady change

Clinical Application[2]:

Important that stretching is slow, rapid stretching or "bouncing" has a tendency to irritate tissue.

Reciprocal Inhibition[2]:

Response from a stretch: excites agonist muscle while simultaneously inhibiting the antagonist muscle.

-Afferents send signal to the CNS, and sends efferent signal to contract agonist group

-Signal also crosses to the opposite side of the cord to cause opposing reaction

-Efferent (alpha motor neuron innervating antagonist muscle) sends the signal to **relax.**

-Mechanism is referred to as: **Reciprocal Innervation**

-Common example: Contraction of quadriceps group causes relaxation of hamstrings muscle group

Autogenic Inhibition[2]:

-Opposite of Reciprocal Inhibition- causes relaxation of muscle being stretched- due to override of GTO

Post-Isometric Relaxation Technique[2]:

-Utilizes the contract relax technique with an added gentle stretch

-Contraction activates GTO's which in turn inhibits target muscle (GTO can override the impulses from the muscle spindle)

Application of MET

Indications of MET:

- Lengthen shortened, contractured, or spastic muscle[6-8]
- Strengthen weakened muscle or group of muscles [6]
- Malpositioning of a bony element[6]
- Restoration of joint motion associated with articular dysfunction[6, 9]

Precautions of MET:

- Unknown pathology[6, 9]
- Stress fractures[6]
- Strains, infections or diseases causing musculoskeletal pain[6, 9]
- Osteoporosis or tumors in the area of treatment [6]

Contraindications of MET:

- Acute musculoskeletal injuries[6, 9]

- Unset or unstable fractures[6]
- Unstable or fused joints[6]

** Good results of MET depend on: accurate diagnosis, appropriate levels of force, and sufficient localization.[9]
**Poor results of MET are attributed to: inaccurate diagnosis, improperly localized force, or forces that are too strong.[9]

Techniques Separated by Type of Contraction:

Patient-Direct [2]

- Isometric- Utilizing Autogenic Inhibition
  - Patient attempts to push through the barrier of restriction, utilizing autogenic inhibition of the target muscle.
  - Frequency: 3-5 reps
  - Intensity: Operator and patient's forces are matched. Patient provides effort at 20% of their strength increasing to no more than 50% on subsequent contractions.
  - Duration: 4-10 seconds initially, increasing up to 30 seconds in subsequent contractions.

  - Isometric Patient-Direct (Hamstrings Muscle Group) [2]
  - Video Example 1 of technique (URL below references)
    - **Position:** Patient is supine and flexes the affected hip completely. The knee is extended as far as possible and the back of the lower leg is resting on the shoulder of the operator who stands facing the patient. The operator's right hand stabilizes the patient's extended unaffected leg against the table.
    - **Action:** The patient attempts to flex the knee (causing downwards pressure against the operator's shoulder, with the back of the lower leg) engaging the hamstrings isometrically for 4-10 seconds. After relaxation, the muscles are taken to a new barrier.
    - Frequency: Repeat until no further gain is achieved.
    - Duration: 4-10 seconds

Operator-Direct [2]

- Isometric- Utilizing Reciprocal Inhibition
  - Operator attempts to push through the barrier of restriction, utilizing reciprocal inhibition which causes relaxation of the target muscle.
  - Frequency: 3-5 reps
  - Intensity: Operator and patient's forces are matched. Patient provides effort at 20% of their strength increasing to no more than 50% on subsequent contractions.
  - Duration: 4-10 seconds initially, increasing up to 30 seconds in subsequent contractions.

  - Isometric Operator-Direct (Hamstring Muscle Group) [2]
  - Video example 2 of technique (URL below references)
    - **Position:** Patient is supine and flexes the affected hip completely. The knee is extended as far as possible and the back of the lower leg is resting on the shoulder of the operator who stands facing the patient. The operator's right hand stabilizes the patient's extended unaffected leg against the table.
    - **Action:** The patient contracts the quadriceps isometrically for 4-10 seconds relaxing the hamstrings and the operator engages the barrier.
    - Frequency: Repeat until no further gain is achieved.
    - Duration: 4-10 seconds

- Isotonic Concentric- Utilizing Autogenic Inhibition [2]
  - Target muscle is allowed to contract with some resistance from the operator. This technique utilizes autogenic inhibition of the target muscle.
  - Frequency: 5-7 reps
  - Intensity: Patient's force is greater than operator's resistance. Patient utilizes maximal effort and force is built slowly, not suddenly.
  - Duration: 3-4 seconds

  - Isotonic Concentric (Hamstrings Muscle Group) [2]
  - Video example 3 of technique (URL below references)
    - **Position:** Patient is supine and flexes the affected hip completely. The knee is extended as far as possible and the back of the lower leg is resting on the shoulder of the operator who stands facing the

patient. The operator's right hand stabilizes the patient's extended unaffected leg against the table.

    - **Action:** The patient attempts to flex the knee (causing downwards pressure against the operator's shoulder, with the back of the lower leg) engaging the hamstrings isotonically for 4-10 seconds. After relaxation, the muscles are taken to a new barrier.
    - Frequency: Repeat until no further gain is achieved.
    - Duration: 3-4 seconds

- Isotonic Eccentric- Utilizing Reciprocal Inhibition [2]
  - Target muscle is prevented from contracting by superior operator force, utilizing reciprocal inhibition which causes relaxation of the target muscle.
  - Frequency: 3-5 reps as long as tolerable
  - Intensity: Operator's force is greater than patient's force. Patient utilizes less than maximal force initially and subsequent contractions build towards patient's maximal force.
  - Duration: 2-4 seconds

  - Isotonic Eccentric (Hamstrings Muscle Group) [2]
  - Video example 4 of technique (URL below references)
    - **Position:** Patient is supine and flexes the affected hip completely. The knee is extended as far as possible and the back of the lower leg is resting on the shoulder of the operator who stands facing the patient. The operator's right hand stabilizes the patient's extended unaffected leg against the table.
    - **Action:** The patient contracts the quadriceps isotonically for 4-10 seconds which eccentrically lengthens the hamstrings and the operator engages the barrier.
    - Frequency: Repeat until no further gain is achieved.
    - Duration: 2-4 seconds

*It should be noted that the duration of the post-isometric stretch phase results in no differences in range of motion of the hamstrings.[10]

Review of Non-Peer Reviewed Websites

The NATA has a thorough breakdown of "Muscle Energy Techniques for the Sacroiliac Joint". There are lectures and labs posted that go through an entire course on muscle energy. All lectures are posted as a video of the presenter and a copy of the power point presentation. Lab sessions are also recorded to observe for a better understanding of techniques.

NATA: http://www.nata.org/virtuallibrary/sacroiliac/flash/Course_Page.html

Lectures:

- Anatomy and Pathomechanics of Sacrum and Pelvis
- Muscle energy
- Ilial Pathology
- Treatment for Sacroiliac Joint Dysfunction
- Basic concepts of Muscle Energy
- Evidence Based Medicine

Labs:

- Ilial Lab
- Muscle Energy Lab
- Sacroiliac Join Dysfunction Lab

Another video posted on the NATA website is "Muscle Energy Techniques for the Low Back" presented by Dr. Miller: http://206.211.148.195/muscleenergy/

This is a power point presentation that includes audio of the presenter explaining the content of each slide. Dr. Miller goes through a descriptive explanation of somatic dysfunction of the lumbar spine, Fryette's laws, what is muscle energy?, and how to treat dysfunctions in the lower back.

While muscle energy presented several hits with a web search, NATA had the best informational presentations. Most other sites were advertising books for muscle energy techniques or courses to learn about muscle energy.

Literature Review of Database

Muscle Energy was defined as a procedure that involves voluntary contraction of a patients' muscle in a precisely controlled direction, at varying levels of intensity. Search terms for this literature review database included; muscle, energy, spine, sacrum, joint, low back, performance, techniques, PNF, pain. Databases searched included PubMed, Medline, Cinahl, and Cochrane. The attached database includes 18 articles and is in order based on the level of evidence (as determined by the Oxford Centre for Evidence-based medicine). The first chart (see below) describes the databases, limits, and search terms associated with each article.

Overall conclusions based on the review of the database indicated that the definition muscle energy technique is not consistent throughout the literature. Descriptions of application and parameters of MET vary. Additionally, outcome measures used throughout the literature are not consistent, and vary between range of motion, pain, motor coordination, task performance, and self-reported outcome scores. Although muscle energy techniques were shown to be different from control groups there was either no difference or a marginal difference from other treatments including static stretching, dynamic warm-up, and mobilizations.

Literature Search

Limits	Database	Search Terms	Results
English, Human	PubMed	PNF	NN Mahieu et al[11] BK Christensen et al[12]
		PNF Technique	JM Fasen et al[8]
		PNF AND Techniques AND pain	N Kofotolis et al[13] MC Weng et al[7]
		PNF AND Techniques AND performance	MJ Sharman[14]
		Muscle AND Energy AND PNF	N Caplan et al[15]
		muscle energy techniques AND low back	JW Atchison[16]
		muscle energy technique AND (spine OR sacrum OR joint)	M Smith et al[10] DK Burns et al[17] BL Roberts[18] JD Cassidy et al[19] NM Selkow et al[20] E Wilson et al[21]
		muscle energy technique AND physical therapy	JP Goodridge[22]
	CINAHL	muscle energy techniques	JA Cleland et al[23]

Current Literature Database

Author	Study type and Level of Evidence*	Purpose	Subjects	Treatment	Outcome measures	Results	Author Conclusions
DK Burns et al, 2006[17]	Randomized Controlled Trial; OCEBM: 1b; PEDro: 10	Examine effectiveness of spinal manipulation for decreasing hypertonicity and increasing range-of-motion in asymptomatic patients	N=32. Inclusion: no previous exposure to muscle energy techniques that have a medical condition involving the neck or cervical spine, including previous trauma, chronic conditions, acute undiagnosed pain, or hypermobility.	Manipulative treatment group: 3-5 second contract/relax MET. Repeated 4 times. Sham treatment group: passive motion three times in each direction.	Cervical AROM and PROM before and immediately after treatment with 3D motion analysis system; measured as total angular displacement	Increase in the three planes of motion (rotation, lateral bending, flexion/extension) and overall range of motion compared to control group.	Manipulation to the cervical spine can increase ROM in three planes in asymptomatic subjects; gives evidence that muscle energy techniques could be useful in clinical practice.
NM Selkow et al, 2009[20]	Randomized Controlled Trial (Pilot Study); OCEBM: 1b; PEDro: 10	Examine effectiveness of treating lumbopelvic pain due to rotations of the ilium with PNF technique of the hamstrings	16 males and 4 females; Inclusion: lumbopelvic pain (LPP) in past 6-weeks; anterior innominate rotation (bilateral difference of 2 degrees or greater) Exclusion: Back pain lasting longer than 6 weeks, pain radiating past the knee, or previous surgery	4 5-sec hold/relax periods of the hamstrings and hip flexors. Performed 1 time.	VAS scale measurement: current pain, worst pain the past 24 hours, pain during provocation tests (taken immediately after and day after treatment)	MET group had significantly less "worst pain reported in the past 24 hours" on the VAS compared to the control group.	MET effective in short-term pain relief for patients with lumbopelvic pain.

JD Cassidy et al, 1992[19]	Randomized Controlled Trial; OCEBM: 1b; PEDro: 8	Compare the effectiveness of a single rotational manipulation and muscle energy in relieving unilateral neck pain that refers to the trapezius.	N=100; 52 in group 1 (manipulation group); 48 in group 2 (Mobilization group); Inclusion: Patients suffering from mechanical neck pain that radiated to the trapezius. Exclusion: Evidence of neurological deficit	Group 1: single rotational manipulation (high-velocity, low-amplitude thrust); Group 2: 4, 5-sec contract/relax of the agonist.	Cervical range of motion in three planes. Pain intensity on 101-point Numerical Rating Scale. Measures taken before and immediately after treatment	1.5 times greater decrease in pain for manipulation group compared to mobilization group. Both groups increased cervical ROM.	A single manipulation is more effective than muscle energy for pain relief of mechanical neck pain.
JA Cleland et al, 2009[23]	Randomized Clinical Trial; OCEBM: 1b; PEDro: 8	Examine the generalizability of 3 manual therapy techniques in patients with low back pain that satisfy a clinical prediction rule (CPR)	N= 112; Inclusion: Oswestry Disability Questionnaire (ODQ) score of 25%, 18 and 60 years of age, positive for the spinal manipulation CPR. Exclusion: Tumors, metabolic diseases, arthritis, osteoporosis, prolonged history of steroid use, nerve root compression, prior surgery to spine and current pregnancy	Spine thrust manipulation group, side- lying thrust manipulation gorup, non-thrust manipulation technique group. 5 treatment sessions over 4 weeks. Subjects also given ROM exercises to be repeated 3-4 times daily.	Self reported outcome scores; Oswestry Disability Questionnaire (ODQ) and the Numerical Pain Rating Scale (NPRS).	Significant group by time interaction for the ODQ and NPRS scores. No difference between STM and SLTM at any follow-up. Significant differences in ODQ and NPRS at each follow-up between thrust and nonthrust groups at 1 and 4 weeks.	Results support the generalizability of the Clinical Prediction Rule to another thrust manipulation technique, but not to the nonthrust manipulation technique.

MC Weng et al, 2009[7]	Randomized Controlled Trial; OCEBM: 1b; PEDro: 8	Compare effects of different stretching techniques on outcomes of isokinetic muscle strengthening exercises in subjects with bilateral knee osteoarthritis	N=132; Inclusion: Bilateral knee OA (Altman grade II) Exclusion: Hip joint OA, or any other hip problems with ROM limitations	Group 1: Isokinetic muscular strengthening exercises. Group 2: Bilateral knee static stretching therapy before isokinetic exercise. Group 3: PNF stretching before isokinetic exercise. Group 4: Control	Bilateral changes in ROM, pain measured on visual analog scale, Lequesne's Index (LI), peak muscle torque during knee flex/ext (isokinetic dynamometer after treatment and one year f/u)	Increases in ROM after treatment and follow-up for groups 2 and 3. All treatment groups had significant decreases in pain and LI scores. MPT increased in all treatment groups. Improvements at 60 degrees/sec were greatest in groups 2 and 3.	Stretching therapy, combined with isokinetic muscle strengthening, can be beneficial for long-term knee pain reduction and it is found that PNF stretching is more effective than static stretching.
M Smith, 2008[10]	Randomized Clinical Trial; OCEBM: 1b; PEDro: 7	Determine the relative efficacy of two variations of PNF techniques for increasing the extensibility of the hamstring muscles in asymptomatic patients.	40 healthy subjects randomly allocated to 2 treatment groups; Inclusion: between 18-65 years old, shortened hamstrings (<75 degrees of active knee extension) Exclusion: lower extremity or back pain	Group 1: Contract-relax technique with 30 sec post-isometric stretch phase; Group 2: Contract-relax technique with 3-sec post-isometric stretch phase. Treatment was given twice, one week apart.	Active Knee Extension (supine, hip flexed to 90 degrees) measured using a photograph; taken before and after each treatment for analysis.	Both groups had similar pre-post gains at weeks 1 and 2. Time effect, but no group by time interactions. Pooled group comparison over time: pre-measurement for week-one was different than all other measurements.	Both approaches increase active knee extension immediately after intervention. Carryover effect demonstrated 1 week following treatment. Duration of passive stretch may not have significant influence on hamstring flexibility.

N Kofotolis et al, 2006[13]	Randomized Controlled Trial; OCEBM: 1b; PEDro: 5	Examine the effects of 2 PNF techniques on trunk muscle endurance, flexibility, and functional performance in subjects with chronic low back pain	86 women; Inclusion: complaints of low back pain (LBP) during or after activity, sitting, or stairs	4 week programs; RST- trunk flexion/ extension, max isometric contractions against resistance for 10 seconds followed by 30 sec rests. COI- concentric/ eccentric trunk flexion/extension contractions of agonists without relaxation. Contractions held 5 seconds for 3sets of 15secs.	Lumbar sagittal mobility, static trunk flexion endurance, dynamic trunk extension and flexion endurance, Oswestry Index. Measured before, immediately after, 4 and 8 weeks after the 4-week training session.	Both groups: significant improvements in lumbar flexion, static and dynamic muscle endurance, and Oswestry Index. RST group: significant increase in lumbar extension	Application of 4-week RST and COI PNF programs increase muscle endurance and decrease pain in patients with chronic low back pain. Combination of isometric exercise is the most effective technique.
N Caplan et al, 2009[15]	Randomized Clinical Trial; OCEBM: 2b; PEDro: 6	Determine the effect of a 5-week static stretching or PNF program on high-velocity running	18 healthy Rugby League players; Inclusion: Train at least 4x/wk in addition to competition	5 week supervised stretch training protocol. Three repetitions of 10s stretch (supine hip flexion with knee extension). Static group held position for 10 seconds. PNF group pushed against examiner into hip extension for 10 seconds.	Hip flexion and knee extension angles, stride rate, stride length, and contact time during sprinting	Both groups: Increase in hip flexion and stride length. Decrease in knee extension and stride rate. No change in contact time. No differences between groups for any outcome measures.	Stretch training in addition to regular sport training can improve running mechanics (in university rugby players).

BK Christensen et al, 2008[12]	Randomized Cross-over Design; OCEBM: 2b; PEDro: 6	Investigate the effects of 3 different warm-ups on vertical jump performance and compare jump performance by gender after the warm-ups.	68 NCAA Division I athletes	Three warm-ups: 1- 600m jog. 2- 600m jog, skips, walking lunges, side shuffling, carioca low knees, carioca high knees, backwards run, high knee running, butt kickers. 3- 600m jog, HS, quad, hip adductor, and calf stretch	Vertical jump measurements averaged and compared between groups and genders	No differences between groups in vertical jumping. No gender differences in vertical jump performance between groups.	Jogging warm-up, dynamic warm-up, and PNF warm-up will have little or no impact on vertical jump performance during competition.
JM Fasen et al, 2009[8]	Randomized Controlled Trial; OCEBM: 2b; PEDro: 6	Determine whether active stretches are more effective than passive stretches and whether adding a neuromobilization maneuver to active stretches enhances hamstring flexibility	100 adult Subjects; Inclusion: 18-80 years old; Exclusion: Hypermobility (defined: initial HS length greather than 90 degrees, Hx of HS tear, upper motor neuron disease, lower motor neuron disease, pasat participation in formalized stretching programs	group A-control; group B-90/90 passive stretch; group C-90/90 active stretch (antagonist contraction); group D-SLR active-assisted stretch (added neuromobilization component); group E-SLR passive stretch.	Hamstring length, perceived level of hamstring tightness. Hamstring flexibility measured initially, 4wks, 8wks	Women showed greater improvements than men. Groups C and D: improvement at 4 weeks. Groups A and B: no improvements. Group E: most improvement in HS length at 8 weeks.	Improvement of HS flexibility was greatest for the SLR passive stretch. Using PNF in the 90/90 active stretch provided better knee ROM improvements than the 90/90 passive methods.

E Wilson et al, 2003[21]	Clinical Trial (Pilot Study); OCEBM: 2b	Examine the outcomes of muscle energy techniques (MET) on low back pain	N=16; Inclusion: 18 to 65 years old, an initial Oswestri Disability Index (ODI) score of 20% to 60%, low back pain, lumbar flexion restriction; Exclusion: Neurological symptoms, spondylolisthesis, chronic low back pain of more than 12 weeks, and previous back surgeries	Experimental group: MET for flexion restrictions of the spine performed and given 7 exercises in a home exercise program. Control group: placebo MET. Repeated for 8 visits (twice a week for 4 weeks).	Self reported outcome scores; ODI	Experimental group showed greater improvement in ODI score than control group.	MET along with resistive exercises and supervised motor control may be better than neuromuscular re-education for decreasing disability and increasing function in patients with low back pain.
NN Mahieu et al, 2009[11]	Case-control; OCEBM: 3b; PEDro: 7	Investigate the mechanism of effect of PNF stretching on changes in ankle ROM	N=62 adults; Inclusion: Recreational athletes maintaining normal activity throughout trial; Exclusion: History of lower-leg injuries	Six week PNF stretching program: Contact-relax-antagonist-contract	Dorsiflexion ROM (knee flexed and extended), passive resistive torque of the plantar flexors, and stiffness of the achilles tendon	Increase in dorsiflexion ROM for PNF group in both conditions. No difference between groups for passive resistive torque of the plantar flexors. No change in achilles tendon stiffness.	6 week PNF stretching program can increase ankle dorsiflexion ROM. No measurable structural changes in the muscle-tendon unit were identified.

JW Atchison, 1998[16]	Review; OCEBM: 5	Literature review discussing manual therapy tx for patients with low back pain (mobilization with impulse, thrusting, high velocity/low amplitude manipulations, soft tissue, muscle energy, counterstrain, myofascial release)	N/A*	N/A	N/A	N/A	Guidelines for manipulations did not describe parameters for use in the tx of low back pain. Manipulation should be a small component of a treatment plan. There are several manual therapies that may be of use in treating low back pain
JP Goodridge, 1981[22]	Review/Instructional; OCEBM: 5	Overview of muscle energy treatment with examples of hypertonicity of the lower extremity and dysfunction in the lumbar spine	N/A	N/A	N/A	N/A	Principles of muscle energy can me applied to all joints in the extremities, ribs, spine, and pelvis.
BL Roberts, 1997[18]	Review/Instructional; OCEBM: 5	Describe muscle energy technique (MET) and neuromuscular technique (NT), their mechanism of action, assessment, and performance	N/A	Discusses NT and MET	N/A	N/A	MET and NT may improve ROM, muscle strength, and motor coordination as well as decrease muscle tension, spasm, and pain

MJ Sharman et al, 2006[14]	Review ; OCEBM: 5	Current literature on the use of PNF to elongate muscle: description of techniques, proposed mechanisms, evidence based recommendations for parameters, and long term ROM changes	N/A	N/A	N/A	N/A	Literature supports PNF as most effective way of increasing ROM by stretching, especially in the short term. PNF is safe and time efficient. There is need for uniformity in the classification and implementation of PNF stretching.

*OCEBM-Oxford Centre for Evidence-based Medicine Levels of Evidence
PEDro-Physiotherapy Evidence Database scale
N/A- Not Available or Not Applicable
tx- treatment

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1. Video Example 1 link **http://www.youtube.com/watch?v=GZFiQoz8skg**
2. Video Example 2 link **http://www.youtube.com/watch?v=xLxXarxjjp8**
3. Video Example 3 link **http://www.youtube.com/watch?v=EtV7GJ13QSs**
4. Video Example 4 link **http://www.youtube.com/watch?v=jNlTjPFNltI**