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THE PNF (PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION) STRETCHING TECHNIQUE – A BRIEF REVIEW

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Abstract
The aim of this paper is to realize a brief review on the PNF stretching technique.
PNF stretching (or proprioceptive muscular facilitation) is one of the most effective forms of flexibility training for increasing range of motion. PNF stretching is a method of flexibility training that can reduce hypertonus, allowing muscles to relax and lengthen and can be applied to patients of all ages. PNF can be used to supplement daily stretching and these techniques help develop muscular strength and endurance, joint stability, mobility, neuromuscular control and coordination. PNF techniques are as follows: Contract Relax, Hold Relax, Rhythmic Initiation, Rhythmic Stabilisation, Slow reversals, Alternating isometrics and Alternating rhythmic stabilization.
Conclusion. Whether promoting flexibility, developing muscular strength and endurance, improving joint stability or increasing neuromuscular control and coordination, PNF is a valuable part of every rehabilitation program.
Key words: stretching, proprioceptive muscular facilitation, neuromuscular control and coordination.

Intoduction

PNF stretching, or proprioceptive neuromuscular facilitation, is a method of flexibility training that can reduce hypertonus, allowing muscles to relax and lengthen. PNF stands for proprioceptive muscular facilitation and it is generally considered as one the most effective forms of stretching available. (http://articles.submityourarticle.com/the-basics-and-benefits-of-pnf-stretching-83751). PNF stretching, or proprioceptive neuromuscular facilitation stretching, are stretching techniques commonly used in clinical environments to enhance both active and passive range of motion with the ultimate goal being to optimize motor performance and rehabilitation (http://en.wikipedia.org/wiki/PNF_stretching).
Generally an active PNF stretch involves a shortening contraction of the opposing muscle to place the target muscle on stretch, this is followed by an isometric contraction of the target muscle. PNF can be used to supplement daily stretching and is employed to make quick gains in range of motion to help athletes improve performance (Marek, Cramer, Fincher, Massey et al., 2005)

Proprioceptive neuromuscular facilitation (PNF) was first developed by Margaret Knott PT, and Herman Kabat MD in the 1940's to treat neurological dysfunctions.(http://www.stretching-exercises-guide.com/pnf-stretching.html).

Initial PNF techniques were used to aid the rehabilitation of clients with spasticity and weakness by facilitating muscle elongation. This is theorized to be accomplished through enhanced inhibitory mechanisms affecting the spastic muscle, and improving the muscle strength through improved excitation mechanisms in the weakened muscle. (Sharman, Cresswell, Riek, 2006). And R. Lane sustained that "PNF stretching initially developed as a form of rehabilitative therapy so as to lessen and hopefully reverse the impact of a paralysis or stroke. The effectiveness of the technique led physiotherapists and other health/sports professionals to investigate it further and apply it to other areas" (http://articles.submityourarticle.com/the-basics-and-benefits-of-pnf-stretching-83751)
PNF techniques help develop muscular strength and endurance, joint stability, mobility, neuromuscular control and coordination–all of which are aimed at improving the overall functional ability of patients (Scifers, 2004, http://physical-therapy.advanceweb.com/Article/The-Truth-About-PNF-Techniques-1.aspx).
PNF techniques have broad applications in treating people with neurologic and musculoskeletal conditions, most frequently in rehabilitating the knee, shoulder, hip and ankle (Surburg, Schrader, 1997). Stretching is a main component of PNF. In fact, PNF stretching is superior to other stretching techniques (Burke, Culligan, Holt, 2000; Funk, Swank, Mikla, et al., 2003).
PNF exercises can be applied to patients of all ages. Klein et al., 2002, found that using PNF techniques for older adults improved range of motion, isometric strength and selected physical function tasks (Klein, Stone, Phillips, et al., 2002).
Whether promoting flexibility, developing muscular strength and endurance, improving joint stability or increasing neuromuscular control and coordination, PNF is a valuable part of every rehabilitation program.

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Proprioceptive neuromuscular facilitation encompasses all aspects of the rehabilitation process—and can help patients with various dysfunctions achieve their goals (Scifers,2004, http://physical-therapy.advanceweb.com/Article/The-Truth-About-PNF-Techniques-1.aspx).

PNF patterns of movements were developed because all normal coordinated human movements occur in spiral or diagonal motions. Muscular contractions are strongest and most coordinated during these diagonal patterns of movement. These diagonal patterns involve rotation of the extremities and require core stability. Muscular contraction is also enhanced through irradiation and there is optimal facilitation of the stretch reflex in a synergistic muscle group during movements within these patterns of movement (Knott, Voss, 1968).

Proprioceptive neuromuscular facilitation (PNF) stretching techniques are commonly used in the athletic and clinical environments to enhance both active and passive range of motion with a view to optimising motor performance and rehabilitation. PNF stretching is positioned in the literature as the most effective stretching technique when the aim is to increase passive range of motion (Sharman, Cresswell, Riek, 2006).

Terms about muscle contraction are commonly used when discussing PNF. Concentric isotonic contraction is when the muscle shortens, eccentric isotonic is when it lengthens even though resisting a force is being applied, and isometric contraction is when the muscle remains the same length even while it is contracting (McAtee, Charland, 1999).

On the other hand, we can not talk about PNF technics without making reference to Golgi tendon organ and Muscle spindles.

Muscle spindles are sensory receptors within the belly of a muscle, which primarily detect changes in the length of this muscle. They convey length information to the central nervous system via sensory neurons. This information can be processed by the brain to determine the position of body parts. The responses of muscle spindles to changes in length also play an important role in regulating the contraction of muscles, by activating motoneurons via the stretch reflex to resist muscle stretch (Dumitru, 1988). Muscle spindles are found within the belly of muscles, embedded in extrafusal muscle fibers. Its are composed of 3-12 intrafusal muscle fibers, of which there are three types:

- dynamic nuclear bag fibers (bag1 fibers)
- static nuclear bag fibers (bag2 fibers)
- nuclear chain fibers and the axons of sensory neurons (Heckmann, Gorassini, Bennett, 2005)

The Golgi organ (also called Golgi tendon organ, tendon organ, neurotendinous organ or neurotendinous spindle), is a proprioceptive sensory receptor organ that is located at the insertion of skeletal muscle fibers into the tendons of skeletal muscle. It provides the sensory component of the Golgi tendon reflex. When the muscle generates force, the sensory terminals are compressed. This stretching deforms the terminals of the Ib afferent axon, opening stretch-sensitive communication channels. As a result, the Ib axon is depolarized and fires nerve impulses that are propagated to the spinal cord. The action potential frequency signals the force being developed by the 10 to 20 motor units within the muscle. This is representative of whole muscle force (Heckmann, Gorassini, Bennett, 2005; Prochazka; Gorassini, 1998).

Techniques

Most PNF stretching techniques employ isometric agonist contraction/relaxation where the stretched muscles are contracted isometrically and then relaxed. Some PNF techniques also employ isometric antagonist contraction where the antagonists of the stretched muscles are contracted. In all cases, it is important to note that the stretched muscle should be rested (and relaxed) for at least 20 seconds before performing another PNF technique. The most common PNF stretching techniques are:

Contract Relax: Passive placement of the restricted muscle into a position of stretch followed by an isometric contraction of the restricted muscle. Most isometric contractions in PNF stretching techniques should he held for a minimum of 3 seconds (Surburg, Schrader, 1997) at a sub maximal effort (20-50% of maximal effort) to avoid muscle fatigue and injury (Feland, Marin, 2004). After the contraction period the patient is instructed to relax the restricted muscle that was just contracting and activate the opposing muscle to move the limb into a greater position of stretch. Through Reciprocal Inhibition, the tight muscle is relaxed, and allowed to lengthen.

Hold Relax: Very similar to the Contract Relax technique. This is utilised when the agonist is too weak to activate properly. The patient's restricted muscle is put in a position of stretch followed by an isometric contraction of the restricted muscle. After the allotted time the restricted muscle is passively moved to a position of greater stretch. Contraction times and efforts will remain the same as the Contract Relax technique. This technique utilizes the golgi tendon organ, which relaxes a muscle after a sustained contraction has been applied to it for longer than 6 seconds (http://en.wikipedia.org/wiki/PNF_stretching).

Hold-Relax Agonist: Most familiar. It can be used to lengthen out tight muscle and increase passive range of motion. In this technique, the tight muscle is the antagonist, hence the agonist contracts (provided that the agonist is strong enough). The therapist asks the patient to isometrically contract the agonist for around 6 seconds before it gets moved further into range. Through Reciprocal Inhibition, the tight muscle is

relaxed, and allowed to lengthen. Verbal cues for the patient performing this exercise would include, "Hold. Hold. Don't let me move you."(http://en.wikipedia.org/wiki/PNF_stretching)

Hold-Relax Antagonist: Very similar to the Hold-Relax Agonist technique. This is utilised when the agonist is too weak to activate properly. The patient isometrically contracts the tight muscle (the antagonist muscle) against the therapist's resistance. After a 6 second hold has been achieved, the therapist removes his/her hand and the patient concentrically contracts the agonist muscle (the muscle opposite the tight muscle, the non-tight muscle) in order to gain increased range of motion. This technique utilizes the golgi tendon organ, which relaxes a muscle after a sustained contraction has been applied to it for longer than 6 seconds.

Notice that in the hold-relax-contract, there is no final passive stretch. It is replaced by the antagonist-contraction which, via reciprocal inhibition (see section Reciprocal Inhibition), serves to relax and further stretch the muscle that was subjected to the initial passive stretch. Because there is no final passive stretch, this PNF technique is considered one of the safest PNF techniques to perform (it is less likely to result in torn muscle tissue). Some people like to make the technique even more intense by adding the final passive stretch after the second isometric contraction. Although this can result in greater flexibility gains, it also increases the likelihood of injury (http://web.mit.edu/tkd/stretch/stretching_4.htm).

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Hold Relax Swing: This technique (and a similar technique called the hold-relax-bounce) actually involves the use of dynamic or ballistic stretches in conjunction with static and isometric stretches. It is very risky, and is successfully used only by the most advanced of athletes and dancers that have managed to achieve a high level of control over their muscle stretch reflex (see section The Stretch Reflex). It is similar to the hold-relax technique except that a dynamic or ballistic stretch is employed in place of the final passive stretch (http://web.mit.edu/tkd/stretch/stretching_4.html).

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Hold-Relax-Swing/Hold-Relax Bounce: These are similar techniques to the Hold-Relax and CRAC. They start with a passive stretching by the therapist followed by an isometric contraction. The difference is that at the end, instead of an antagonist muscle contraction or a passive stretching, dynamic stretching and ballistic stretching is used. It is very risky, and is successfully used only by people that have managed to achieve a high level of control over their muscle stretch reflex. Ballistic stretching should ONLY be used by athletes prior to engaging in a *High Energy* movement (e.g. A sprinter running a 100m dash) (Arredondo, 2009).

Rhythmic Initiation: Developed to help patients with Parkinsonism overcome their rigidity. Begins with the therapist moving the patient through the desired movement using passive range of motion, followed by active-assistive, active-resisted range of motion, and finally active range of motion.

Rhythmic Stabilisation: and Alternating Isometrics are very similar in that they both encourage stability of the trunk, hip, and shoulder girdle. With this technique, the patient holds a weight-bearing position while the therapist applies manual resistance. No motion should occur from the patient. The patient should simply resist the therapist's movements. For example, the patient can be in a sitting, kneeling, half-kneeling, or standing position when the therapist applies manual resistance to the shoulders. Usually, the therapist applies simultaneous resistance to the anterior left shoulder and posterior right shoulder for 2–3 seconds before switching the resistance to the posterior left shoulder and the anterior right shoulder. The therapist's movements should be smooth, fluid, and continuous. In AI, resistance is applied on the same side of the joint. In RS, resistance is applied on opposite sides of the joint. Note this is not a stretching technique, but instead a technique used to strengthen joint musculature and improve proprioception (http://en.wikipedia.org/wiki/PNF_stretching).

Slow reversals: This technique is based on Sherrington's principle of successive induction, i.e. that immediately after the flexor reflex is elicied the exitability of the extensor reflex is increased.This technique is used to strengthen and buildup endurance of weaker muscles and develop co-ordination and establish the normal reversal of antagonistic muscles in the performance of movememt (http://en.wikipedia.org/wiki/PNF_stretching).

Alternating isometrics: This technique encourages stability of postural trunk muscles and stabilizers of the hip and shoulder girdle. With alternating isometrics, the patient "holds" his position, while manual resistance is alternately applied in a single plane from one side of the body to the other. No motion should occur. Instead, the patient should maintain the starting position of the involved limb. This technique can strengthen the trunk, a single extremity or bilateral extremities, and can be applied with the limbs in the open- or closed-kinetic chain (Scifers, 2004).

Alternating rhythmic stabilization: This technique is simply an extension of alternating isometrics in which the involved muscle groups co-contract. Rhythmic stabilization is most commonly performed in a closed-chain position to further enhance muscular co-contraction and joint stability. With this technique, the clinician applies manual isometric resistance in a multidirectional pattern. The clinician may apply simultaneous manual resistance in multiple directions, forcing the multiple muscle groups to contract simultaneously to support and stabilize the extremity. This technique is particularly beneficial in isometrically contracting the proximal joint rotators (Kisner, Colby, 2002).

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PNF stretching is probably "the most effective form of flexibility training available to you for increasing your range of motion (ROM)". This is a more advanced form of flexibility training, involving both the stretch and contraction of the targeted muscle group

(http://www.google.ro/imgres?imgurl=http://www.projectswole.com/wpcontent/uploads/2009/10/pnf-stretching-1.jpg&imgrefurl=http://www.projectswole.com/flexibility/).

There are two types of PNF stretching:
passive - stretching without a muscular contraction
active - using a voluntary muscular contraction
PNF techniques can be both passive (no associated muscular contraction) or active (voluntary muscle contraction). While there are several variations of PNF stretching, they all have one thing in common - they facilitate **muscular inhibition**. It is believed that this is why PNF is superior to other forms of flexibility training.

How PNF Stretching Works

For the following information, you should know that the golgi tendon organ relaxes a muscle after a sustained contraction has been applied to it for longer than 6 seconds.
Isometric contractions (the hold phase) and concentric contractions (the contract phase) used immediately before the passive stretch (the relax phase) facilitate autogenic inhibition. Autogenic inhibition is a reflex relaxation that occurs in the same muscle where the golgi tendon organ is stimulated.
Similarly, we can use a technique that involves a concentric contraction of the muscle group opposing that which is being stretched, in order to achieve reciprocal inhibition. Reciprocal inhibition is a reflex muscular relaxation that occurs in the muscle that is opposite the muscle where the golgi tendon organ is stimulated.

Using the hold, contract, and relax phases, we can develop the following 4 PNF stretching techniques. While slightly different, each technique starts by holding a passive stretch for about 10 seconds (http://www.google.ro/imgres?imgurl=http://www.projectswole.com/wpcontent/uploads/2009/10/pnf-stretching1.jpg&imgrefurl=http://www.projectswole.com/flexibility/improve recovery time after a strenuous workout).

Benefits of PNF stretching:

- targeting a specific muscle group
- increasing flexibility and ROM
- increasing muscular strength
- physical therapy
- rehabilitation(http://www.google.ro/imgres?imgurl=http://www.projectswole.com/wpcontent/uploads/2009/10/pnf-stretching-1.jpg&imgrefurl=http://www.projectswole.com/flexibility/improve recovery time after a strenuous workout).

General Guidelines for PNF Stretching
Always precede PNF stretching with 10-15 minutes of moderate exercise.
Avoid PNF prior to exercise. Choose dynamic stretching and mobility work instead.
Perform only one stretch per muscle group per PNF session.
Perform at least two sets of each stretch for the chose muscle group.
Hold each stretch for 30 seconds after the initial contraction.
Separate PNF stretching routines with at least a 48 hour recovery period (http://www.google.ro/imgres?imgurl=http://www.projectswole.com/wpcontent/uploads/2009/10/pnf-stretching1.jpg&imgrefurl=http://www.projectswole.com /flexibility/improve recovery time after a strenuous workout).
PNF stretching usually involves a 10 second push phase followed by a 10 second relaxation phase, typically repeated a few times. PNF stretching is capable of producing greater improvement in flexibility compared to other techniques. Its disadvantage is that it typically requires a partner, although stretching with a partner may have some motivational advantage for some individuals (http://www.exrx.net/ExInfo/Stretching.html).

Bibliography

Burke, D., Culligan, C., Holt, L., 2000, The theoretical basis of proprioceptive neuromuscular facilitation. Journal of Strength and Conditioning Research, 14(4), 496-500

Dumitru, G., 1988, Fiziologia educatiei fizice si sportului. Ovidius University Press, Constanta: 52-55.

Funk, D., Swank, A., Mikla, B., Fagan, T., & Farr, B., 2003, Impact of prior exercise on hamstring flexibility: A comparison of proprioceptive neuromuscular facilitation and static stretching. Journal of Strength and Conditioning Research, 17(3), 489-492

Heckmann, C.J., Gorassini, M.A., Bennett, D.J., 2005, Persistent inward currents in motoneuron dendrites: implications for motor output. Muscle Nerve 31: 135-156

http://articles.submityourarticle.com/the-basics-and-benefits-of-pnf-stretching-83751, viewed 15.01.2013

http://physical-therapy.advanceweb.com/Article/The-Truth-About-PNF-Techniques-1.aspx,viewed 15.01.2013

http://www.stretching-exercises-guide.com/pnf-stretching.html, viewed in 09.01.2013

http://en.wikipedia.org/wiki/PNF_stretching, viewed in 09.01.2013

http://www.ncbi.nlm.nih.gov/pubmed/17052131, viewed in 09.01.2013

http://web.mit.edu/tkd/stretch/stretching_4.html, viewed in 05.02. 2013

http://www.google.ro/imgres?imgurl=http://www.projectswole.com/wpcontent/uploads/2009/10/pnf-stretching-1.jpg&imgrefurl=http://www.projectswole.com/flexibility, viewed in 12.01.2013

http://www.exrx.net/ExInfo/Stretching.html , viewed in 12.01.2013

http//:www.crossfitoakland.comarchives201003pnf-stretching-and-daylight-saving-time, viewed in 09.01.2013.

http//:www.exrx.netStretchImagesHipExternalRotatorsSeatedPeriformisPNF.jpg, viewed in 09.01.2013

Kisner, C., Colby, L.A., 2002, Therapeutic Exercise: Foundations and Techniques (4th edition). F.A. Davis: Philadelphia.

Klein, D., Stone, W., Phillips, W., Gangi, J., Hartman, S., 2002, PNF training and physical function in assisted-living older adults. Journal of Aging and Physical Activity, 10(4), 476-488

Knott, M., Voss, D., 1968, Proprioceptive Neuromuscular Facilitation (2nd ed.). Harper & Row: Philadelphia.

Marek, S., Cramer, J., Fincher, A., Massey, L., Dangelmaier, S., Purkayastha, S., Fitz, K., Culbertson, J. Y., 2005, Acute effects of static and proprioceptive neuromuscular facilitation stretching on muscle strength and power output. Journal of Athletic Training, 40, 94-103

Mcatee RE, Charland J., 1999, Facilitated stretching: assisted and unassisted PNF stretching made easy. 2nd ed. Champaign (IL): Human Kinetics.

Prochazka, A., Gorassini, M., 1998, Ensemble firing of muscle afferents recorded during normal locomotion in cats, J Physiology 507 (1): 293–304. DOI:10.1111/j.1469-7793.1998.293bu.x. PMC 2230769. PMID 9490855

Scifers, J.R., 2004, The Truth About PNF Techniques, Vol. 15 •Issue 26 • Page 40 , http://physical-therapy.advanceweb.com/Article/The-Truth-About-PNF-Techniques-1.aspx viewed 15.01.2013.

Sharman, M., Cresswell, A. AND Riek, S., 2006, Proprioceptive Neuromuscular Facilitation Stretching. Sports Medicine, 36, 929-939

Surburg, P., Schrader, J., 1997, Proprioceptive neuromuscular facilitation techniques in sports medicine: A reassessment. Journal of Athletic Training, 11(4), 34-39