IAAF @-*Letter*

for CECS Level II Coaches

August 2009 No. 2

SPECIFIC THEME: PNF self-stretches

GENERAL THEME: PNF basics

Specific Theme

PNF SELF-STRETCHES

1 How PNF stretching works

During an isometric stretch, when the muscle performing the isometric contraction is relaxed, it retains its ability to stretch beyond its initial maximum length. PNF (*Proprioceptive Neuromuscular Facilitation*) tries to take immediate advantage of this increased range of motion by immediately subjecting the contracted muscle to a passive stretch.

The isometric contraction of the stretched muscle accomplishes several things:

- It helps to train the stretch receptors of the muscle spindle to immediately accommodate a greater muscle length.
- The intense muscle contraction, and the fact that it is maintained for a period of time, serves to fatigue many of the fast-twitch fibres of the contracting muscles. This makes it harder for the fatigued muscle fibres to contract in resistance to a subsequent stretch.
- The tension generated by the contraction activates the golgi tendon organs (GOTs), which inhibits contraction of the muscle via the lengthening reaction. Voluntary contraction during a stretch increases tension on the muscle, activating the GOTs more than the stretch alone. So, when the voluntary contraction is stopped, the muscle is even more inhibited from contracting against a subsequent stretch.
- PNF stretching techniques take advantage of the sudden "vulnerability" of the muscle and its increased range of motion by using the period of time immediately following the isometric contraction to train the stretch receptors to get used to this new, increased, range of muscle length. This is what the final passive stretch accomplishes (APPLETON, no year).

2 Some exemplary PNF self-stretches

2.1 Hamstrings self-stretch, supine, with stretching strap

- Lie on your back and lift your leg as high as possible, keeping your knee straight. Keep both hips flat on the floor during the entire sequence. You may bend your right knee and rest your foot flat on the floor, instead of having your right leg outstretched, if this is a more comfortable position. Use a towel or stretching strap wrapped around the arch of your foot, close to the heel to provide resistance to the hamstrings contraction (Fig. 1).

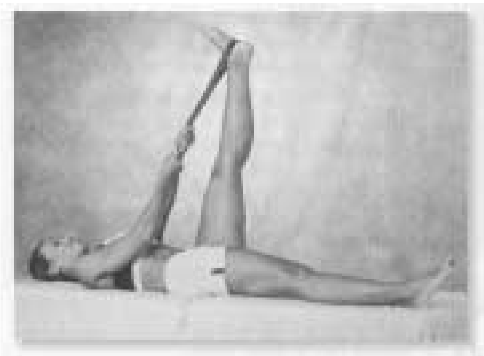

Fig. 1: Hamstrings self-stretch with a stretching strap (taken from: MCATEE & CHARLAND, 2007, p. 41)

- Begin slowly to attempt to push your left heel toward the floor, isometrically contracting the hamstrings for six seconds. After the isometric push, relax and inhale deeply. During this time, maintain the leg in the starting position.

- As you exhale, contract your hip flexors (quadriceps and psoas) to lift the leg higher, keeping your left knee straight. This deepens the hamstrings stretch. Do not pull on the strap to deepen the stretch.

- Repeat 2-3 times.

2.2 Hamstrings self-stretch, standing

- Stand with your right leg and foot stretched out comfortably in front of you, with your heel on the floor (toes up). Bend forward from your hips (no stooping) until you feel a stretch developing in your right hamstrings (Fig. 2(a)).

- From this starting position, the floor provides resistance as you try to drag your right heel back toward you, isometrically contracting your hamstrings for six seconds. After the isometric push, relax and inhale deeply. During this time maintain your leg in the starting position.

Fig. 2(a): Starting position of the hamstrings standing self-stretch (taken from: MCATEE & CHARLAND, 2007, p. 41)

Fig. 2(b): Deepening the stretch (taken from: MCATEE & CHARLAND, 2007, p. 41)

- As you exhale, lean forward until you once again feel a stretch in your right hamstrings (Fig. 2(b)).
- Repeat 2-3 times.

2.3 Gluteus maximus self-stretch, supine

- Lie on your back and bring your left knee to your chest as far as is comfortable, keeping both hips flat on the floor. You may need to place your hands behind your knee and pull your thigh toward you before you feel the stretch on the gluteus maximus (Fig. 3).
- From this starting position, push against your clasped hands as if you were going to put your thigh back down on the floor. Hold the isometric contraction of the gluteus maximus for six seconds. After the isometric push, relax and inhale deeply. During this time, maintain the leg in the starting position.

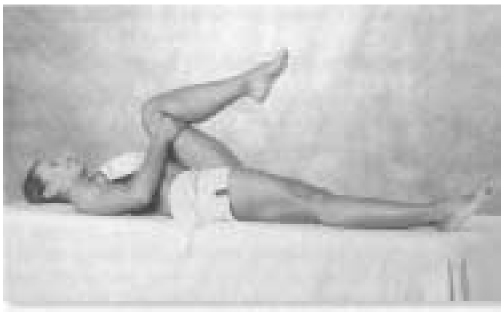

Fig. 3: Starting position for the gluteus maximus self-stretch (taken from: MCATEE & CHARLAND, 2007, p. 42)

- As you exhale, pull your thigh closer to your chest, deepening the stretch on the gluteus maximus.
- Repeat 2-3 times.

2.4 Piriformis self-stretch, sitting

- Sit at the edge of a chair and cross your left ankle over your right knee. Keeping your spine lengthened, bend at the hips (no stooping) until you feel a stretch deep in the buttocks. Stretch only in the “feels-good” range, and not into discomfort (Fig. 4).
- From this starting position, push your left ankle into your right thigh, isometrically contracting the piriformis, for six seconds. It may also feel good to push against the inside of your left knee with your left hand. After the isometric push, relax and inhale deeply.
- As you exhale, sit up tall and bend forward from the hips to deepen the piriformis stretch.
- Repeat 2-3 times.

Fig. 4: Piriformis self-stretch, sitting (taken from: McATEE & CHARLAND, 2007, p. 46)

2.5 Quadriceps self-stretch, standing

- Stand comfortably and use a stationary object to help you stabilise as you bend your left knee and lift your heel toward your buttocks. Hold your left leg or foot with your left hand, keeping your low back flat and being careful to bring your heel toward the centre of your buttock and not toward the outside of your hip, as this may stress your knee ligaments (Fig. 5a).
- From this starting position, attempt to straighten your left leg against your own resistance, isometrically contracting your quadriceps for six seconds. After the isometric push, relax and inhale, and as you exhale, pull your heel closer to your buttock.

Fig. 5(a): Quadriceps standing self-stretch – heel toward buttock (taken from: McATEE & CHARLAND, 2007, p. 57)

Fig. 5(b): Quadriceps standing self-stretch – If your heel can easily reach your buttock, then try to point your knee directly to the floor (taken from: McATEE & CHARLAND, 2007, p. 57).

- As your flexibility improves, you may find that your heel can easily reach your buttock. If this is the case, then your goal with each stress is to bring your thigh to a more vertical position so that the knee points directly to the floor, all the while keeping your low back flattened to prevent hyperextension of the lumbar spine (Fig. 5b).
- Repeat 2-3 times.

2.6 Psoas self-stretch, standing

- Stand with your right leg forward and left leg back, keeping your torso upright and your low back flat.
- Keeping your left foot flat on the floor, lunge forward with your left hip to lengthen the left iliopsoas. Allow your right knee to bend as you push forward. You should feel the stretch high on the front of the left thigh (Fig. 6).
- Isometrically contract the left iliopsoas by attempting to pull your left leg forward but keeping the foot anchored on the floor. To avoid an unnecessary cocontraction pattern, be sure your gluteal muscles are relaxed. Maintain the isometric contraction for six seconds, then relax.
- You can now stretch the iliopsoas by pushing the left hip forward again, being sure to maintain an upright posture with your low back flat.

Fig. 6: Standing psoas self stretch. Keep your low back flat and focus on feeling the stretch high on the front of your left thigh (taken from: MCATEE & CHARLAND, 2007, p. 60).

2.7 Gastrocnemius self-stretch, sitting, with stretching strap

Fig. 7: Gastrocnemius self stretch, sitting, with a stretching strap (taken from: MCATEE & CHARLAND, 2007, p. 63)

- Sit comfortably with your right leg straight, a stretching strap looped around the ball of your foot. If you have enough flexibility, hold the foot in your hands instead of using a stretching strap. Use your leg muscles to bring your foot and toes as close to you as possible (Fig. 7).
- From this starting position, try to push your foot away from you, isometrically contracting the gastrocnemius for six seconds. After the isometric push, relax and inhale, and as you exhale, use your leg muscles again to bring your foot toward you, deepening the stretch on the gastrocnemius.
- Repeat 2-3 times.

Key Facts About PNF
• PNF stretching, which was initially developed as a method of rehabilitating stroke victims, is currently the fastest and most effective way known to increase static-passive flexibility.
• PNF is a technique of combining passive stretching and isometric stretching in order to achieve maximum static flexibility.
• PNF refers to any of several *post-isometric relaxation* stretching techniques in which a muscle group is passively stretched, then contracts isometrically against resistance while in the stretched position, and then is passively stretched again through the resulting increased range of motion.
• PNF stretching usually employs the use of a partner to provide resistance against the isometric contraction and then later to passively take the joint through its increased range of motion. It may be performed, however, without a partner, although it is usually more effective with a partner's assistance
• 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.
• Like isometric stretching, PNF stretching is not recommended for children and people whose bones are still growing. Also like isometric stretching, PNF stretching helps strengthen the muscles that are contracted and therefore is good for increasing active flexibility as well as passive flexibility.
• Furthermore, as with isometric stretching, PNF stretching is very strenuous and should be performed for a given muscle group no more than once per day (ideally, no more than once per 36 hour period).
• The initial recommended procedure for PNF stretching is to perform the desired PNF technique 3-5 times for a given muscle group (resting 20 seconds between each repetition). However, research results suggest that performing 3-5 repetitions of a PNF technique for a given muscle group is not necessarily any more effective than performing the technique only once. As a result, in order to decrease the amount of time taken up by the stretching routine (without decreasing its effectiveness), it is recommended to perform only one PNF technique per muscle group stretched in a given stretching session.

General Theme

PNF BASICS

1 Definition of PNF

PNF (*Proprioceptive Neuromuscular Facilitation*) is a method of promoting or hastening the neuromuscular mechanism through stimulation of the proprioceptors (KNOTT & VOSS, 1968).

A proprioceptor is "a sensory receptor located in muscles, tendons, and joints which conveys information about the physical state and position of skeletal muscles and joints. Proprioceptors provide essential information for smooth coordinated movements and the maintenance of bodyposture." (KENT, 1998, p. 406).

PNF stretching is a method adapted from physiotherapy treatment of patients who have had strokes. PNF involves a series of movements designed to get the maximum out of a muscle by using muscle reflexes (NORRIS, 2004, p. 59). The emphasis is placed on maximal resistance throughout the range of movement (ROM), using many motion combinations related to primitive movement patterns and righting reflexes (VOSS et al., 1985). These motion combinations include isometric, concentric, and eccentric contractions, along with passive movement.

2 A brief history of PNF

PNF was developed in the mid-twentieth century by Herman Kabat, Margaret Knott and Dorothy Voss. Kabat based much of the theoretical structure of PNF on the work of Sir Charles Sherrington, whose research in the early to mid-1900s helped develop a model for how the neuromuscular system operates (SHERRINGTON, 1947).

In the early to mid-19th century, physiologist Charles Sherrington popularised a model for how the neuromuscular system operates. *Irradiation* is when maximal contraction of a muscle recruits the help of additional muscles. *Reciprocal innervation* causes one muscle to relax when its antagonist contracts, allowing a joint to bend. *Successive induction* is the contraction of one muscle followed immediately by the contraction of its antagonist, and this promotes strength and flexibility.

Kabat believed that the principles of neurophysiological development and Sherrington's laws of irradiation, successive induction, and reciprocal innervation should be applied in the rehabilitation of patients with paralysis. With backing from industrialist Henry Kaiser, Kabat founded the Kabat-Kaiser Institute (KKI) in Washington, DC, in 1946 and began working with paralysis patients to find combinations and patterns of movement that were consistent with neurophysiological theory. By 1951, Kabat and Knott had identified and established nine techniques for rehabilitating muscles.

Physical therapist Dorothy Voss became interested in PNF in 1950 as she learned from and worked with Knott, whose assistant she became in 1952. Voss and Knott realised that

PNF was more than a sysem for the treatment of paralysis; it was a new way of thinking about and using movement and therapeutic exercise. By 1954 Voss and Knott were conducting two-week training programmes, and in 1956 they published the first edition of their book *Proprioceptive Neuromuscular Facilitation*.

During the 1960s, PNF courses became available through physical therapy departments at several universities, and their popularity continued to grow. By the late 1970s PNF stretching methods gained even more popularity. PNF stretching began to be used by athletes and other healthy people for more flexibility and range of motion.

3 Basic neurophysiological principles of PNF

As indicated above, PNF techniques are based on the following neurophysiological mechanisms:

- facilitation;
- inhibition;
- resistance;
- irradiation;
- reflexes.

3.1 Facilitation

Facilitation or *facilitatory techniques* are designed to increase motor neuron excitability. Examples of facilitatory PNF techniques are any stimuli that increase the excitability of motor neurons or cause the recruitment of additional motor neurons.

3.2 Inhibition

In contrast, *inhibitory techniques* are designed to decrease excitability. They initiate stimuli that reduce the excitability of motor neurons or result in a drop in the number of actively discharging motor neurons (HARRIS, 1978; KNOTT & VOSS, 1968; PRENTICE, 1983). Although inhibition is the opposite of facilitation, the two processes are inseparable: facilitation of the agonist simultaneously results in inhibition of the antagonist. Thus, an overlapping effect occurs on both opposing muscle groups (KNOTT & VOSS, 1968). However, inhibitory techniques are of greatest relevance to increasing flexibility. The underlying assumption is that by inhibiting motor neurons to antagonistic muscles, these muscles will be more relaxed and therefore will provide less active resistance to the intended agonist movement.

3.3 Resistance

Facilitation and *inhibition* produce muscular resistance (i. e., active contractions). Originally, maximal resistance was defined as the greatest amount of resistance (opposing force) that can be applied to an isotonic contraction or an active contraction allowing full ROM to occur (KNOTT & VOSS, 1968). Currently, the terms *optimal resistance* or *appropriate resistance* are considered more accurate (ADLER et al., 2000).

3.4 Irridiation

Maximal resistance produces overflow, or *irradiation*, from stronger to weaker patterns of movement. Thus, irradiation is the spread of excitation in the CNS that causes contraction of synergistic muscles in a specific pattern (ADLER et al., 2000; SURBURG, 1981).

3.5 Reflexes

The effectiveness of PNF techniques also involves the stretch reflex. The stretch reflex depends on muscle spindles, which are sensitive to a change in length as well as to the rate of change in length of the muscle fibre. Golgi tendon organs (GTOs), which detect changes in tension, may also be activated by extremes of passive stretch. Both receptors help produce changes in the excitability of motor neurons that cause muscles to relax under specific conditions. Efforts to increase ROM by moving the joint to its physiological extreme will excite not only the muscle spindles and GTOs but also the sensory endings in the joint itself.

4 Spiral-diagonal movement as the basis of PNF

PNF is based on a spiral-diagonal movement. Kabat and Knott observed that normal movements seen in sports and physical activities are spiral-diagonal in nature. They defined these “mass-movement patterns” as “various combinations of motion ... [that] require shortening and lengthening reactions of many muscles in varying degrees” (VOSS et al., 1985). The spinal-diagonal character of normal movements arises from the design of the skeletal system and the placement of the muscles on it. The muscles spiral around the bones from the origin to insertion, and therefore, when they contract, they tend to create that spiral in motion.

> The motions required when combing one’s hair, swinging a golf club, or kicking a ball all have spiral (rotational) and diagonal components; that is, they do not occur in straight lines, but through several planes of motion. (MCATEE, R. E. & CHARLAND, J., 2007, p. 12).

If, for example, one looks at a bowler in motion (Fig. 8), one can see that his right arm is moving not only forward, but also diagonally up and across his body. One can also see the spiral component of his motion if one looks at the rotation of his arm. Spiral-diagonal motion is also taking place at his left arm and left leg.

Fig. 8: The bowler illustrates arm movement with three components of motion: forward, diagonally across, and rotating. Spiral-diagonal motion is also occurring at his left arm and left leg (taken from: McATEE & CHARLAND, 2007, p. 12).

5 PNF techniques

Most PNF stretching techniques are generally done with the assistance of a partner. The two main types are contract-relax (also called hold-relax) and contract-relax-contract (also called hold-relax-contract).

5.1 Contract-relax (CR)

The CR technique requires the individual to stretch the desired muscle gently. When the muscle is stretched to the point of slight discomfort, the individual isometrically contracts the muscle for 5-15 seconds against the partner's resistance. This is then followed by a brief period of relaxation before the partner slowly moves the muscle through an extended ROM. This enhanced ROM is thought to

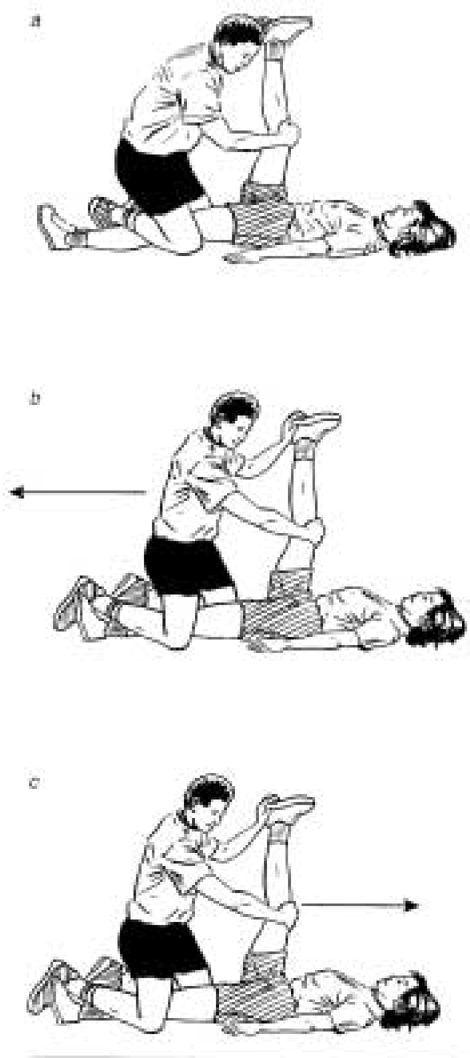

Fig. 9: PNF hamstrings stretch. (a) First phase: Subject is lying on his or her back with one leg raised 50-60° with knee locked and ankle at 90°. The partner then straddles the subject and with the partner assisting the subject, the hamstrings approach the end of their range of motion. (b) Second phase: Subject isometrically contracts the muscle for 5-15 seconds against the partner's manual resistance. (c) Third phase: Subject briefly relaxes muscle and the partner slowly moves the muscle through an extended ROM (taken from: HOFFMAN, 2002, p. 158).

occur because the isometric contraction causes a reflex facilitation and contraction of the agonist muscles (muscles that are not being stretched). This action suppresses the contraction of the antagonist muscles (muscles being stretched) during the final phase of the stretch, allowing for a greater ROM. Figure 9 provides an example of CR-PNF technique using the partner-assisted hamstrings muscle stretch.

5.2 Contract-relax-contract (CRC)

The CRC-PNF technique begins in a similar fashion to the CR technique. However, after the relaxation phase, the individual contracts the agonist muscle group (in the case of the hamstrings being stretched, the quadriceps would be contracted). The partner can also assist with this movement. The theory behind the agonist contraction is that performing a submaximal contraction of the opposite (agonist) muscle group induced additional inhibitory input to the hamstrings through reciprocal inhibition and results in a greater ROM (MOORE & HUTTON, 1980).

6 Benefits of PNF stretching techniques

- Regarding ROM, it was found that PNF techniques produce the largest gains in flexibility, as compared with other forms of stretching.
- Among other potential benefits of PNF are greater strength, greater balance of strength, and improved stability about a joint.
- Because flexibility without strength may predispose the individual to joint injury, specific PNF techniques may be useful in preventing athletic injuries by developing both qualities together.
- PNF techniques also have been claimed to improve endurance and blood circulation and to enhance coordination.
- Proponents further claim that PNF techniques result in superior relaxation of the muscles.
- Application of the PNF principles of spiral and diagonal movement patterns also produces superior three-dimensional functional ROM to standard static stretches (ALTER, 2004, pp. 166-167).

7 Controversy about PNF stretching techniques

Although PNF techniques offer many potential benefits, they also have disadvantages:

- Most PNF methods require a well-motivated individual.
- PNF stretching requires a certain amount of initial instruction and supervision.
- The assistance of a partner is often required, increasing training time.
- Certain PNF techniques are perceived as more uncomfortable and painful than static stretch.
- PNF stretching is sometimes more dangerous than static stretching because PNF stretching actually occurs with more

tension in the muscle. In particular, the CR technique, which employs an isometric contraction of the antagonist at its extreme range, applies an additional stretching force to the structures in series with that muscle, such as the tendon and its attachment. PNF procedures therefore must be closely monitored to minimise the chance of soft-tissue injury (ALTER, 2004, p. 167).

The basis of PNF is also challenged. For example, while it has been claimed that prior contraction of the muscle to be stretched will evoke more inhibitory GTO activity, HUTTON (1992) argues that there is no research evidence to support such a claim. "In fact, it has been found that PNF procedures produce greater muscle activity (as measured by electromyography) in stretched muscle. It has been proposed that effectiveness of PNF procedures may be due to an analgesic effect of 'stretch tolerance,' i. e. subjects feel less pain for the same force applied to the muscle. The result is increased range of motion, even though true stiffness does not change" (JENKINS, 2005, p. 305).

In 1998, the ACSM "added flexibility training to its exercise recommendations: stretching the major muscle groups using static or PNF techniques with a minimum frequency of 2 or 3 days per week and 3 to 4 repetitions per stretch. The intensity is holding at a position of 'mild discomfort' for 10 to 30 seconds (static) or a 6-second contraction followed by 10 to 30 seconds of assisted stretch for PNF" (JENKINS, 2005, p. 305).

References:

ADLER, S. S., BECKERS, D. & BUCK, M. (2000). *PNF in practice: An illustrated guide* (2nd ed.). New York: Springer

ALTER, M. J. (2004). *Science of flexibility* (3rd ed.). Champaign, Ill.: Human Kinetics

APPLETON, B. (no year). Stretching and flexibility. URL: http://www.cmcrossroads.com/bradapp/docs/rec/stretching/stretching_5.html

HARRIS, F. A. (1978). Facilitation techniques in therapeutic exercise. In: J. V. Basmajian (ed.), *Therapeutic exercise* (3rd ed., pp. 93-137). Baltimore: Williams & Wilkins

HOFFMAN, J. (2002). *Physiological aspects of sport training and performance*. Champaign, Ill.: Human Kinetics

HUTTON, , R. S. (1992). Neuromuscular basis of stretching exercises. in: P. V. Komi (ed.), *Strength and power in sport* (pp. 29-38). Oxford: Blackwell

JENKINS, S. P. R. (2005). *Sports science handbook: The essential guide to kinesiology, sport and exercise science* (Vol. 2: I-Z). Brentwood, UK: Multi-Science Publishing Co. Ltd.

KENT, M. (1998). *The Oxford dictionary of sports science and medicine*. Oxford: Oxford University Press

KNOTT, M. & VOSS, D. E. (1968). *Proprioceptive neuromuscular facilitation*. New York: Harper and Row

MCATEE, R. E. & CHARLAND, J. (2007). *Facilitated stretching: PNF stretching and strengthening made* *easy* (3rd ed.). Champaign, Ill.: Human Kinetics

MOORE, M. A. & HUTTON, R. S. (1980). Electromyographic investigation of muscle stretching techniques. *Medicine and Science in Sports and Exercise, 12*(5), pp. 322-329

NORRIS, C. M. (2004). *The complete guide to stretching* (2nd ed.). London: A & C Black

PRENTICE, W. E. (1983). A comparison of static stretching and PNF stretching for improving hip joint flexibility. *Athletic training, 18*(1), pp. 56-59

SHERRINGTON, C. (1947). *The integrative action of the nervous system* (2nd ed.). New Haven, CT: Yale University Press

SURBURG, P. R. (1981). Neuromuscular facilitation techniques in sportsmedicine. *The Physician and Sportsmedicine, 18*(1), pp. 114-127

VOSS, D. E., IONTA, M. J., MYERS, B. J. & KNOTT, M. (1985). *Proprioceptive neuromuscular facilitation* (3rd ed.). New York: Harper and Row