

Modified PNF as a system of physical conditioning

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Proprioceptive neuromuscular facilitation (PNF) invariably is regarded by conditioning coaches as a special type of sophisticated stretching, alongside static, ballistic and passive stretching. PNF is far more than just another stretching technique; it is actually an entire system of therapy comprising a broad spectrum of techniques and procedures for rehabilitating patients with various musculoskeletal injuries or disabilities. Stretching is only one of many aspects in the full repertoire of PNF methods, but even those enlightened coaches who use PNF extol only its virtues as a stretching system.

My earliest concept of PNF was equally narrow. It was only in the early 1970s when I was asked to offer biomechanics and strength conditioning courses for physiotherapy students at the University of Witwatersrand that I discovered PNF actually offers an entire training regimen. It intrigued me that such an extensive and potentially useful body of exercise knowledge had remained almost entirely confined to the realm of clinical practice ever since Knott and Voss had formalized PNF in their classic text of 1956 (1).

This, however, is not surprising

when one notes that the textbook stated that PNF must be applied meticulously with the hands. Those who studied under Knott in Vallejo, California, recall vividly her stern insistence on precise PNF application by well-trained hands, imposing carefully timed patterns of contraction and relaxation. It would have been heretical to have considered modifying PNF for use under less rigid conditions.

Nevertheless, the striking similarity between PNF patterns of movement and techniques of conditioning to their counterparts in sport and weight training led me to modify the broad scope of PNF so that physiotherapy students and sports coaches could apply PNF with training apparatus to prevent rather than merely rehabilitate injuries. Other modified PNF routines have formed part of my aerobic classes at the university since 1977. The modifications were necessary because certain highly efficient sporting movements do not obey all of the PNF rules, yet they offer effective conditioning and performance without injury. Moreover, the discipline of PNF as formulated by Knott and Voss includes some procedures that rely not only on proprioception, but also on other

sensory and cognitive strategies, such as the use of the ears and eyes, and specific verbal commands that elicit higher order mental processes.

Without the help of Ken Kontor, executive director of the NSCA, my modified PNF program probably would have remained just another university course. A casual demonstration of PNF techniques to Ken at NSCA headquarters in Lincoln in 1988 resulted in my presenting modified PNF as a system of physical conditioning at the 1989 and 1990 NSCA conferences.

What is PNF?

PNF was developed by Herman Kabat between 1946 and 1951 on the basis of work by renowned physiologists, including Sherrington, Hellebrand and McGraw, and Pavlov. It created a practical rehabilitative system for applying findings on the reflexes of the body, motor development of the infant and the neuromuscular responses of adults. Essentially, PNF recognizes that all physical conditioning depends primarily on neuromuscular processes involving proprioceptors in the muscles, tendons and joints that enable a person to stabilize and move the body and its

parts. Appropriate recruitment of the various stretch reflexes of the body, therefore, is a vital part of PNF conditioning.

Formally, PNF is defined as a system for promoting the response of neuromuscular mechanisms by stimulating the proprioceptors. Knott and Voss state quite simply that PNF techniques involve placing a demand where a response is required. Its relation to the well-known SAID (Specific Adaptation to Imposed Demands) principle then becomes clear.

Essentially, two types of PNF may be recognized: classical and modified. The former refers to the hands-on clinical approach described in the Knott and Voss text, while the latter refers to an approach that adapts certain PNF techniques and principles for application by hand or apparatus in physical conditioning.

In applying classical PNF, the physical therapist stabilizes specific parts of the body with the hands or body, while the other hand grips the extremity or relevant part of the patient's limb for highly specific patterns of resistance. The therapist's hand presses in a predetermined direction and manner to force the patient to execute a pattern, or the trajectory of the limb that most effectively recruits the relevant muscles. These patterns are usually imposed so that the extremity of the patient's limb is compelled to follow a spiral or diagonal path across the sagittal midline of the body. Depending on the nature and severity of the injury or disability, the therapist will encourage the patient to produce isometric or dynamic contractions for an appropriate period against the resistance of the hand.

PNF stipulates that muscle contraction must be maximal throughout the range of movement, there-

by ensuring that summation occurs at all times. Summation refers to the adding together of individual muscle twitches to produce strong, cooperative muscle movements. It occurs by imposing exercises of high intensity or prolonged duration to increase either the number of motor units contracting simultaneously or their rate of firing (or both).

At times, the therapist will produce a strong involuntary contraction in a debilitated muscle by imposing a sharp jerk during extension of the joint, eliciting the myotatic stretch reflex produced by the muscle spindles. This is particularly useful if the patient finds it difficult to initiate or sustain a muscle contraction. PNF recognizes that the myotatic stretch reflex actually consists of a short, powerful dynamic (phasic) stretch reflex and a longer, weaker static (tonic) stretch reflex. Consequently, short- and long-duration stretching loads are imposed in PNF to achieve different muscular responses.

At other times, resistance will be increased or prolonged to enhance activation of the Golgi tendon reflex, thereby tending to reduce tension in a muscle and promote local relaxation, which is sometimes desirable in executing a certain pattern.

PNF also relies on the phenomenon of reciprocal inhibition, in which strong contraction of the agonist muscles causes reflex relaxation of the antagonist muscles to prevent the latter from being injured. Application of this technique can produce a significantly stronger contraction of the agonists.

In the clinical setting, PNF requires the therapist to make regular use of verbal and non-verbal signals, including contacts with the hands or highly specific spoken

commands to direct, instruct and motivate the patient.

Sometimes, PNF uses supplementary methods such as vibration, massage, electrostimulation, ice, heat, ultrasound or stroking to augment facilitation produced by other primary means.

How PNF Relates to Physical Conditioning

Physical conditioning refers to the imposition of specific exercise loads to enhance the S-factors of fitness: strength, stamina (general cardiovascular endurance and local muscular endurance), suppleness (flexibility), speed, skill (kinaesthesia, motor coordination and control), structure (size, shape) and spirit (psychological fitness). Within the context of this definition, PNF can provide a highly systematic approach to improving all of the S-factors except cardiovascular endurance and psychological fitness.

PNF teaches therapists to apply repetitions of graded resistance, to incorporate phases of relaxation, to elicit reflexes to facilitate contraction and greater range of movement, to impose specific patterns of passive and active movement, to use supplementary procedures for enhancing performance and generally to stimulate all neuromuscular processes related to voluntary and involuntary movement. No training method could be required to offer much more than this repertoire to qualify as an all-around holistic conditioning system.

The Fundamentals of PNF

PNF may be categorized in terms of five P-factors: principles, procedures, patterns, positions and postures, with joint pivots as an important sub-category. The methods comprising these factors were formulated from findings on neuro-

muscular development, such as total to individual, proximal to distal, mobile to stable, gross to selective, reflexive to deliberate, overlapping to integrative, and incoordinate to coordinate.

The Principles of PNF

The basic principles of PNF may be summarized as follows:

1. Use of spiral and diagonal movement patterns.
2. Motion crossing the sagittal midline of the body.
3. Recruitment of all movement components, especially, flexion-extension, adduction-abduction and internal-external rotation.
4. Exercising of related muscles groups.
5. Judicious eliciting of reflexes.
6. Movement free of pain but not free of effort.
7. Comfortable full-range movement.
8. Application of maximal resistance throughout the range of non-ballistic movement.
9. Use of multiple joint and muscle action.
10. Commencement of motion in the strongest range.
11. Use of static and dynamic conditions.
12. Appropriate positioning of joints to optimize conditioning.
13. Exercising of agonists and antagonists.
14. Repeated contractions to facilitate motor learning, conditioning and adaptation.
15. Selection of appropriate sensory cues (tactile, auditory, visual) to facilitate action.
16. Emphasis on visuo-motor and audio-motor coordination.
17. Use of distal to proximal sequences in neuromuscularly mature subjects.
18. Use of stronger muscles to

augment the weaker.

19. Progression from primitive to complex actions.
20. Planning of each phase to lay foundations for the next phase.
21. All activities are integrated and goal-directed.
22. Use of adjunct techniques (cold, electrostimulation, massage, vibration, stroking).

Procedures of PNF

The procedures (or techniques) used in PNF include:

1. Use of specific manual contacts with the body to facilitate and guide movement.
2. Application of maximal tolerated resistance.
3. Use of oral commands and non-verbal cues to facilitate correct movement.
4. Eliciting of maximal stretch reflex in the lengthened muscle range (Starling's Law).
5. Use of appropriate timing and sequencing of all actions.
6. Application of traction or approximation (compression) to stimulate joint receptors.
7. Inclusion of recuperative motion to reduce or avoid fatigue produced by resisted activity.
8. Use of Specific Activation Techniques to develop full range of voluntary movement.
9. Use of Specific Relaxation Techniques.

The Specific Activation Techniques need to be elaborated upon, as follows:

Repeated Contractions. Repetition of muscle contraction is necessary for motor learning and the development of strength, muscle endurance and flexibility. PNF uses precise sequences or patterns of isometric, concentric and eccentric contraction, sometimes augmented by application of neuromuscular

reflexes (i.e. methods that are sometimes equivalent to plyometrics).

Rhythmic Initiation. This technique employs phases of voluntary relaxation, passive movement and repeated dynamic contractions of the major muscle groups involved in the agonistic pattern of movement. It is valuable with subjects who struggle to initiate activity because of rigidity or spasticity.

Reversal of Antagonists. This action occurs naturally in numerous activities such as walking, running and sawing wood. If the antagonists do not reverse competently in terms of strength, speed and coordination, motor efficiency is impaired. PNF uses three methods of reversal: slow reversal, slow-reversal-hold and rhythmic stabilization.

Slow reversal involves dynamic contraction of the antagonist slowly followed by dynamic contraction of the agonist. Slow reversal-hold employs dynamic contraction followed by isometric contraction of the antagonist, finally followed by the same contraction sequence for the agonist. Rhythmic stabilization involves isometric contraction of the antagonist, followed by isometric contraction of the agonist, thereby producing co-contraction of the antagonists.

The Specific Relaxation Techniques similarly need to be expanded upon, because they include the so-called PNF stretching techniques popularly used in athletic conditioning.

Contract-Relax. This action involves a dynamic contraction of the antagonist against maximal resistance, followed by a phase of relaxation. This technique is repeated several times, beginning and continuing from a point where the limb is moved to its limit of pain-free action. The practitioner

resists the contraction as strongly as possible and then instructs the patient to relax before decreasing the force and waiting for the relaxation to occur. The limb is moved passively to its new limit of extension and the process is continued gently for a few repetitions.

Hold-relax. This action is similar to contract-relax except that isometric rather than dynamic contraction against maximal resistance is applied at the limit of the patient's movement before relaxation is commanded.

Slow-Reversal-Hold-Relax. This movement comprises four stages: dynamic contraction of the antagonists involved, isometric contraction of the antagonists, brief voluntary relaxation and dynamic contraction of the agonists. These stages are applied to the muscles in the specific pattern needed to relax the group of muscles concerned, using several repetitions to enhance functional flexibility.

Patterns of PNF

Probably the most neglected aspect of PNF by the athletic community is the employment of specific patterns of joint and limb movement to recruit and condition muscles in the most efficient manner. Physiotherapists spend considerable time learning the intricacies of patterns to stabilize some parts of the body and to activate other parts using the procedures outlined above.

In conditioning the developing neuromuscular systems of the patient, novice or child, there is always an emphasis on progression from primitive to complex, gross to individual, mobile to stable, reflexive to deliberative, proximal to distal and incoordinate to coordinate. Contrary to common belief, the novice must be taught from a base of mobility to progress to stability,

just as an infant learns to stand by first moving, staggering and exploring the environment.

The movement patterns involve the application of all the above principles of PNF, such as the use of spirals and diagonals, crossing of the body's midline, judicious eliciting of reflexes, and emphasis of muscle actions by use of correct timing. Movement is promoted by the eyes following the extremities or the extremities following the eyes.

Because all physical conditioning requires a constant interplay of mobility and stability, all patterns implicate some parts of the body in stabilizing and other parts in mobilizing. For instance, both static strength and static muscular endurance might have to be developed in the back muscles of an athlete, while three-dimensional dynamic strength, dynamic muscular endurance and dynamic flexibility might have to be developed in the upper leg. This type of conditioning cannot be applied by machines, although a pulley system may be used to produce the appropriate whole-body patterns of movement required. In other situations, the goal of training may be to prevent motion and stimulate stability or maintain balance. Compensatory movements of additional muscle groups may be resisted or even elicited by brief, sudden actions or deviations from optimal patterns.

Some devices, such as pec decks, back hyperextension machines, seated pressing machines, hack squat machines and leg extension machines, cause such large deviations from recommended PNF patterns that they can impose excessive loads on certain joints and are suitable only for a small part of the training of highly conditioned athletes. Even then,

machine training often is not functionally similar to the natural patterns of exercise movement upon which PNF is based, so it requires a disproportionate number of machines to approximate the training offered by free weight and pulley training in three-dimensional space under conditions of normal timing (yet another PNF principle). Normal timing refers to the timing of the phases of a movement or series of movements that occur naturally in a healthy patient carrying out a prescribed activity efficiently and safely.

PNF offers an enormous repertoire of patterns, including those for sitting, sitting up, rotating, standing, kneeling, crawling, raising the head, raising and lowering the arms or legs, moving the trunk and raising or lowering the body. There are distinctive patterns for actions with straightened, flexed and extended limbs.

Because weight training is aimed at maximal muscle conditioning through the use of techniques experimented with by weightlifters, bodybuilders and powerlifters for many years on every conceivable type of apparatus, there is no better environment to apply modified PNF for improving overall conditioning. It is impossible within the constraints of this article to cover how the encyclopedia of PNF techniques may be adapted for the gymnasium environment, so future articles will have to focus on specific applications. Meanwhile, the reader can refer to videotapes of the modified PNF training system presented by the author at the 1989 NSCA conference. They illustrate much of the basic theory as well as some typical movement patterns.

Positions and Postures of PNF

Positions and postures are an

integral part of the use of PNF patterns. The body and its limbs have to be held in carefully prescribed postures, with the joints and limbs maintained in certain positions or moved to establish stability of some systems and mobility of others in order to enhance neuromuscular development and safety. All action can then take place around specific joints as pivots. For instance, a dumbbell curl performed with the elbow dug firmly into the side will produce activation patterns and results that are distinctively different from dumbbell curls done with the elbow and shoulder free to flex, extend or rotate. Besides the possibility for cheating and trapezius involvement for the unrestrained elbow curl, downward traction can occur at the shoulder joint.

What is Modified PNF?

Modified PNF refers to the adaptation of aspects of strict PNF for use in the athletic conditioning setting or fitness class. Not only does it modify some PNF partner stretches for use by unassisted individuals, but it can also include application or adaptation of any of the PNF principles, procedures, patterns, positions and postures in the normal conditioning environment.

Pulleys and dumbbells are especially suitable for application of the spiral and diagonal, midline-crossing PNF techniques. The standing, full-range, cable cross-over exercise with external-internal rotation of the shoulder joint is just one example of an adapted PNF pattern. Barbell training provides fewer opportunities for the use of PNF training, while machines offer the fewest possibilities for use of modified PNF.

This does not imply that barbell and machine training should be avoided. On the contrary, it can be used effectively under special cir-

cumstances, sometimes to cause intentional deviations from PNF patterns to adapt the body to potentially harmful actions that may occur in real sport situations. A major error in the use of machines is that they are invariably regarded as offering greater stability and safety for beginners than free weights. In fact, their design imposes body positions, postures and activation of pivots that usually differ considerably from those recommended by PNF and compromise the effectiveness and safety of the exercise. In other words, instructors must always spot for the users of machines as well as of free weights, just as physiotherapists regularly use manual contact and verbal reinforcement.

Conclusion

Although some of us in the strength and conditioning profession have used the term "modified PNF" for many years, its appropriateness needs to be re-examined for a variety of reasons. First, it is sometimes desirable to deviate from strict PNF principles to achieve a specific goal. Second, there are other movement disciplines, such as Feldenkrais, Alexander, yoga, tai chi and Laban, which offer invaluable additional methods of conditioning the body. Third, PNF might not only involve neuromuscular processes, because contractile activity in a muscle may be facilitated by local after-discharge of the same muscle (3). Fourth, the PNF repertoire includes methods that may not be classified accurately as proprioceptive, such as cognitive, perceptual and other sensory mechanisms. Finally, the term proprioceptive neuromuscular facilitation is too technically daunting for the average coach or athlete.

Consequently, the term functional neuromuscular conditioning

(FNC) would be more appropriate, because PNF and other movement disciplines stress the importance of optimizing the conditioning effect to produce functional fitness of the neuromuscular system at work and play. Because Wolff's Law states that function precedes structure, FNC may be seen to embrace holistic development of function and structure. This is precisely how FNC should be regarded, as an entire conditioning system that is capable of developing any desired type of musculoskeletal fitness. ☉

References

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