The Application of the Principles and Procedures of PNF for the Care of Lumbar Spinal Instabilities

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Abstract: Proprioceptive Neuromuscular Facilitation (PNF) is a dynamic manual approach to the evaluation and treatment of the neuromusculoskeletal system. This treatment approach has broad application for patients with both neurological and orthopedic problems. The authors have developed a systematic protocol using the philosophy and procedures of PNF integrated with other manual therapy procedures for the care of lumbar instabilities. This article will present the history, philosophy, basic principles, and procedures of PNF and their use in the treatment of lumbar spine instabilities.

Key Words: Proprioceptive Neuromuscular Facilitation, Lumbar Spine, Hypermobile, Exercise, Rehabilitation

PNF was developed by Herman Kabat, MD[1-2] and Margaret Knott, PT,[3] during the 1940s and early 1950s. Initially the approach was developed as a method to treat patients with neurological dysfunctions. Kabat explored the literature to find basic neurophysiologic principles that could serve as the foundation for a more dynamic and functional approach to patient care. As cited by Knott and Voss[4] and Voss[5], he studied researchers such as Sherrington, Gellhorn, Coghill, Gesell, Hellebrandt, and others. These authors reported that resistance, stretch reflexes, irradiation, and other proprioceptive inputs could influence a muscle response. Stimulated by his findings, Kabat researched the work of Sister Elizabeth Kenny who, according to Knapp[6], was successfully using manual resistance and neurophysiological principles to facilitate active functional movement in patients with poliomyelitis.

Kabat, a physician who enjoyed treating patients using manual techinques, began to put into action the knowledge he had acquired through research, along with the clinical knowledge gained from studying the Kenny approach. His goal was to meet the needs of patient's with neurological disorders by focusing on the reeducation of the patients' developmental postures and movements. Kabat[2] believed this approach would help patients achieve more efficient function and independence.

Over time, this new approach, later called PNF, evolved in its specificity and application for other patient populations. When Knott began to work with Kabat in the mid-1940s, they focused on using these concepts for the facilitation of efficient motor recruitment patterns. This commitment towards developing specificity through facilitation laid the groundwork for the effectiveness of PNF as a broadly applicable manual therapy approach. During this time period, the PNF patterns of facilitation were developed.

Regardless of the underlying pathology, evaluation and treatment of structural and neuromuscular dysfunctions depends on specific motor recruitment and control. The PNF approach offers the trained clinician tools to evaluate quickly and effectively both neuromuscular control and structural components. It builds on the concept that motor recruitment may be enhanced through appropriate use of reflexes and proprioceptive input. PNF con-

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tinues to evolve through clinical experience and scientific advances, but the initial concepts and principles developed by Kabat and Knott remain the same. From these original concepts, scientific advances and clinical experience have assisted in developing an organized approach for the care and management of spinal instabilities.

Functional and Neuromussular Approach to Spinal Problems

A primary goal of the PNF approach is to facilitate an optimal structural and neuromuscular state. PNF applies neurophysiological principles of the sensorimotor system to manual evaluation and treatment of neuromuscular skeletal dysfunctions. The approach provides the therapist with an efficient means for evaluating and treating structural and neuromuscular dysfunctions[2, 4,5,7,8].

Structural dysfunctions (myofascial and articular hypermobilities and hypomobilities) affect the body's capacity to assume and perform optimal postures and motions. Structural dysfunctions are often are associated with the presenting symptoms[4, 9-11].

Neuromuscular dysfunctions (inability to coordinate and efficiently perform purposeful movements) cause repetitive, abnormal, and stressful usage of the articular and myofascial system, often precipitating structural dysfunctions and symptoms[7, 12-14].

By emphasizing the treatment of dysfunctions, PNF assists in reducing symptoms, improving the distribution of forces through the symptomatic region, and reducing the inherent functional stresses caused by poor neuromuscular control[4,7,15-16]. The PNF method integrates soft tissue mobilization and joint mobilization with neuromuscular reeducation, melding them into a dynamic treatment approach. This multidimensional treatment approach is called *Functional Mobilization*[10,15-16].

Improvements in medical evaluation of spinal problems through innovative imaging techniques and injections have assisted in establishing diagnoses, whereas new surgical procedures have improved the prognosis of complex spinal problems[9,12-13,17-18]. Conservative care clinicians and researchers have begun to add functional and neuromuscular assessments to the classical symptomatic and structural approaches. Functional and neuromuscular approaches expand upon the classical diagnostic evaluations[19]. These new approaches espouse basic philosophies that evaluate the patients:

Habitual use of inefficient and stressful postures and movements.

Dynamic strength, controlled stability, flexibility, and coordination.

Specific muscle function within functional movement patterns.

Existing environmental and personal factors.

The foundation of these approaches is the recognition that there are chronic processes and activities that contribute to the development of spinal symptoms and pathology. Regardless of the specific diagnosis, the patient's habitual patterns of spinal usage and motor recruitment need to be addressed as a component of a comprehensive rehabilitation program[13, 14, 17, 20,21-24].

Definition of Terms

Within the medical profession the terms *hypermobility* and *instabilities* have often been interchanged. The following definitions from the literature describe the degenerative progression from normal mobility to varying degrees of hypermobility and clinical instability.

Hypermobility - A range of motion somewhat in excess of the expected for the particular segment, given the subject's age, body type, and activity status. These joints are essentially normal and "generally" do not give rise to symptoms unless the ligamentous components, including the outer annulus, have elongated to the extent that upon the assumption of a static posture, further elongation triggers the nocioceptors, giving rise to discomfort, necessitating another change in posture[25].

Instabilities - Exists only when, during the performance of an active motion, there is a sudden aberrant motion, such as a visible slip, catch, or shaking of the motion segment, or when there is a palpable difference in the body position between standing and lying (e.g., an unstable spondylolisthesis). These differences between hypermobility and instability can and should be detected during the physical therapy examination[25].

Clinical instability - Segmental instability occurs when an applied force produces displacement of part of a motion segment exceeding that found in a normal spine[26-28].

Lack of stability - The maintenance of stability of the lumbar spine during movement requires the coordinated actions of multiple motion segments; a lack of stability may potentially occur at any lumbar segment in either transitional or rotational movements, or both[29].

Neutral zone concept - Panjabi defines segmental instability as a decrease in the capacity of the stabilizing system of the spine to maintain the spinal neutral zones within physiological limits so that there is no neurological deficit, no major deformity, and no incapacitating pain[30].

The PNF and Functional Mobilization approaches expand these mobility concepts through the functional component of evaluation through manual resistance. The therapist assesses the quality of neuromuscular recruitment and control that exists in the tonic (stabilizing) and phasic (movement) muscles at the level of the dysfunction. The most problematic instabilities involve segments where there is insufficient muscle control to stabilize and control movement in a coordinated and pain free manner[31-32].

PNF and Functional Mobilization Ten-Step Protocol for Lumbar Instabilites

The following ten-step protocol has been developed for the management of spinal and pelvic girdle instabilities:

1. Conventional physical therapy orthopedic evaluation[9, 11-12].
2. Functional postural assessment tests - Vertical compression and elbow flexion tests[10,15].
3. Trunk responsiveness assessment - Lumbar protective mechanism[10,15,19].
4. Preparation of the surrounding myofascial components[10].
5. Lumbar spine and pelvic girdle passive and active intersegmental mobility for the identification of hypermobilities and hypomobilities[11].
6. Neuromuscular control and segmental stability of the hypermobile segments[10,15].
7. Trunk coordination through mass trunk and reciprocal patterns[10,15-16].
8. Weight bearing segmental and lumbo-pelvic girdle stability[10,15].
9. Back Education and Training - Teaching the patient how to perform activities of daily living in the most efficient and strain-reducing manner to protect the unstable segment[19].
10. Exercise and rehabilitative program - A specific rehabilitative exercise program designed to maintain and gain mobility, stability, strength, and coordination of the affected region.

Before presenting an in-depth coverage of each protocol, an overview of the basic philosophies, principles, and procedures of PNF is provided.

PNF Basic Philosophy

The philosophy of the PNF approach is based upon the premise that "all humans have untapped existing potential". Therefore, the physical therapists role is to identify dysfunctions, facilitate the patient's optimal physical capacity, and develop effective patient rapport[4,33]. An important aspect of establishing rapport is to emphasize the individual's physical, mental, emotional, and spiritual strengths, rather than their deficits. Optimal results are best achieved by developing clear and attainable short and long-term goals. Based on these established goals, the treatment program is specifically designed to address the identified functional limitations and personal needs.

The basic premise of treating orthopedic patients with neuromuscular dysfunctions is to initially treat the individual components of dysfunctional complex motor skills. This developmental approach emphasizes selective reeducation of individual motor elements through developing the foundational skills of trunk control, stability, and coordinated mobility. Basic motor skills are progressed and integrated into complex postures and movements such as rolling, crawling, and gait. Each movement and posture learned is reinforced through repetition in an appropriately demanding and intense training program developing a base line of strength and endurance. This rehabilitative program may include manual treatment, a home exercise program, group exercise classes, and/or a progressive gym program. The programs intensity is graded to meet the patient's specific needs related to their daily activities[4,15-16].

PNF Basic Principles

The basic principles of PNF are founded upon clinical experience and sound neurophysiological and kinesiological principles[4, 15,16]. Each principle is an essential component of the approach and provides the basis for developing consistency throughout the evaluation and treatment process. The therapist uses these basic principles to assess and enhance postural responses, movement patterns, strength, and endurance.

Patient Position

Position the patient for comfort, optimal facilitation, and accessibility to the dysfunctional region. The initial consideration of the therapist includes use of appropriate supports.

Manual Contacts

The psychological effect of manual contact is well known[4, 34]. The comment "you are the first one to really touch me where it hurts" is frequently made after the initial evaluation by a skilled manual therapist. The inherent responsibility of a manual therapist is to maximize the psychological benefit of touch, by establishing trust and cooperation without facilitating dependency. The quality of touch influences the patient's confidence and the appropriateness of the motor response and relaxation. Therefore, sensitivity and specificity should be employed when applying a manual contact. The therapist should be consistent and specific with all manual contacts to allow for accurate evaluation, effective treatment, and continuous reassessment.

On a physical level, appropriate manual contacts to the skin and deeper receptors influence neuromuscular responses[35-36]. Through the use of appropriate and specific manual contacts, the therapist can influence and enhance the direction, strength, and coordination of a motor response. Appropriate manual contacts are applied to the skin surface on the side to which the movement or stabilizing contraction is desired[4,15-16]. Use of a lumbrical grip is the most effective means of applying appropriate manual contracts. This allows for a less compressive grip, while still facilitating specific unidirectional contact.

Therapist Position and Body Mechanics

An essential aspect in applying appropriate manual contacts is the therapist's use of proper body position and mechanics[4,15]. The therapist needs to position his or her center of gravity and base of support in line with the direction of motion being resisted. This position allows the movement to occur either towards or away from the therapist, so that weight transference and acceptance can be coordinated and smooth. The therapist's total body and arm movement should equal the same excursion and reflect the same arch of motion as the body part being treated. The therapist's spine should remain in a neutral alignment with motion occurring primarily in the hips, legs, and arms.

Appropriate manual contacts and body position provide resistance from the therapist's trunk rather than the upper extremities. Therefore, the arms can relax and better translate the resistance and evaluate the motor response. The slightest deviation from the use of appropriate position and body mechanics can alter the desired response and distort the therapist's evaluation[4,15-16].

Appropriate Resistance

Appropriate resistance is the amount of resistance, which facilitates the desired motor response of a smooth, coordinated, and optimal muscle contraction[4,15-16]. Appropriate and variable resistance is applied to an active contraction for two purposes:

Initially, the resistance allows the therapist to evaluate the patient's motor response. Characteristics of motor control include factors such as coordination, strength, initiation, stabilization, endurance, relaxation, and quality of contraction. These characteristics are assessed when manual resistance is applied to the patient's contraction[4,7,15].

If a dysfunction is identified in any of these characteristics, appropriate resistance applied in conjunction with various PNF techniques facilitates the relearning and rehabilitation process[4,7-8,15].

During normal activities the neuromuscular system utilizes a variety of muscle contractions to meet the normal demands of efficient motor control[32,37]. The patient's capacity to stabilize (isometric), as well as move (isotonic), can be specifically evaluated through manual resistance. The use of resistance allows the therapist to determine the patient's ability to perform and integrate each of these contractions selectively and efficiently. Identified dysfunctions are specifically treated to facilitate optimal function. The kinesiologic definitions of isometric and isotonic contractions vary within the literature. We define these terms to correspond with *functional evaluation and treatment* represented by the PNF approach.

Isometric contractions - Traditionally, an isometric contraction is one in which "the external force is equal to the internal force developed by the muscle and no external movement occurs"[37-38]. The functional definition builds to include the intention of the patient. We believe that an isometric contraction is a stabilizing contraction "in which the patient's intention is to maintain a consistent position in space". The use of slowly building and matching resistance, coupled with the verbal command, "keep it there," allows the therapist to specifically isolate motor contractions without facilitating compensatory motions[4,15].

Isotonic contractions - The traditional definition of an isotonic contraction is, "a contraction in which the external force is constant and motion occurs"[36-37]. An isotonic contraction as defined in the PNF approach is one "in which the patient's intention is to move" [4,15]. Isotonic contractions are subdivided into concentric (a dynamic shortening of a muscle), eccentric (a dynamic controlled lengthening), and maintained contraction. A maintained contraction is a dynamic contraction in which the patient's intention to produce movement is limited by a greater external force. We believe that this contraction differs from an isometric contraction, because the intention of the patient is to maintain a stable position. By applying increased resistance without allowing movement, the therapist allows for appropriate summation to occur[4,15-16].

Each of these contractions needs to be specifically evaluated and facilitated through manually applied appropriate resistance. Whereas, mechanical resistance that does not vary, cannot create the adaptability needed to stimulate these differentiated contractions. The therapist varies the type and degree of resistance to facilitate an appropriate response. The resistance must vary in application to evaluate and treat dysfunctions of selective motor control, coordination, endurance, strength, initiation, stabilization, and/or relaxation.

Irradiation - Resistance can also be used to produce appropriate irradiation[4,15]. Irradiation is defined as "the overflow of excitation from stronger components to weaker or inhibited components"[4,15-16,22,39-40]. This overflow is accomplished through the application of graded resistance to stronger components to facilitate irradiation and produce an appropriate and enhanced contraction in weaker ones.

Many variables need to be considered in order to facilitate an efficient motor response with appropriate resistance. The therapist must be aware of the patient's position, gravity, existing normal and abnormal reflexes, manual contacts, and body mechanics. The encouragement and training of controlled breathing further reinforces efficient movement.

Traction and Approximation

Traction and approximation utilize force vectors to assist the resistance and to facilitate the desired motor response[4,15-16,39]. They supply a reflex enhancement to the volitional response to resistance. Therefore, a blending of traction or approximation with resistance ensures smooth and appropriate resistance.

Traction - The elongation of a segment and separation of joint surfaces that facilitates an enhanced muscular response to promote movement or stability. The direction of traction is always applied perpendicularly away from the apex of the arc of motion[4,15].

Approximation - Approximation is a compressive force toward the axis of motion resulting in joint surfaces being compressed. It facilitates an increased muscular response and promotes stability and is applied when facilitating stability in weight bearing postures or positions[4,8,15,16,41-42]. The desired response can be initiated or reinforced by a reflex producing quick approximation followed immediately by a maintained approximation and resistance. Even though reflex responses can be facilitated through use of traction and approximation, these responses are not therapeutic unless coupled with a volitional contraction and appropriate resistance.

Caution - When applying traction or approximation care must be taken to avoid increasing pain and consideration must be given to the underlying pathology. In many cases in which the joint is the source of pain, judicious use of traction or approximation may decrease symptoms and allow for a more intensive rehabilitation program. Pain that is secondary to articular instability may be reduced with a combination of resistance and traction or approximation, allowing for greater facilitation of neuromuscular stabilization.

Quick Stretch

In the presence of weakness, in-coordination, poor initiation, or poor endurance a volitional contraction can be heightened and reinforced through the use of spinal reflexes. PNF uses a facilitating cue termed *quick stretch* to offer a stretch stimulus and produce a desired stretch reflex[4,8,15,43-44]. The reflex response produces a quick, short-lived contraction. To be facilitatory and therapeutic, this contraction is reinforced with a volitional contraction, resistance, and appropriate verbal command. Quick stretch can be applied at the beginning of a contraction when the muscle group is lengthened or throughout an active contraction.

Verbal Stimuli

The therapist's verbal command is a primary link between reflex responses and the patient's volitional response[4,15-16]. Without the use of verbal commands, there is no cognitive reeducation taking place, only reflex responses to proprioceptive input. Verbal commands coupled with manual contacts provide the therapist with the primary tools for establishing communication and cooperation. Verbal commands should be simple, concise, and unidirectional. In addition, the quality of the verbal command should vary depending upon the type of motor response desired from the patient[4,15].

Visual Stimuli

The visual system is important in the normal development and coordinated use of the body. The therapeutic use of visual stimuli goes beyond the use of vision to teach an activity. Developmentally, the neuromuscular system gains control in a cephalic to caudal direction. Movement of the trunk and extremities can be facilitated by the incorporation of the visual system, which requires integration of the head and neck. Failure to evaluate and include the visual system in a rehabilitation program can inhibit or retard the development of complete and coordinated trunk and extremity control. In addition, balance and equilibrium responses rely heavily on visual input for accurate interpretation of spatial relationships[4,15-16,35,45-46].

Patterns of Facilitation

The patterns of facilitation were discovered by Kabat in the final stages of his development of the PNF approach[4]. Through the use of all the previously identified principles, Kabat began to understand and recognize the inherent movement patterns that humans use to perform normal functional and athletic activities. He observed that normal coordinated activities are accomplished by moving the extremities and trunk in diagonal and spiral motions in relationship to each other. He noted that muscular responses were stronger and more coordinated when resisted within specific diagonal patterns. In addition, the use of reflex facilitation such as the stretch reflex, was most effective when the part was elongated in its specific diagonal. These observations lead Kabat to question the validity of using cardinal plane motions in the rehabilitation of functional activities, because normal motion is performed in diagonal and spiral patterns. Through trial and error, Kabat and Knott developed the specified trunk and extremity patterns of facilitation.

The patterns exist in narrow diagonals in relationship to the central axis of motion of the extremity and trunk. Each pattern is as wide as the part being treated and moves within a smooth arc of motion. Three components of motion are blended within each diagonal movement pattern. In the trunk the components are flexion/extension, lateral movement, and rotation. In the extremities the components are flexion/extension, abduction/adduction, and rotation. The scapula and pelvis perform anterior/posterior and elevation/depression motions[4,15,-16]. By using the PNF patterns of facilitation, the therapist can evaluate more quickly and effectively neuromuscular control and range of motion within synergistic muscle groups and the mobility of underlying articulations. When dysfunctions are identified, specific PNF techniques are applied to enhance the desired movement.

Patterns of facilitation provide tools to evaluate and treat dysfunctions of neuromuscular control and mobility of selective spinal articulations. In addition, patterns provide the ability to evaluate synergistic muscle group's ability to integrate and coordinate their contractions. As selected control is developed, synergistic muscle activity is integrated into functional whole body movements. Through use of patterns of facilitation, the patient is given the opportunity to perform correctly and learn the desired motor response and integrate that response into daily functional activities[15].

Timing

Normal timing refers to the efficient sequencing of dynamic muscle contractions to achieve a desired functional result[4,46-47]. This timing includes the sequence in which the muscle fires and the controlled interaction between mobility and stability of the selected components of a movement. In patients with orthopedic and sports injuries, there is often a deficit in normal timing during the performance of patterns within symptomatic regions. These deficits are identified through manual and observational assessment. Treatment of dysfunctions of normal timing can occur through multiple avenues[4,15-16].

The motion or activity is reduced to the simplest components, and an optimal contraction of each is facilitated. These individual components are then combined into the desired functional motion or activity. If abnormal timing is evaluated in a complex skill, such as walking, less complex motions, such as rolling and crawling, can be used initially to train timing and kinesthetic awareness.

Resistance, quick stretch, and verbal commands are used to reinforce normal timing.

The PNF Techniques

A basic tenet of PNF is to use the proprioceptors and other neural facilatory or inhibitory mechanisms to hasten or make easier the learning of a neuromuscular skill. Success of treatment is achieved through the therapist's ability to evaluate the functional and structural problems and to select the appropriate technique to address the dysfunction. Of the many techniques developed within the PNF system, the following have been selected as the most important in the care of spinal instabilities.

Combination of Isotonics

Combination of isotonics[15] is used to evaluate and develop the ability to perform controlled, purposeful movements. Evaluation is accomplished through the assessment of the patient's capacity to alternate between the three types of isotonic contractions (concentric, eccentric, and maintained).

The therapist begins by assessing the patient's capacity to perform and transition between the three types of isotonic contractions within the normal range of a selected agonistic contraction. The exact timing and speed of the transitions depend on the patient and the goals of treatment. When the dysfunction is identified, the technique is initiated by using the type of contraction the patient performs best. Dysfunctions include poor concentric, eccentric, and control of maintained contractions; inability to utilize full range of motion; decreased neuromuscular control; and decreased range of motion.

Reversal of Antagonists

Most activities depend on coordinated control of antagonistic muscle groups[4]. This control is essential to produce efficient interaction between the demands for mobility and stability. When an agonist fails to work in accordance with the demand of the activity, function is immediately impaired. These techniques are based upon Sherrington's principle of successive induction[4]. The reversal of antagonists techniques are designed to:

Facilitate coordinated transitions between reciprocal contractions.

Facilitate a weaker antagonist.

Reduce fatigue.

Improve coordination.

Increase active range of motion.

Enhance carry-over of reciprocal function into functional activities.

Produce a reduction in antagonistic activity. There are two reversal of antagonists techniques - isotonic reversals and stabilizing or isometric reversals.

Isotonic Reversals

The isotonic reversal technique, also called slow reversals, is applied by resisting alternating concentric contractions[15]. The speed and the range of motion used depend on the patient's needs and abilities. This tool is used in the middle stage of rehabilitation for spinal instabilities to assist in developing controlled reversals of motion in the unstable segment.

A concentric contraction is initiated, through either a verbal command alone or one that is timed with a stretch reflex. At the location in the range of motion that the reversal is desired, the therapist smoothly shifts from applying resistance with both hands to one (usually freeing the proximal hand). The free hand then begins to apply resistance to the antagonistic surface, and for a brief time the hands are contacting both surfaces. A reversal of direction is elicited through a verbal command. The goal is to train the patient to change direction smoothly.

Applying manual resistance to the antagonist pattern before the reversal can facilitate a weaker agonist group. When the patient demonstrates difficulty in reversing the direction smoothly, the therapist may us a maintained isotonic contraction to the agonistic motion. This maintained isotonic contraction facilitates the antagonistics motion and allows the therapist time to change manual contacts. As the patient develops the ability to reverse directions smoothly with simple non-weight-bearing patterns the skills are advanced to more complex functional activities[15].

Stabilizing Reversals

Stabilizing reversals, also called *Rhythmic Stabilization,* are applied by resisting alternating isometric contractions[4]. The goals of the technique are to improve stability around a segment, to increase positional neuromuscular awareness, to improve posture and balance, and to enhance strength or stretch sensitivity of the tonic muscles in their functional range. The technique is also used to reduce pain, facilitate relaxation, and increase range of motion. This technique also offers the therapist a significant amount of information about the patient's ability to reinforce the contraction through appropriate irradiation.

To apply the technique, manual contacts can be placed on either one side of the trunk or extremity or on both sides. The therapist begins by gradually increasing resistance, either unidirectional or rotational, through both hands coupled with the verbal command, "keep it there; don't let me move you." The therapist slowly increases the resistance in direct proportion to the patient's response. This matching or isometric contraction is built to a maximal level without promoting a concentric response. Once the contraction has plateaued, the therapist can slowly change the manual contacts to place a varying demand on the stabilizing muscles. To shift a manual contact, one hand must adjust resistance to maintain the contraction, while the other hand slowly releases its resistance. The free hand is then shifted to another appropriate surface. The transition must be smooth, not allowing for any relaxation or initiation of motion. If the patient is not able to perform an isometric contraction a maintained isotonic contraction is used.

Contract and Hold Relax

The techniques of contract and hold relax are designed to facilitate relaxation and increase range through neuromuscular relaxation and stretching of the intrinsic connective tissue elements of the muscle[4]. The contract relax technique utilizes either a concentric or a maintained isotonic contraction, whereas the hold relax uses an isometric contraction. Hold relax is the technique of choice in the presence of pain or when the concentric contraction is overpowering for the therapist.

To perform these techniques, the segment is placed at the point of limitation within the movement pattern. Resistance is applied to a concentric contraction of either the restricted agonist (direct contraction), or to the antagonist (reciprocal relaxation). All components of the pattern should be resisted, and with contract relax a few degrees of motion is allowed. Special emphasis should be placed on the rotatory component of the pattern, because it facilitates a more complete contraction and relaxation. The direction and intensity of the contraction should be sufficient to generate a strong contraction within the target muscles. After the contraction, the patient is asked to relax completely, and upon full relaxation the segment is passively or actively taken into the new available range. Resisted motion into the new range can be used for reinforcement, strengthening, or further reciprocal inhibition[4,8,15,33,48-50]. For treatment of pain with hold relax, the part should be positioned in a pain-free aspect of the range of motion. The isometric contraction is slowly built and released. These contractions can be repeated until the degree of pain is reduced.

Ten Step Protocol for Lumbar Instabilities

The use of PNF for spinal dysfunction is enhanced by a working knowledge of arthrokinematics, neurophysiology, and pathomechanics of the lumbar spine. The following protocol's effective application requires an in-depth understanding of the principles of manual therapy.

1. Conventional physical therapy orthopedic evaluation

Subjective evaluation - The initial subjective evaluation should provide insight into symptoms, history, irritability, and normal daily course of symptoms. Specific subjective information can assist both the patient and therapist in understanding the evolution and status of the present symptoms and for evaluating the effectiveness of treatment. Instabilities or hypermobilities can be noted through the following subjective reports[12,15-17,25,51]:

Repetitive motions of the segment frequently produce symptoms that ease with rest.

Prolonged end-range postures produces symptoms that ease with changing positions and/or movement.

"Catching" or sudden sharp pain occurs during specific motions. These motions generally include rotation, and the symptoms eases with return to a neutral posture. Patients tend to grasp or push on the thighs to assist in returning from a flexed standing posture.

Fixation or locking of segment with acute symptoms often persist until the restriction is resolved.

Localized muscle guarding around dysfunctional segments.

The patient often reports feeling vulnerable or unstable in that region and is naturally cautious and hesitant with normal and stressful activities.

Objective Evaluation - The initial orthopedic objective evaluation, that includes a neurologic screening, helps to provide objective parameters from which to set goals for treatment and to assess progress. The evaluation should include specific measurements and documentation of the patient's posture, range of motion, symptom-producing motions, joint and soft tissue mobility, functional capacity, and any neurological involvement[11-12]. Instabilities and hypermobilities are noted objectively by the following[11-12,25]:

1. *Structural Assessment*
   Posturally, often these hypermobile segments occur at transition zones "hinge points" or fulcrums of the hypermobile segment.
2. *Movement Assessment*
   During movement, the segment, if not acutely locked, is observed and palpated to move more than the surrounding segments. This increased mobility is especially noted with side-bending and lateral shear motions.
   For pelvic girdle hypermobilities, excessive motion is noted in the iliosacral articulation during the leg swing test (Fig. 1). This test is used to observe and palpate the innominate motion while the patient swings a leg as a pendulum.
3. *Palpatory Assessment*
   With palpation, the surrounding soft tissues are often tender and the surrounding muscles are in spasm.
   In cases of chronic hypermobilities, the tissues are often fibrous around the dysfunctional segment and the muscles do not contract with normal timing and force.
4. *Neuromuscular Assessment*
   The spinal *intrinsic* or primarily tonic muscles are unisegmental and control movement and stabilization of each spinal articulation and segment. These muscles are located on each side of the spine and are posteriorly the multifidus; anteriorly the deep fibers of psoas; and laterally the deep fibers of quadratus lumborum[38]. In the hip are the external rotators and gluteus medius and minimus. In dysfunctional segments these muscles will frequently be found to be inhibited and weak. They do not fire and have lost their ability to effectively stabilize or control the segment under normal demands or resistance[17,26,52-55]. This dysfunction illustrates the basic developmental concept of developing proximal stability before distal mobility[35].
   The spinal *extrinsic* or primarily phasic muscles are multisegmental and control general motions of the spine and extremities. These muscles include the paraspinals, abdominals, long fibers of the quadratus and psoas, latissimus, and gluteus maximus (which is primarily a one joint muscle, that is primarily phasic). These multisegmental muscles in regions of hypermobilities become dysfunctional and do not contract in normal timing. In some they become inhibited such as the lower abdominal and the transverse abdominus, while others become excessively facilitated and fire out of normal timing such as the paraspinals. These dysfunctions can be identified through performance of the PNF pelvic and lower trunk patterns[15,38].

Fig. 1: The leg swing test to evaluate innominate mobility.

2. Functional Postural Assessment Tests

Two postural assessment tools are helpful in evaluating postural integrity and identifying the symptoms that are posturally related. These tests are the vertical compression and the elbow flexion tests. These tests provide powerful educational tools for the patient to experience and notice the effects of the stressful postures they assume.

Vertical Compression Test - The purpose of the vertical compression test is to assess the postural integrity of the patient in normal upright postures. The test is performed by the therapist applying vertical pressure (approximation) to the superior shoulders (just lateral to the neck), and assessing the distribution of the pressure through the structure (Fig. 2). In the efficient state, there will occur only a slight compression of the system, as the force will be equally distributed to the base of support. In a dysfunctional state, the spine buckles at the transitional zones, and motion of the thoracic cage or pelvic girdle occurs in the horizontal or transverse plane. If the patient's symptoms are intensified or reproduced, a postural component to the symptoms is assumed. Many patients with moderate to advanced instabilities buckle when vertical compression is applied, and symptoms are intensified.[10,15,19.]

Elbow Flexion Test -The elbow flexion test assesses the inherent structural integrity in addition to the el-

Fig. 2: Vertical compression test efficient.

Fig. 3: Elbow flexion test.

bow flexion strength and the trunk's responsiveness and stability. The test is performed with the arms at the side, with the forearms bent to 90 degrees and supinated (Fig. 3). The therapist stands in front and applies vertical resistance to both forearms. In an efficient state, the contraction is unbreakable with firm resistance and the trunk muscles appropriately respond to stabilize and maintain a stable posture. In a dysfunctional state, the elbow flexion response is weak and often sluggish without efficient trunk muscular support. In cases of lumbar instabilities, the response is usually weak, the structure buckles, and the trunk at the level of instability does not stabilize effectively to support the upper extremity demands[10,15].

3. Trunk Responsiveness Assessment

Lumbar Protective Mechanism - The purpose of the lumbar protective mechanism test is to assess the ability of the trunk muscles to respond and maintain a stable posture against external resistance. The test is administered with the patient in standing, standing in the stepage position, or sitting while the therapist applies unidirectional pressure to the shoulders in posterior, anterior, and diagonal directions (Fig. 4a and b). The patient is instructed to hold, and the responsiveness and strength of the resulting contraction are graded. When tested in the efficient state, there is minimal lumbar motion. The therapist assesses for three specific components of the stabilizing contraction: (1) the quality and existence of initiation, (2) the strength, and (3) the endurance. In a dysfunctional state, one or all of these components are weak and inhibited, and the patient is unable to maintain a stable posture. When instabilities exist, the therapist can assess the patient's ability to stabilize that segment in all directions. In most cases, the angle of dysfunctional lumbar protective mechanism correlate with the directions of segmental instabilities. With this information, a program of manual therapy, neuromuscular reeducation, and specific rehabilitative exercise program can be developed[19].

4. Preparation of the surrounding myofascial components

In regions of spinal hypermobilities the soft tissues tend to become dysfunctional. There are three specific

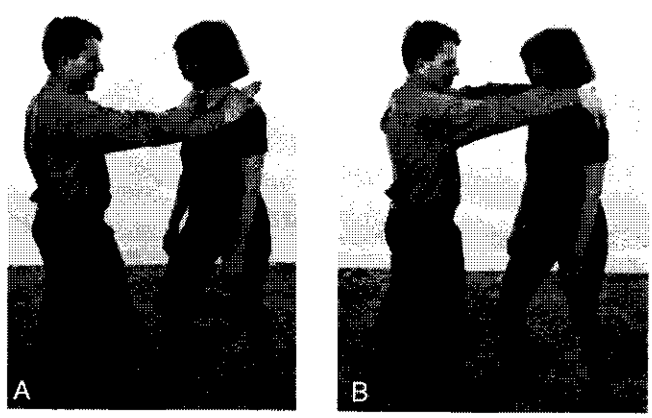

Fig. 4a and b: a) Lumbar protective mechanism flexion. b) Lumbar protective mechanism extension.

myofascial dysfunctions; 1) increased tone or spasm, 2) decreased muscle play (accessory mobility of the muscle in relationship to the surrounding structures) and 3) limited functional mobility.[10] The biomechanics of the region can be significantly altered through soft tissue dysfunctions and need to be normalized early in the treatment program. Treatment includes normalization of skin and superficial fascia, soft tissues along bony contours, (Fig. 5) and management of the myofascial unit. Techniques include perpendicular strumming, (Fig. 6a and b) direct oscillations, unlocking spirals, and parallels (Fig. 7).

5. Lumbar spine and pelvic girdle passive and active intersegmental mobility

A. Assessment

A skilled, properly trained manual therapist using conventional assessment tools can evaluate each articular interface of the lumbopelvic girdle region and determine the relative mobility of each plane of available motion

Fig. 5: Soft tissue mobilization along spinal bony contours.

of individual movement segments. These conventional assessments are generally performed passively in a non-weight-bearing position[11]. Pelvic patterns can also be used to assess spinal mobility.

1. Passive - For the lumbar spine, the pelvic patterns are used to evaluate segmental mobility. For passive assessment, the patient is placed in the side-lying position while the therapist moves the pelvis through each diagonal (anterior elevation/posterior depression and posterior elevation/anterior depression) palpating the mobility of each lumbar segment at the spinous process interspace (Fig. 8a and b). A hypomobile articulation has minimal motion, while a hypermobile one moves excessively. The therapist notes through which ranges of the diagonals and on which side the primary hypermobilities exist[15].

2. Active Assessment - There are two primary means of evaluating the patient's active mobility at each segment. One is to have the patient actively attempt the patterns while the therapist evaluates each lumbar segment. The second is to have the patient drop the feet off the edge of the treatment table, which produces the depression motions of the pelvis, and to lift the feet upward to produce the elevation motions. The specific patterns are accomplished by positioning the hips above 90 degrees of flexion for posterior elevation/anterior depression and below 90 degrees for anterior elevation/posterior depression patterns (Fig. 9a and b)[15].

3. Resisted Assessment - To evaluate lumbar mobility during resisted motions, the therapist monitors the spine while the patient performs the pattern against manual resistance (Fig. 10). Hypermobilities will be noted through arcs of weaknesses during the range.

B. Treatment

Once hypermobilities and hypomobilities are identified the therapist can begin selective treatment. Clinically, in most cases of hypermobilities and instabilities there are segmental hypomobilities in the region that precipitate more demand on the hypermobile segments. One of the most important initial steps in relieving the strain on the hypermobile segments is to improve the mobility in the hypomobile segments. The primary concern in mobilizing these segments is the protection of the hypermobile segment. This protection is generally

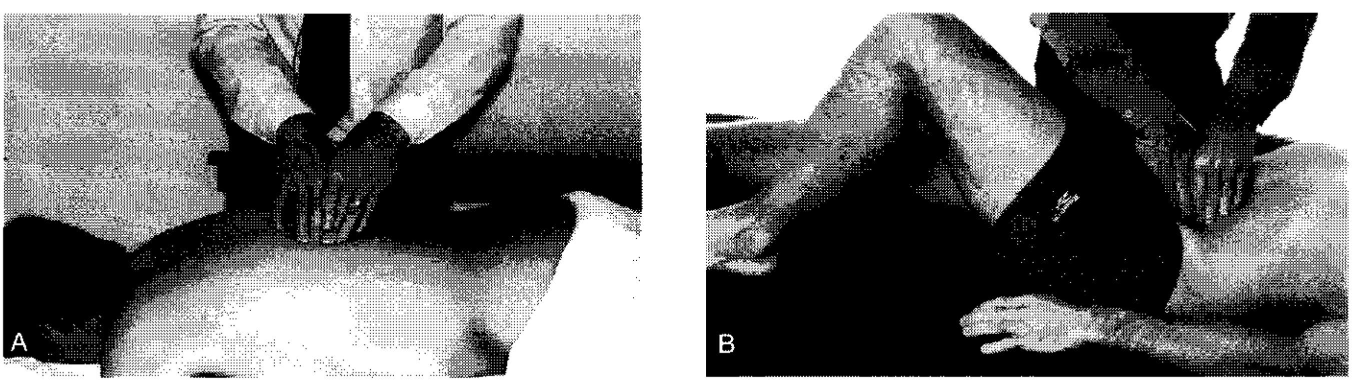

Fig. 6a and b: a) Perpendicular strumming on paraspinals. b) Perpendicular strumming on psoas.

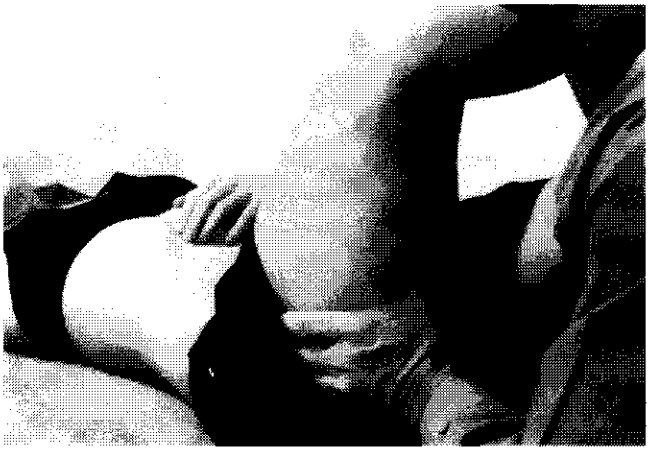

Fig. 7: Parallel technique separating hamstring bellies.

Fig. 8a and b: a) "Resisted anterior elevation." b) Selective articular assessment through passive pelvic patterns.

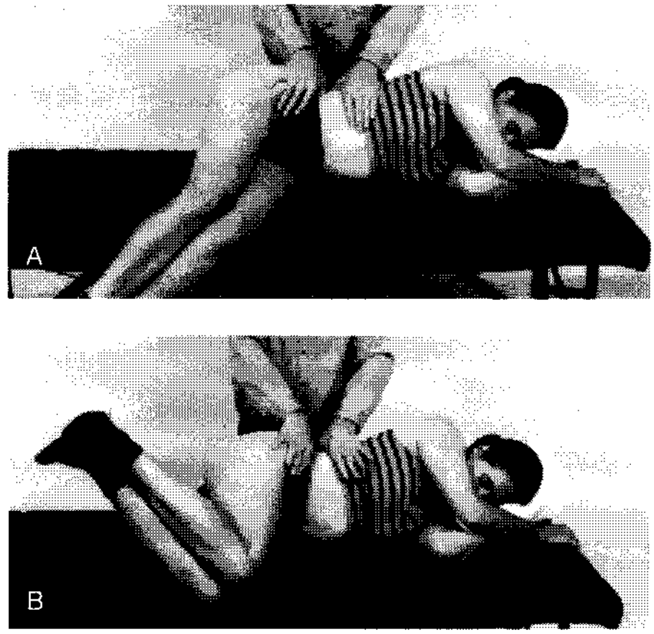

Fig. 9a and b: a) Active assessment of posterior depression. b) Active evaluation of anterior elevation segmental mobility.

accomplished by selectively mobilizing the hypomobile segment or by utilizing physiological locking procedures for the hypermobile articulation[11]. The following are several avenues by which PNF can be used to mobilize hypomobile segments:

1. Direct mobilization techniques which are taught by Paris[56], Maitland[11], apply passive prolonged or oscillatory pressure in the direction of restriction to the hypomobile vertebra and superimpose some PNF techniques to assist the mobilization. The following are some of the procedures (Fig. 11):

   The patient breathes toward the pressure and then relaxes.

   The patient attempts to contract the vertebra into the pressure and then relaxes.

   Resistance is given to a related segment that produces irradiation to the dysfunctional segment. For example, to enhance backward bending at a lower segment, the therapist could resist bilateral knee extension (Fig. 12).

   Quadruped functional mobilization through rocking forwards and backwards or arching up into the therapists pressure (Fig. 13a and b).

   During the performance of the side-lying pelvic pattern, stabilize the superior vertebra at the spinous process of the hypomobile segment while resisting the elevation pattern that is most restricted (8b). As the restriction begins to resolve, the contraction is shifted to a *combination of isotonics,* and once the mobilization is complete, the antagonistic motion is reeducated through resisting the opposite depression pattern and completing with an *isotonic reversal.*

2. Using joint mobilization positions the therapist can use a more active approach by adding resistance as the mobilizing medium. After localizing the hypomobile joint,

Fig. 10: Resisted evaluation of posterior depression.

Fig. 11: P/A mobilization with patients active participation.

the therapist initiates a *contract relax, hold relax, or stabilizing reversal* contraction to facilitate mobilization (Fig. 14a and b). As the restriction begins to release, shifting to a *combination of isotonics* contraction educates the segmental muscles and produces further mobilization. When optimal mobilization has been achieved the antagonistic muscles are then resisted throughout their new range through the *combination of isotonic techiques* followed by an *isotonic reversal*[15].

The primary component in the pelvic girdle, that becomes hypermobile, is the innominate. Hypermobilities of the sacrum and coccyx also occur and are managed, but for the purpose of this presentation only innominate hypermobility is addressed. Hypomobilities of the coccyx (Fig. 15a and b) and sacrum (Fig. 16a and b) are frequent and can be managed through functional mobilization. We view the innominate as the functional extension of the lower extremity as it moves in accordance with leg motions. Therefore, motions of the innominate are named the same as the lower extremity motions. The innominate motions are flexion, extension, internal and external rotation, abduction, adduction, elevation, and depression. Innominates can be hypermobile or hypomobile in any of these directions. Often a hypermobile innominate becomes fixated in the direction of hypermobility.

Fig. 12: Functional mobilization of lower lumbar segment into extension.

Fig. 13a and b: a) Mobilization into extension in quadruped with patients active contraction. b) Functional mobilization of lower lumbar flexion.

To evaluate mobility of innominate flexion, the patient is placed in supine and the hip flexed to end range. At this point, the therapist can note the end-feel and mobility of the innominate moving into flexion by localizing restrictions through abduction/adduction and

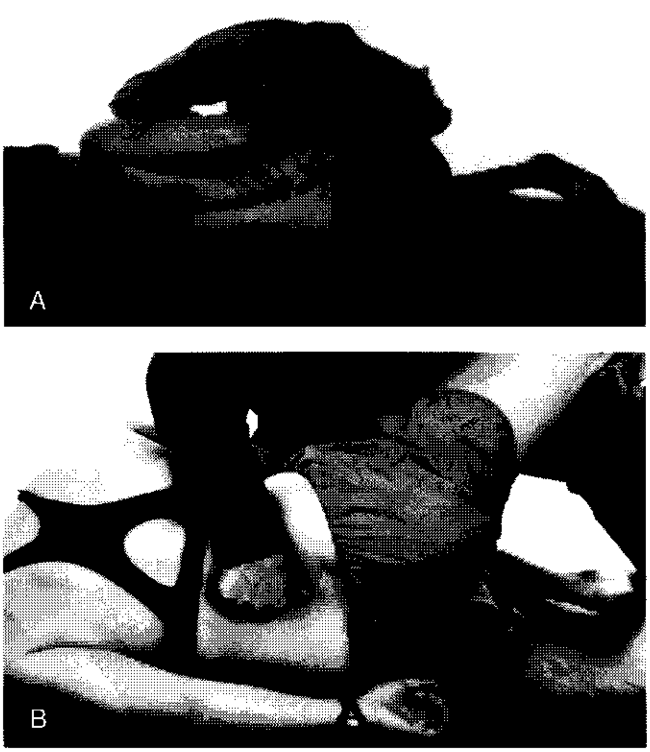

Fig. 14a and b: a) Resisted mobilization of localized lumbar segment into rotation. b) Side gliding functional mobilization of lower lumbar segment.

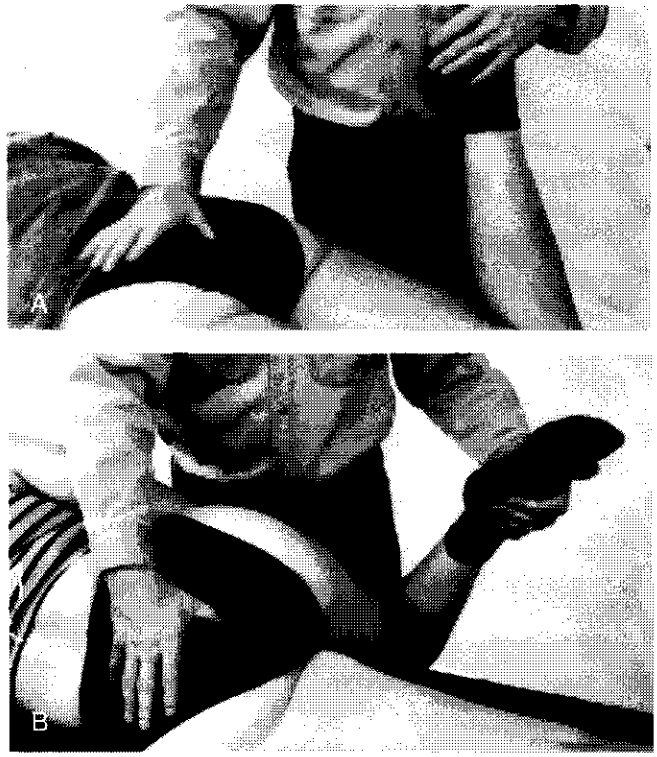

Fig. 15a and b: a) Sacral coccygeal rotational mobilization. b) Coccyx deviation mobilization.

rotation (Fig. 17a). For extension, the patient is positioned in prone or prone with one foot off the table and the hip lifted to end of range extension, and the end-feel and mobility of innominate extension evaluated (Fig. 17 b). All other innominate motions can be selectively evaluated and treated (Fig. 17c and d).

For treatment, the restriction is localized and then mobilized through functional mobilization progression as previously described (Fig. 18). Once the restriction is resolved the innominate needs to be assessed for hypermobilities. The goal of treatment is to develop the patient's ability to stabilize in the midrange through stabilizing reversals and prolonged holds of innominate motion and then progress to controlled *combination of isotonics.*

6. Neuromuscular control and segmental stability of the hypermobile segments

Initial management of a hypermobile lumbar segment is the facilitation of stabilizing contraction of the intrinsic or the one and two joint muscles. Initially, facilitate the segment in midrange or neutral position[15,57]. As previously presented these muscles include the mutifidus posteriorly, the deep tonic one joint fibers of the psoas anteriorly, and the deep tonic one joint fibers of the quadratus lumborum laterally[26,38,52,54-55]. In addition, research has demonstrated the importance of the transverse abdominis and the pelvic floor muscles in the proper sequencing and control of stabilizing contractions.[26,53,58-59.]

The most effective and efficient mechanism to facilitate these muscles is to use prolonged holding contractions. These prolonged sustained contractions of the region are held until the dominant phasic muscles begin to fatigue and the tonic components begin to contract. Localize the segment to optimize the contraction and the patient will initially feel weak as they attempt to maintain the position against resistance. As the phasic muscles begin to fatigue (they will begin to shake which has been termed "the phasic shake"), the stabilizing components begin to contract, stabilizing the trunk with greater strength and less effort than the initial contraction. When this enhances the stabilizing contraction, progress to stabilizing reversals, combination of isotonics, and isotonic reversals.

Research has identified that the multifidus muscle is easily inhibited in cases of lumbar pain[26,52,60,61]. Knott made this observation more than 40 years ago; she considered the facilitation of the multifidus as a primary factor in rehabilitating patients with low back pain[15, 26]. There are many different avenues and positions in which the therapist can facilitate these stabilizing contractions. In this article, only one of the procedures is presented to facilitate a segmental stability contraction of the multifidus muscles.

Fig. 16a and b: a) Sacral P/A mobilization with lower trunk rotation. b) Sacral posterior mobilization.

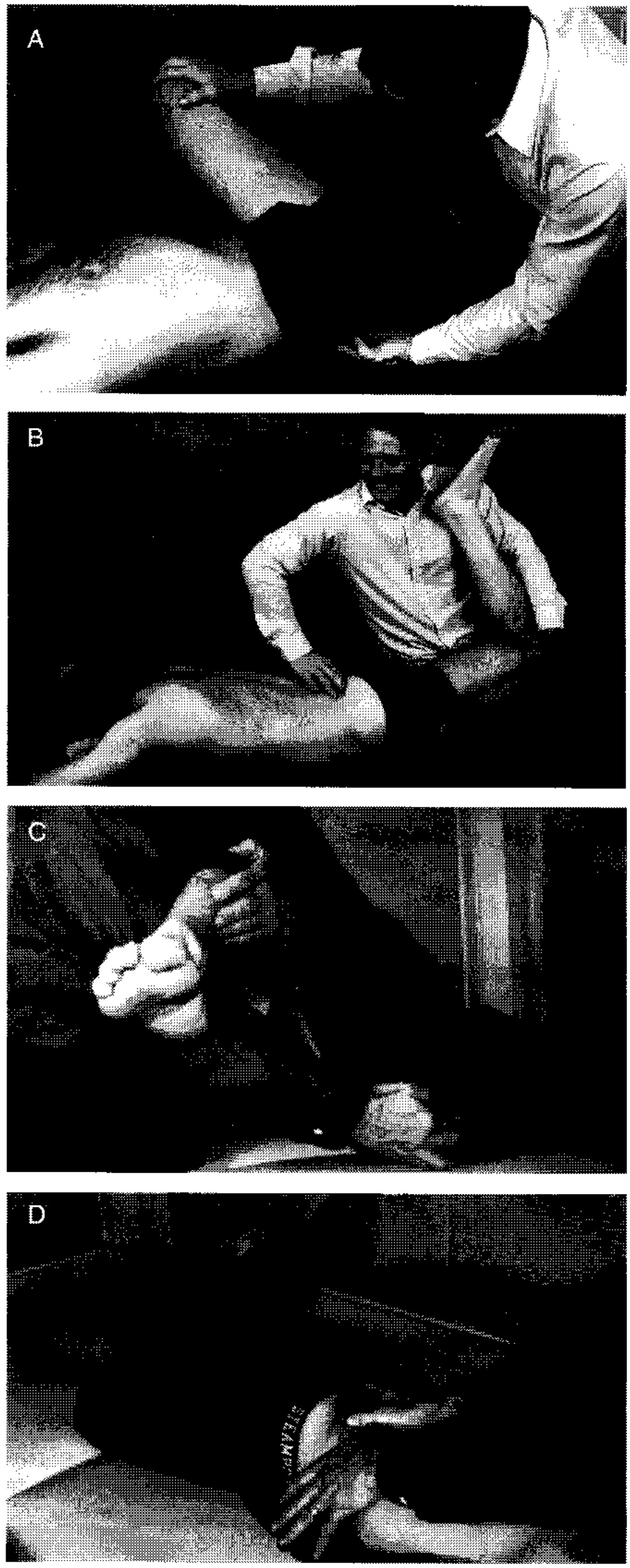

Fig. 17a, b, c, and d: a) Evaluation of innominate flexion. b) Evaluation of innominate extension. c) Innominate abduction. d) Innominate depression.

Multifidus stabilizing control evaluation and treatment

The patient is positioned in prone with a pillow under the abdomen to support the lumbar spine. If this position is uncomfortable or the patient is markedly extension sensitive, additional postures can be assumed, such as positioned over a bolster or suspending the legs off from the edge of the table. This procedure is divided into several phases, including observation of motion, palpation of muscle firing patterns, positioning to facilitate a stabilizing contraction, initiation of a maintained contraction, maintaining that prolong contraction until the stabilizing muscles respond, shift to a combination of isotonics technique, and educate for use in a home program[18,63].

Evaluation of motion - With the patient in prone, they attempt to lift up the leg off the table with the knee in extension. If the motion is performed efficiently, the spine stays stable as the leg is lifted, and at the end of hip range, the innominate will begin to extend. As the motion progresses, extension of the sacrum and lumbar spine occurs in a normal sequence. Normally, the motion appears to be performed with only minimal effort (Fig. 19).

In a dysfunctional state, the spine and pelvic girdle are not stable at initiation or as the lower extremity lifts. There may be rotational, flexion, extension, side bend-

Fig. 18: Resistance to new range of innominate extension.

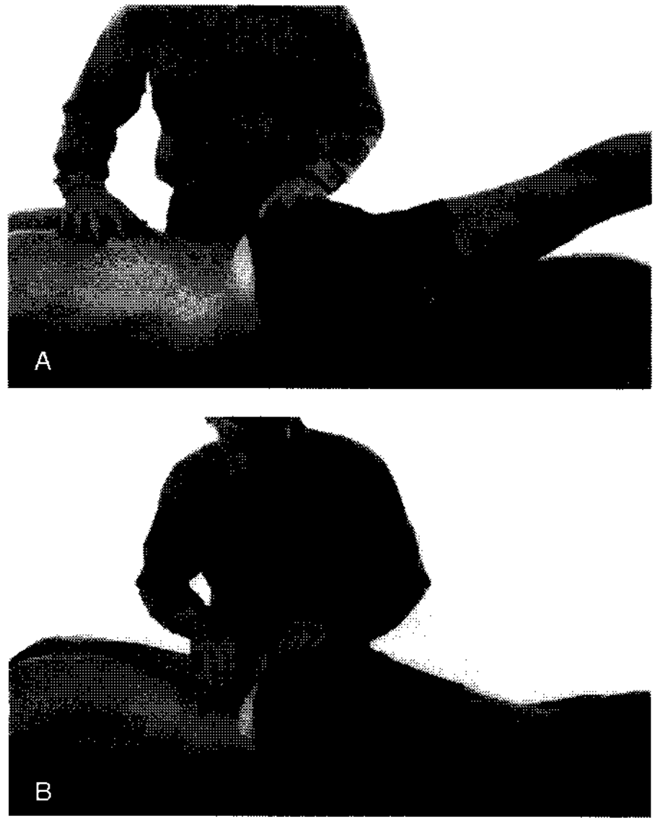

Fig. 20a and b: a) Excessive lumbar extension. b) Excessive lumbar rotation.

ing or a combination of spinal motions occurring (Fig. 20a and b). There are less involved cases in which the spine is relatively stable on initiation of the motion, but as the motion progresses, the lumbar spine or pelvis deviates during the motion. Many times, patients are not able to generate enough force to lift the leg more than a couple inches off the underlying surface.

Palpation – The purpose of palpation is to determine the quality and sequencing of muscle firing and to identify myofascial and articular tightness. The therapist evaluates for a specific sequence of motor recruitment. If the sequencing is performed efficiently, there is a preparatory contraction of the multifidus before any notable motion in the lower extremity (Fig. 21)[52]. This contraction is in conjunction with firing of the transverse abdominis and pelvic floor muscles (that should also be palpated). The next muscles to contract are the hip rotators followed by the hamstrings and gluteus maximus. The final muscle group to contract are the paraspinals as the pelvis lift from the supporting surface and the spine begins to extend. Following are several dysfunctional states that may be identified:

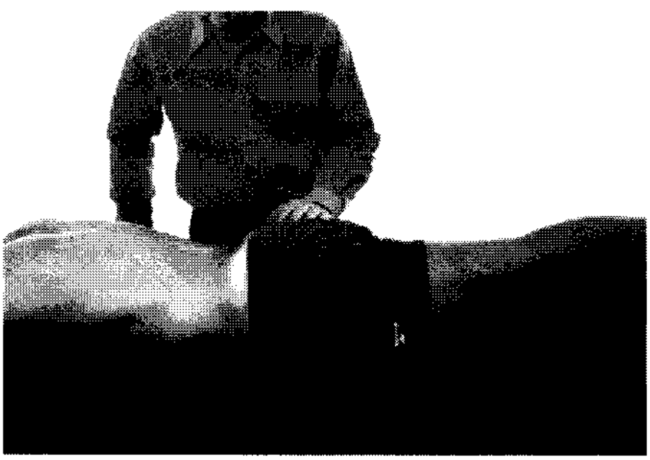

Fig. 19: Efficient lumbar stabilization with hip extension.

The multifidus do not contract on either side of the spine, but most notably on the same side as the extending leg. These muscles are palpated in the groove between the spinous and transverse processes. When they contract normally the fingers will be pushed away from the spine.

The paraspinals become the dominate muscle contraction.

The external rotators of the hip do not fire prior to the gluteus maximus.

The hamstring dominates the hip extension contraction with reduced gluteus maximus contraction.

The patient requires excessive effort with abnormal supporting contractions and motions of the upper trunk and extremities.

Treatment

Positioning of the trunk and extremity for treat-

ment - One of the basic tenants of PNF is that if a patient is unable to accomplish a motion or the sequencing of muscle firing is dysfunctional, the part is placed at the end range of motion for training. The benefit of using the end-range is that the patient can become cognizant, kinesthetically, and neuromuscularly aware of the target for the desired motion. In addition, the motor system most effectively develops proper sequencing of motor recruitment in this position. The therapist lifts the lower extremity up off the table to a point where the pelvis begins to tilt while maintaining the hypermobile segments in neutral.

Initiation of a maintained contraction - The therapist using proper manual contacts on the lower extremity and pelvis, provides the verbal command of, "keep your leg up here; do not let me push it down", and slowly applies increasing resistance. If the patient responds with an efficient contraction and maintenance of the lumbopelvic position, the therapist proceeds to facilitating a prolong contraction. Often, however, a patient does not respond efficiently and requires additional support or facilitation. Some of the common problems and procedures are as follows:

Fig. 21: Palpation of multifidus contraction during lower extremity extension.

1. The lumbar spine and sacrum immediately extend when the contraction is attempted. Some potential solutions are:
   Attempt the contraction in a position of less hip extension.
   Patient performs a pelvic tilt before initiating the contraction.
   Therapist palpates the anterior bodies of the spine and with that pressure trains the patient not to extend the spine (Fig. 22).
   Probably the most effective maneuver is to have the patient look over the shoulder on the side of the contraction (Fig. 23). This rotational and extended position of the cervical spine facilitates the multifidus muscles. This maneuver assists in inhibiting the paraspinals that often cause the dysfunctional spinal extension.
2. The lumbar spine and pelvis rotate in the opposite direction of the lifting leg. This causes the lumbar spine and pelvis to drop on the side of the lifting leg. This rotation is best treated by a combination of the patient looking over the shoulder on that side and the therapist assisting by holding the trunk stable, blocking the dysfunction rotational motion (Fig. 24).
3. The multifidus does not perform a preparatory contraction or performs too weakly to provide stability. This is best treated by:
   a) The therapist palpating the muscles to assist their contraction.
   b) The patient looking over the same shoulder as described earlier.
   c) The patient supporting the spine and pelvis in neutral while performing a prolonged contraction.
   d) Perform a contraction in side-lying (Fig. 25).
4. The external rotators of the hip do not contract before the gluteus maximus and hamstrings. This dysfunction is treated the same as the multifi-

Fig. 22: Palpation of anterior bodies of spine during lower extremity extension.

Fig. 23: Multifidi facilitation with cervical rotation to side of inhibition.

Fig. 24: Therapist supports pelvis to train lumbar stability.

Fig. 25: Perform prolonged hold in side-lying.

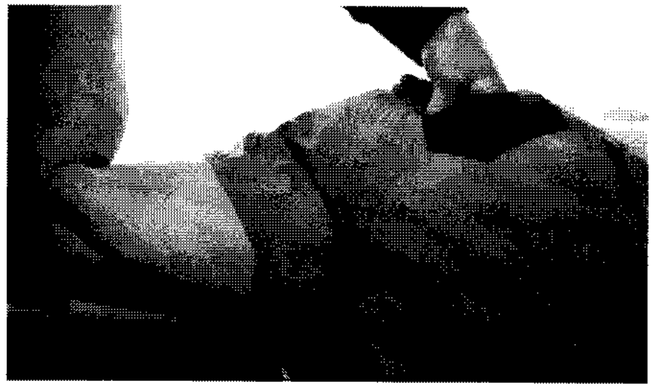

Fig. 26: Hip rotator facilitation with lower extremity extension.

dus through selective palpating, positioning, and resistance. It is important to have the multifidus, pelvic floor, and transverse abdominis contracting in normal sequence before focusing on facilitating the rotators of the hip (Fig. 26).

Maintaining prolonged contraction until the stabilizing muscles fire strongly

We have often have patients maintain contractions for as long as 2-3 minutes before the stabilizing muscles begin to contract. During the period when the stabilizing muscles are not firing, the patient is making an effort to maintain a contraction. The quality of the contraction is often erratic with accompaning shaking, "phasic shake". Both the patient and the therapist feel the contraction entering into a transition period when the trunk muscles begin to stabilize with more efficient irradiation. When a stabilizing contraction begins there is an immediate improvement in the quality and strength of the contraction. The multifidus, transverse abdominis, and pelvic floor muscles begin contracting and the trunk becomes more stable. In addition, the patient's effort noticeably reduces and the patient breathes with greater ease.

Transition to a combination of isotonics technique - Once a good stabilizing contraction has been achieved, the therapist shifts to a *combination of isotonics* technique. This technique generally begins with an eccentric contraction. This eccentric contraction should be of short excursion (without losing the quality of the stabilizing contraction), and then switching to a concentric contraction to return to the previous position followed by another maintained contraction. This process is continued several times, increasing the excursion of the motion while maintaining the quality of the stabilizing contraction. Some patients fatigue quickly and can only perform a couple of these contractions before resting. In most cases, when repeating the procedure, the stabilizing contraction is facilitated with greater ease. A contraindication to these contractions is increased pain, especially radicular symptoms.

Home program - Once the patient is capable of performing these contractions with proper muscle firing pattern and position, the motion is given as a home program to reinforce the strengthening and neuromuscular training. A teaching aide asks the patient to lift the lower extremity as if they were trying to roll from the stomach to the side by lifting the lower extremity and pelvis off the underlying surface and maintaining the contraction.

Additional lumbo-pelvic exercises – There are many important exercises that are designed to enhance mobility and produce strength and stability of the lumbo-pelvic girdle region. The abdominal series is used for initial facilitation of the stabilizing components of the abdominals, tonic fibers of the psoas, and multifidus. The abdominal series can also normalize many mechanical dysfunctions (Fig. 27a, b, and c). Prone resisted hip rotation with tubing can be used to improve sacroiliac stability and strength.

Belts – Some hypermobile segments need external lumbar or pelvic girdle support to maintain and protect the segment during the rehabilitative phase. Once they develop the ability to function without exacerbating the

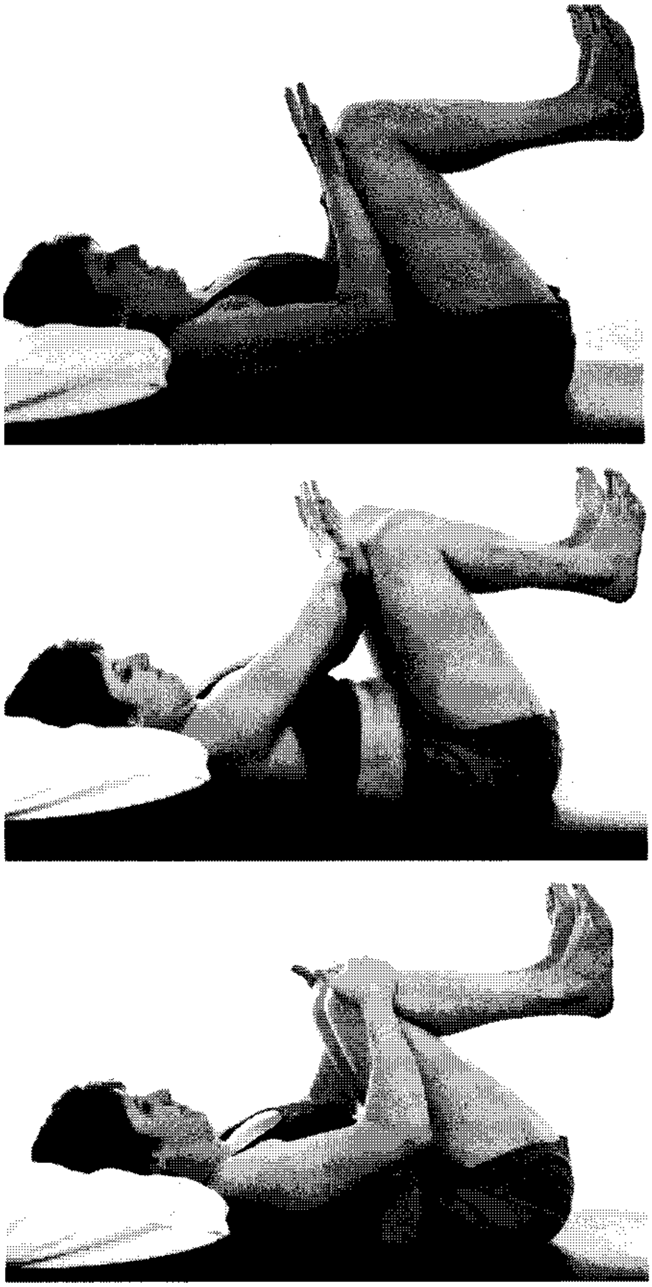

Fig. 27a, b, and c: Abdominal series. a) Bilateral flexion. b) Diagonal flexion. c) Bilateral extension.

segment, use of the belt is discontinued. There are many cases where belts need to be used when performing certain stressful activities to provide protection.

7. *Trunk coordination through mass trunk and reciprocal patterns*

Once the ability to stabilize has been obtained, treatment progresses to mass movements. Non-weight-bearing mass trunk and reciprocal patterns are used to build on the foundation of stabilization. Coordinated motions are trained first with mass flexion and extension, progressing to reciprocation. These patterns assist in training coordination of the stabilizing muscles, together with the extrinsic prime movers. The patient is initially trained to perform controlled pelvic patterns and progresses to resisted lower extremity motions coupled with the pelvic pattern (Fig. 28a and b). When the patient is able to control this motion, they are progressed to resisted mass trunk flexion. The resistance is applied to pelvic girdle anterior elevation and shoulder girdle anterior depression to produce the mass flexion rolling pattern (Fig. 29). For the mass extension-rolling pattern, the resistance is applied to shoulder girdle posterior elevation and pelvic girdle posterior depression. As the patient's skill level improves in performing these individual mass-rolling patterns, the patient can progress to performing isotonic reversals, progressing to extremity patterns with resistance to train proximal stability with distal mobility (Fig. 30). These mass motions can be reinforced through a home program of resisted rolling using elastic tubing, pulleys, or sports cords attached to the foot and ankle. The final aspect of progression is the performance of reciprocal patterns where the shoulder and pelvic girdles move in opposition as required in gait activities (Fig. 31). As the patient develops these skills, they are ready for weight-bearing activities.

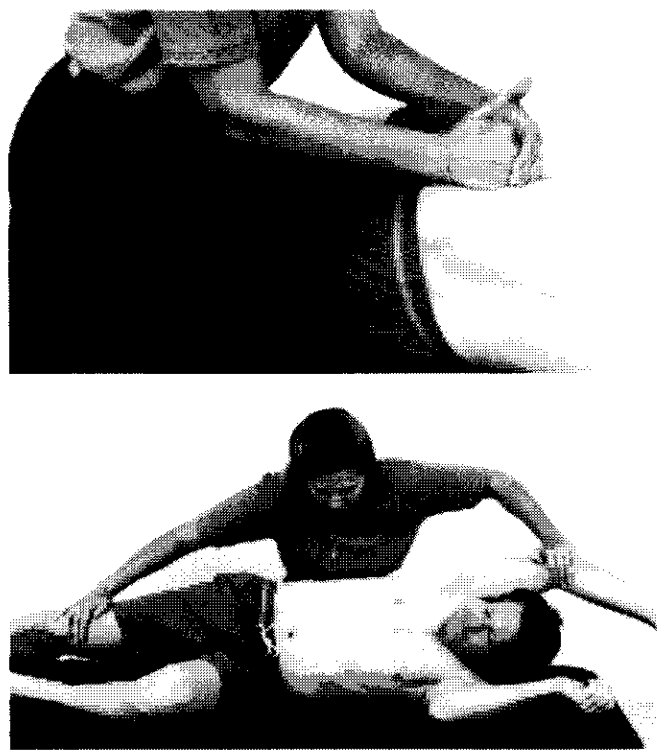

Fig. 28a and b: a) Use of pelvic patterns to develop lumbar control. b) Resisted pelvic and lower extremity pattern to develop trunk control.

Fig. 29: Mass flexion resisted motion.

Fig. 30: Resisted mass flexion rolling with lower extremity flexion.

8. Weight bearing segmental and lumbar pelvic girdle stability

Progression to weight bearing activities begins when joint and soft tissue mobility and neuromuscular reeducation has improved. Initially, in quadruped, direct resistance is applied to the unstable segments as the patient attempts to maintain stability while performing selected motions (Fig. 32). When a stabilizing contraction is facilitated, activities such as rocking forwards and backward, lifting an arm or leg, or looking over the shoulders is performed. This kind of treatment strategy can also be used during sitting, standing, and lifting activities.

Additional weight-bearing activities can be performed on unstable surfaces, such as balls, foam rolls, bolsters, and balance boards (Fig. 33). Stabilization training during gait is performed through resistance to the pelvis or resistance directed through a dowel that the patient is holding (Fig. 34). Prior to discharge the patient should be resisted through the primary functional tasks he or she performs at work and at home to develop the specificity of stabilization and controlled mobility.

Home Program – Resisting straps can be secured to

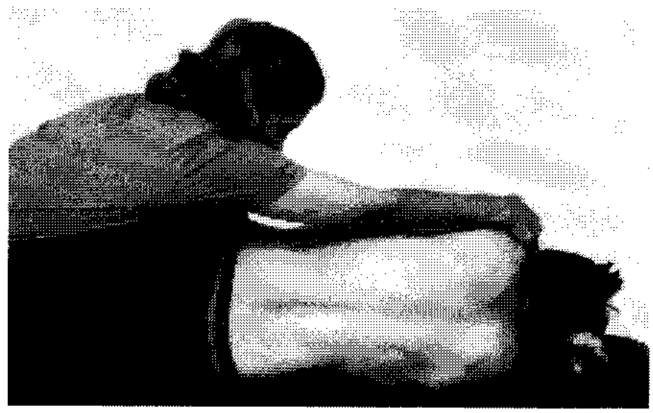

Fig. 31: Shoulder and pelvic girdle reciprocation.

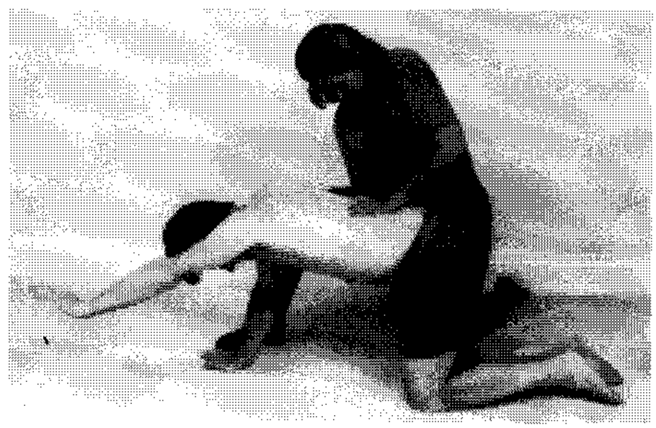

Fig. 32: Quadruped stabilization.

Fig. 33: Stabilization training on Swiss ball and resistance to upper extremity through a wooden dowel.

the hypermobile segment in standing while the patient performs extremity activities.

9. Back education and training[19]

Fig. 34: Resisted gait with dowel through upper extremity.

Educating the patient in use of efficient posture and body mechanics is the most important aspect in developing patient self-responsibility and management. The initial emphasis of educating a patient with lumbopelvic instability is to train them to assume and maintain a neutral posture (Fig. 35). Using the vertical compression and elbow flexion tests, the therapist is able to assist the patient in identifying the most efficient postural alignment. Through the use of stabilizing reversals the patient becomes more aware of the more efficient postures. Once a more efficient alignment is learned, training shifts to the efficient use of base of support and the hips as a primary axis of motion for forward-oriented tasks. The emphasis is to maintain a stable spine during performance of activities of daily living. Initial training usually occurs in sitting and progresses to standing and functional activities (Fig. 36a, b, and c).

Another beginning educational emphasis is training the patient how to support the region of instability with various types of props and pillows during sitting, driving, sleeping, and other static positions (Fig. 37). When proficiency of maintaining neutral during daily activities is achieved, and if symptoms are under control, the next phase of training is to teach efficient sequencing of motion through the unstable region during low-impact and less stressful motions and activities.

Fig. 35: Training in assuming neutral posture in sitting.

10. Exercise and rehabilitative program

As the patient progresses through rehabilitation their exercise program continues to evolve in demand and complexity. Initially, the emphasis is on developing stabilizing muscle control and strengthening of the abdominals, especially the lower and transverse abdominis components. To improve range of motion train the patient in dynamic techniques of combined contract relax and soft tissue mobilization to increase range of motion of tight muscle groups. The program progresses to more advanced stabilization exercises and more advanced trunk and extremity strengthening (Fig. 38). During this time, specific exercise equipment that is designed to stabilize the lumbar spine can accelerate the strengthening process. During this phase, supervision and professional guidance are critical to ensure proper positioning and muscle firing patterns. The final phase of the rehabilitation process is using normal functional activities for strengthening and training (Fig. 39).

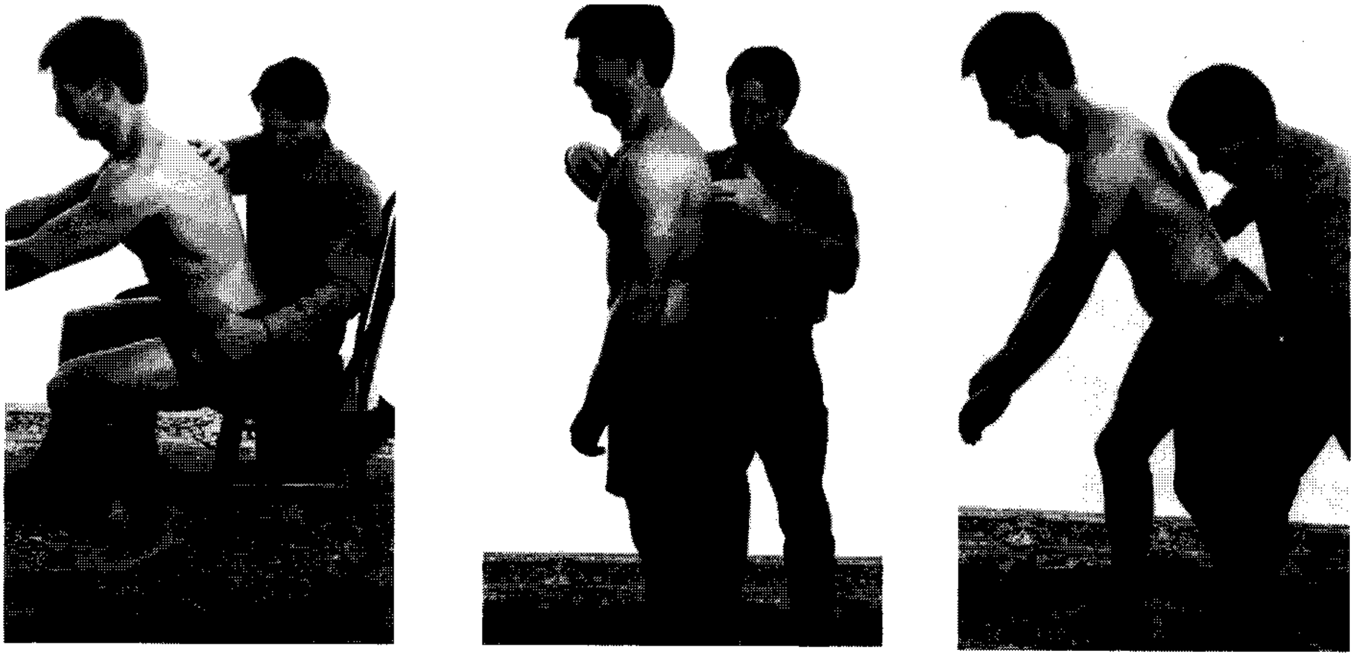

Fig. 36a, b, and c: a) Training in maintaining neutral spine during hip hinging. b) Standing postural training. c) Training hip hinging and weight acceptance in standing.

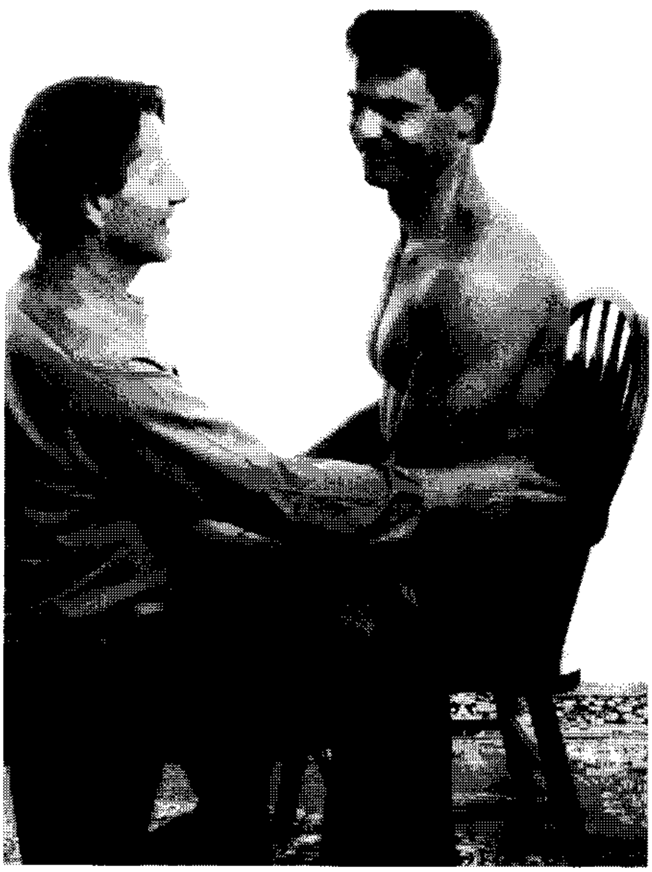

Fig. 37: Use of lumbar supports.

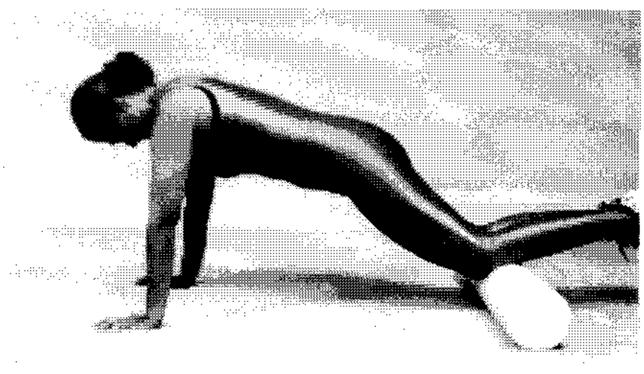

Fig. 38: Advanced stabilization exercise.

Summary

This chapter has provided an overview of the use of PNF, in conjunction with functional mobilization, for the management of lumbar instabilities. This approach is a dynamic system that can be used to mobilize restricted articulations and soft tissues, train the intrinsic tonic muscles to stabilize a hypermobile segment, facilitate proper muscle sequence of firing patterns, and progress to training efficient performance of functional activities.

Fig. 39: Advanced functional exercise

REFERENCES

1. Kabat H. Studies on neuromuscular dysfunction: I. Neostigmine therapy of neuromuscular dysfunction resulting from trauma. II. Neostigmine therapy of hemiplegia: Facial paralysis and cerebral palsy. III. Neostigmine therapy of chronic rheumatoid arthritis and subacromial bursitis. *Public Health Rep* 1944;59:1635-1675.
2. Kabat H. Proprioceptive facilitation in therapeutic exercise. In: Licht E. ed. Therapeutic Exercise, 2nd ed. New Haven: E Licht, 1961.
3. Knott M. In the groove. *Phys Ther* 1973;53:365-372.
4. Knott M, Voss B. *Proprioceptive Neuromuscular Facilitation.* 2nd ed. London: Balleire, Daintily & Cogs, 1968.
5. Voss DE. Proprioceptive neuromuscular facilitation. *Phys Ther* 1967;46:838-899.
6. Knapp ME. The contributions of Sister Elizabeth Kenny to treatment of poliomyelitis. *Arch Phys Med Rehabil* 1955;36:510-517.
7. Guyner AJ. Proprioceptive neuromuscular facilitation for vertebral joint conditions. In: Grieve GP. ed. *Modern Manual Therapy of the Vertebral Column.* London: Churchill Livingstone, 1986.
8. Sullivan PE, Markos PD, Minor MAD. *An Integrated Approach to Therapeutic Exercise: Theory and Clinical Application.* Reston: Reston Publishing, 1982.
9. Greenman PE. *Principles of Manual Medicine.* Baltimore: Williams & Wilkins, 1989.
10. Johnson GS. Soft tissue mobilization. In: Donatelli R, Wooden M. eds. *Orthopaedic Physical Therapy.* 2nd ed. New York: Churchill Livingstone, 1994.
11. Maitland GD. *Vertebral Manipulation.* 5th ed. London: Butterworths, 1986.
12. Grieve GP. *Common Vertebral Joint Problems.* London: Churchill Livingstone, 1981.
13. Janda V. Muscle weakness and inhibition (pseudoparesis) in back pain syndromes. In: Grieve G. ed. *Modern Manual Therapy of the Vertebral Column.* London: Churchill Livingstone, 1986.
14. Lewit K. The contribution of clinical observation to neurological mechanisms in manipulative therapy. In: Korr I. ed. *The Neurobiologic Mechanisms in Manipulative Therapy.* London: Plenum Press, 1978.
15. Saliba VL, Johnson GS, Wardlaw C. Proprioceptive neuromuscular facilitation. In: Basmajian JV, Nyberg R. eds. *Rational Manual Therapies.* Baltimore: Williams & Wilkins, 1993.
16. Adler S, Beckers D, Buck M. *PNF in Practice.* 2nd ed. Berlin: Springer-Verlag, 2000.
17. Macintosh JE, Bogduck N. The biomechanics of the lumbar multifidus. *Clin Biomech* 1986;1:205-213.
18. White A, Anderson R. *The Conservative Care of Low Back Pain.* Baltimore: Williams & Wilkins, 1990.
19. Johnson GS, Saliba VL: Lumbar protective mechanism. In: White AH, Anderson R. eds. *The Conservative Care of Low Back Pain.* Baltimore: Williams & Wilkins, 1991.
20. Kendall HO, Kendall FP, Boynton DA. *Posture and Pain.* Huntington: Robert E. Krieger, 1977.
21. Mayer TG, Gatchell RJ, Mayer H, et al. A prospective two-year study of functional restoration in industrial low back injury: An objective assessment procedure. JAMA 1987;258:1763-1767.
22. Morgan D. Concepts in functional training and postural stabilization for the low back injured. *Top Acute Care Trauma Rehabil* 1988;2:8-17.
23. Saal JA. Rehabilitation of sports-related lumbar spine injuries. *Phys Med Rehabil State Art Rev* 1987;1:613-638.
24. Saal JS. Flexibility training. *Phys Med Rehabil State Art Rev* 1987;1:537-554.
25. Paris SV. Physical signs of instability. *Spine* 1985;10:277-279.
26. Fritz JM, Erhard RE, Hagen BF. Segmental instability of the lumbar spine. *Phys Ther* 1998;8:889-896.
27. Morgan FP, King T. Primary instability of the lumbar vertebrae as a common cause of low back pain. *J Bone Joint Surg (Br)* 1957;39:6-21.
28. Pope MH, Panjabi MM. Biomechanical definitions of spinal instability. *Spine* 1985;10:255-256.
29. Frymoyer JW, Selby DK. Segmental instability: Rationale for treatment. *Spine* 1985;10:280-286.
30. Panjabi MM. The stabilizing system of the spine: Part II. Neutral zone and instability hypothesis. *J Spinal Disord* 1992;5:390-396.
31. Panjabi MM, Abumi K, Duranceau J, et al. Spinal stability and intersegmental muscle forces: A biomechanical model. *Spine* 1989;14:194-200.
32. Richardson CA, Jull GA, Hodges PW, et al. *Therapeutic Exercise for Spinal Segmental Stabilization in Low Back Pain: Scientific Basis & Clinical Approach.* London: Churchill Livingstone, 1999.

33. Tanigawa MC. Comparison of the hold relax procedure and passive mobilization on increasing muscle length. *Phys Ther* 1972;52:725-735.
34. Montagu A. *Touching: The Human Significance of Skin.* 2nd ed. New York: Harper & Row, 1978.
35. Hagbarth KE. Excitatory and inhibitory skin areas for flexor and extensor motomeurons. *Acta Physiol Scan* 1952;26:1-35.
36. Nicholas JA, Melvin M, Saraniti, AJ. Neurophysiologic inhibition of strength following tactile stimulation of the skin. *Am J Sports Med* 1980;8:181-190.
37. Gowitzke BA, Milner M. *Scientific Basis of Human Movement.* Baltimore: Williams & Wilkins, 1988.
38. Basmajian JV: Muscles Alive. *Their Functions Revealed by Electromyography.* Baltimore: Williams & Wilkins, 1978.
39. Buchwald JS. Exteroceptive reflexes and movement. *Am J Phys Med Rehabil* 1967;46:121-144.
40. Sherrington CS. Selected writing. In: Denny-Brown D. ed. New York: Paul B. Hoeber, 1940.
41. Adler S. *Effects of "approximation" on normal walking.* Master's Thesis, Downey, CA, University of Southern California, 1982.
42. Ratliffe KT, Alba BM, Hallum A, et al. Effects of approximation of postural sway in healthy subjects. *Phys Ther* 1987;67:502-506.
43. Peele TL. *The Neuroanatomical Basis for Clinical Neurology.* New York: McGraw-Hill, 1954.
44. Simonds HC. *The inside story: Kabat-Kaiser Institute.* Vallejo: Kabat-Kaiser Institute Publishers, 1951.
45. Feldenkrais M. *Awareness Through Movement.* New York: Harper & Row, 1977.
46. Shahini M. Visual input and its influence on motor and sensory systems in man. In: Shahini M. ed. *The Motor System: Neurophysiology and Muscle Mechanisms.* New York: Elsevier, 1976.
47. Harrison VF. A review of the neuromuscular bases for motor learning. *Res Quart* 1962:33:59-78.
48. Medieros JM, Smidt GL, Burmeister LF, et al. The influence of isometric exercise and passive stretch on hip joint motion. *Phys Ther* 1977;57:518-523.
49. Sady SP, Wortman M, Blanke D. Flexibility training: Ballistic, static or proprioceptive neuromuscular facilitation. *Arch Phys Med Rehabil* 1982;63:261-263.
50. Smith JL, Hutton RS, Eldred E. Postcontraction changes in sensitivity of muscle afferents to static and dynamic stretch. *Brain Res* 1974;78:193-202.
51. Nyberg R: *In* Basmajian JV, Nyberg R. eds. *Rational Manual Therapies.* Baltimore: Williams & Wilkins, 1993.
52. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. *Spine* 1996;21:2763-2769.
53. Hodges, PW, Richardson A. Inefficient muscular stabilization of the lumbar spine associated with low back pain. *Spine* 1996;21:2640-2650.
54. McGill SM, Juker D, Kropf P. Quantitative intramuscular myoelectric activity of quadratus lumborum during a wide variety of tasks. *Clin Biomech* 1996;11:170-172.
55. Richardson CA, Jull GA. Muscle control-pain control: What exercises would you prescribe? *Manual Ther* 1995;1:2-10.
56. Paris SV. *The Spinal Lesion.* Christchurch: Pegasus, 1965.
57. McGill SM. Estimation of force and extensor moment contributions of the disc and ligaments at L4-L5. *Spine* 1988;13:1395-1402.
58. Gracovetsky S, Farfan HF, Helleur C. The abdominal mechanism. *Spine* 1985;10:317-324.
59. Hodges PW, Richardson CA. Contraction of the abdominal muscles associated with movement of the lower limb. *Phys Ther* 1997;77:132-142.
60. Ng JK, Richardson CA, Jull GA. Electromyographic amplitude and frequency changes in the iliocostalis lumborum and multifidus muscles during trunk holding test. *Phys Ther* 1997;9:954-960.
61. Ng JK, Richardson CA, Kippers V, et al. Relationship between muscle fiber composition and functional capacity of back muscles in healthy subjects and patients with back pain. *J Orthop Sports Phys Ther* 1988;6:389-402.