PNF
Proprioceptive Neuromuscular Facilitation

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Following injury, soft tissue loses some of its ability to tolerate the demands of functional loading.

A major part of the management of soft tissue dysfunction lies in

- Promoting soft tissue adaptation to restore the tissue's ability to cope with functional loading.

Soft tissue mobilization involves,

- Specific,
- Graded, and
- Progressive Application of force,

Using physiological, accessory, or combined techniques to promote

- Collagen synthesis, orientation, and bonding in the early stages of the healing process or
- Changes in the viscoelastic response of the tissue in the later stages of healing.

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Proprioceptive Neuromuscular Facilitation

PNF is an approach to therapeutic exercise based on the principles of functional human anatomy and neurophysiology.

It uses,
- Proprioceptive,
- Cutaneous, and
- Auditory input
To produce functional improvement in motor output.

These techniques have long been recommended for increasing strength, flexibility, and range of motion.

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The therapeutic techniques of PNF were first used in the treatment of,

- Patients with paralysis and
- Neuromuscular disorders.

Most of the principles underlying modern therapeutic exercise techniques can be attributed to the work of

Sherrington,

Who first defined the concepts of **facilitation** and **inhibition**.

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Facilitation and Inhibition

- An impulse traveling down the corticospinal tract results in
  - The discharge of a limited number of specific motor neurons,
  - As well as the discharge of additional surrounding (anatomically close) motor neurons in the subliminal fringe area.

- An impulse causing the recruitment and discharge of additional motor neurons within the subliminal fringe is said to be
  - **Facilitatory**.

- Any stimulus that causes motor neurons to drop out of the discharge zone and away from the subliminal fringe is said to be
  - **Inhibitory**.

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Facilitation results in increased excitability, and Inhibition results in decreased excitability Of motor neurons.

Thus the function of weak muscles would be aided by facilitation and, Muscle spasticity would be decreased by inhibition.

Sherrington attributed the impulses transmitted from the peripheral stretch receptors via the afferent system as being The strongest influence on the alpha motor neurons,

Therefore the athletic trainer should be able to modify the input from the peripheral receptors and thus Influence the excitability of the alpha motor neurons.

Motor neurons can also be inhibited by peripheral stimulation (inhibitory neurons),

Resulting in muscle relaxation and allowing for stretching of the muscle.

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The principles and techniques of PNF are based primarily on the neurophysiological mechanisms involving,
- The stretch reflex.

The stretch reflex involves two types of receptors:
1. **Muscle spindles**, which are sensitive to a change in length, as well as the rate of change in length of the muscle fiber, and
2. **Golgi tendon organs**, which detect changes in tension.
The Stretch Reflex

Diagram showing the components of the stretch reflex, including Type II afferent nerve fibers from Golgi tendon organs, Type 1a afferent nerve fibers from muscle spindles, and the action of gamma efferent fibers causing reflex relaxation and alpha motorneuron causing reflex contraction.
Two neurophysiological phenomena help to explain *Facilitation* and *inhibition*.

- Of the neuromuscular systems.

- Autogenic inhibition
- Reciprocal inhibition
Autogenic inhibition

- When a muscle is stretched, motor neurons supplying that muscle receive both **Excitatory** and **inhibitory** impulses.

- From the receptors.

- If the stretch is continued for a slightly extended period of time, the inhibitory signals from the Golgi tendon organs eventually **override** the excitatory impulses and therefore cause relaxation.

- The Golgi tendon organs apparently send inhibitory impulses that last for the duration of increased tension (resulting from either passive stretch or active contraction) and

- Eventually **dominate** the weaker impulses from the muscle spindle.

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Reciprocal Inhibition

- It deals with the relationships of the agonist and antagonist muscles.
- When motor neurons of the agonist muscle receive excitatory impulses from afferent nerves,
- The motor neurons that supply the antagonist muscles are inhibited by afferent impulses.
- Thus contraction or extended stretch of the agonist muscle must elicit relaxation or inhibit the antagonist.

![Diagram of reciprocal inhibition](image)
Rationale for use

- The body tends to respond to the demands placed on it.
- The principles of PNF attempt to provide a maximal response for increasing **strength**, **flexibility**, and **coordination**.
- The emphasis is on selective **reeducation** of individual motor elements through development of,
  - Neuromuscular control,
  - Joint stability, and
  - Coordinated mobility.
- Each movement is learned and then reinforced through repetition in an appropriately **demanding and intense rehabilitative program**.

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The PNF approach is holistic, integrating sensory, motor, and psychological aspects of a rehabilitation program.

The brain recognizes only gross joint movement and not individual muscle action.

Moreover, the strength of a muscle contraction is directly proportional to the activated motor units.

Therefore, to increase the strength of a muscle,

The maximum number of motor units must be stimulated to strengthen the remaining muscle fibers.

This "irradiation" or overflow effect, can occur when,

The stronger muscle groups help the weaker groups in completing a particular movement.

This cooperation leads to the rehabilitation goal of return to optimal function.

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Basic principles of PNF

- These principles are the basis of PNF that must be superimposed on any specific technique.

- The principles of PNF are based on sound neurophysiological and kinesiologic principles and clinical experience.

- Application of the following principles can help promote a desired response in the patient being treated.

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The patient must be taught the PNF patterns regarding the sequential movements from starting position to terminal position.

It is sometimes helpful to passively move the patient through the desired movement pattern, to demonstrate precisely what is to be done.

The patterns should be used along with the techniques to increase the effects of the treatment.
When learning the patterns,
The patient is often helped by looking at the moving limb.

This **visual stimulus** offers the patient feedback for
- Directional and
- Positional control.

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Verbal cues are used to coordinate voluntary effort with reflex responses.

Commands should be firm and simple.

Commands most commonly used with PNF techniques are

- "Push" and "Pull," which ask for an isotonic contraction:
- "Hold," which asks for an isometric or stabilizing contraction:
  and
- "Relax."

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Manual contact with appropriate pressure is essential for

- Influencing direction of motion and
- Facilitating a maximal response.

Manual contact should be firm and confident to give the patient a feeling of security.

A movement response may be facilitated by the hand over the muscle being contracted to

Facilitate

- A movement or a stabilizing contraction.
Proper mechanics and **body positioning** of the athletic trainer are essential in applying pressure and resistance.

The athletic trainer should stand in a position that is **in line** with the direction of movement in the diagonal movement pattern.

The knees should be bent and close to the patient such that the direction of resistance can easily be applied or altered appropriately throughout the range.

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The amount or resistance given should facilitate a maximal response that allows smooth, coordinated motion.

The appropriate resistance depends to a large extent on the capabilities of the patient.

It may also change at different points throughout the range of motion.

Maximal resistance may be applied with techniques that use isometric contractions to restrict motion to a specific point,

It may also be used in isotonic contractions throughout a full range or movement.
Rotational movement is a critical component in all of the PNF patterns because,

Maximal contraction is impossible without it.
Normal timing,
Is the sequence of muscle contraction that occurs in any normal motor activity resulting in coordinated movement.

The distal movements of the patterns should occur first.
The distal movement components should be completed no later than halfway through the total PNF pattern.
Timing for emphasis is used primarily with Isotonic contractions.

This principle superimposes maximal resistance, at specific points in the range, upon the patterns of facilitation, allowing overflow or irradiation to the weaker components of a movement pattern.

The stronger components are emphasized to facilitate the weaker components of a movement pattern.
Specific joints may be facilitated by **Traction** or **approximation**.

**Traction** spreads apart the joint articulations, and **Approximation** presses them together.

Both techniques stimulate the joint **proprioceptors**.

**Traction**
- Increases the muscular response,
- Promotes movement,
- Assists isotonic contractions, and
- Is used with most flexion antigravity movements.

**Approximation**
- Increases the muscular response,
- Promotes stability,
- Assists isometric contractions, and
- Is used most with extension (gravity-assisted) movements.
Giving a quick stretch to the muscle before muscle contraction
- Facilitates a muscle to respond with greater force
  - Through the mechanisms of the stretch reflex.

However, this quick stretch can be contraindicated in many orthopedic conditions.
Techniques of PNF

- These techniques may be used in a rehabilitation program either,
  - To strengthen or facilitate a particular agonistic muscle group
  - Or
  - To stretch or inhibit the antagonistic group.

- Specific techniques or combinations of techniques should be selected on the basis of the patient's problem.
Strengthening Techniques

- The following techniques are most appropriately used for the development of,
  - Muscular strength, and
  - Endurance, as well as for
  - Reestablishing neuromuscular control.

- **Rhythmic initiation**
- **Repeated contraction**
- **Slow reversal**
- **Slow-reversal-hold**
- **Rhythmic stabilization**
Rhythmic initiation

- The rhythmic initiation technique involves a progression of
  - Initial passive, then
  - Active-assistive, followed by
  - Active movement against resistance
Through the agonist pattern.

- Movement is slow, goes through the available range of motion, and avoids activation of a quick stretch.

- It is used for patients who are
  - Unable to initiate movement and
  - Who have a limited range of motion because of increased tone.
  - It may also be used to teach the patient a movement pattern.
Repeated contraction

- Repeated contraction is useful when
  - A patient has weakness either at a specific point or throughout the entire range.
- It is used to correct imbalances that occur within the range by
  - Repeating the weakest portion of the total range.
- The patient moves isotonically against maximal resistance repeatedly until
  - Fatigue is evidenced in the weaker components of the motion.
- When fatigue of the weak components becomes apparent,
  - A stretch at that point in the range should facilitate the weaker muscles and result in a smoother, more coordinated motion.
- Quick stretch may be contraindicated with some musculoskeletal injuries.
Slow reversal

- Slow reversal involves
  - An isotonic contraction of the agonist followed immediately by
  - An isotonic contraction of the antagonist.

- The initial contraction of the agonist muscle group facilitates the succeeding contraction of the antagonist muscles.

- The slow-reversal technique can be used for
  - Developing active range of motion of the agonists and
  - Normal reciprocal timing between the antagonists and agonists,

Which is critical for normal coordinated motion.
Slow-reversal-hold

- Slow-reversal-hold is
  - An isotonic contraction of the agonist followed immediately by
  - An isometric contraction of the antagonist,
  With a hold command given at the end of each active movement.
  - The direction of the pattern is reversed by using the same sequence of contraction with no relaxation before shifting to the agonistic pattern.

- This technique can be especially useful in developing strength at a specific point in the range of motion.
Rhythmic stabilization

- Rhythmic stabilization uses
  - An isometric contraction of the agonist, followed by
  - An isometric contraction of the antagonist

To produce **co-contraction** and **stability** of the two opposing muscle groups.

- The command given is always “Hold,” and movement is resisted in each direction.

- Rhythmic stabilization results in an increase in the holding power to a point where the position cannot be broken.

- Holding should emphasize co-contraction of agonists and antagonists.

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Stretching Techniques

- The following techniques should be used to increase
  - Range of motion,
  - Relaxation, and
  - Inhibition.

- **Contract-relax**
- **Hold-relax**
- **Slow-reversal-hold-relax**

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Contract-relax

- A stretching technique that moves the body part passively into the agonist pattern.
- The patient is instructed to push by contracting the antagonist (muscle that will be stretched) isotonically against the resistance of the athletic trainer.
- The patient then relaxes the antagonist while the therapist moves the part passively through as much range as possible to the point where limitation is again felt.
- This contract-relax technique is beneficial when range of motion is limited by muscle tightness.
Hold-relax

- It begins with an **isometric contraction** of the **antagonist** (muscle that will be stretched) against resistance,

- Followed by a **concentric** contraction of the **agonist** muscle

  Combined with light pressure from the athletic trainer to produce maximal stretch of the antagonist.

- This technique is appropriate when there is **muscle tension** on one side of a joint.
**Slow-reversal-hold-relax**

- Slow-reversal-hold-relax technique begins with
  - An *isotonic contraction* of the *agonist*, which often limits range of motion in the agonist pattern, followed by
  - An *isometric* contraction of the *antagonist* (muscle that will be stretched) during the push phase.

- During the relax phase,
  - The *antagonists* are *relaxed* while
  - The *agonists* are *contracting*,

Causing movement in the direction of the agonist pattern and thus stretching the antagonist.

- The technique, like the contract-relax and hold-relax, is useful for
  - *Increasing range of motion*

When the primary limiting factor is the antagonistic muscle group.
Several of PNF techniques are sometimes combined in sequence to accomplish the goals of rehabilitation.
PNF Patterns

❖ The PNF patterns are concerned with gross movement as opposed to specific muscle actions.

❖ The techniques identified previously can be superimposed on any of the PNF patterns.

❖ The exercise patterns have three component movements:
  - Flexion-extension,
  - Abduction-adduction, and
  - Internal-external rotation.
The PNF patterns described by Knott and Voss, involve distinct diagonal and rotational movements of the
- Upper extremity,
- Lower extremity,
- Upper trunk,
- Lower trunk, and
- Neck.

The exercise pattern is initiated with the muscle groups in the lengthened or stretched position.

The muscle group is then contracted, moving the body part through the range of motion to a shortened position.
The upper and lower extremities all have two separate patterns of diagonal movement for each part of the body, which are referred to as the diagonal 1 (D1) and diagonal 2 (D2) patterns.

These diagonal patterns are subdivided into:
- D1 moving into flexion,
- D1 moving into extension,
- D2 moving into flexion, and
- D2 moving into extension.
PNF patterns of the upper extremity

D1 FLEXION
- Forearm: Sup.
- Wrist: Radial Flex.
- Fingers: Flex.

D2 FLEXION
- Forearm: Sup.
- Wrist: Radial Ext.
- Fingers: Ext.

SHOULDER PIVOT
- Shoulder flexion
- External rotation
- Wrist supination

D1 EXTENSION
- Forearm: Pron.
- Wrist: Ulnar Ext.
- Fingers: Flex.

D2 EXTENSION
- Shoulder: Ext.
- Abd.
- Int. Rot.
- Forearm: Pron.
- Wrist: Ulnar Ext.
- Fingers: Ext.
D1 upper-extremity movement pattern moving into flexion. Starting position.
D1 upper-extremity movement pattern moving into flexion.
Terminal position.
D1 upper-extremity movement pattern moving into extension. Starting position.
D1 upper-extremity movement pattern moving into extension. Terminal position.
D2 upper-extremity movement pattern moving into flexion. Starting position.
D2 upper-extremity movement pattern moving into flexion. Terminal position.
D2 upper-extremity movement pattern moving into extension.
Starting position.
D2 upper-extremity movement pattern moving into extension. Terminal position.
PNF patterns of the lower extremity
D1 lower-extremity movement pattern moving into flexion. Starting position.
D1 lower-extremity movement pattern moving into flexion. Terminal position.
D1 lower-extremity movement pattern moving into extension. Starting position.
D1 lower-extremity movement pattern moving into extension. Terminal position.
D2 lower-extremity movement pattern moving into flexion. Starting position.
D2 lower-extremity movement pattern moving into flexion.
Terminal position.
D2 lower-extremity movement pattern moving into extension. Starting position.
D2 lower-extremity movement pattern moving into extension. Terminal position.