Optimizing Motor Planning and Performance in Clients with Neurological Disorders

MOTOR CHARACTERISTICS OF CENTRAL NERVOUS SYSTEM DYSFUNCTION

- Human movement is dependent on complex interactions among multiple systems, with key contributions from integrated motor centres within the brain.
- Damage to neural cells impacts motor, sensory, and cognitive function, and there is typically a direct relationship between anatomical pathology and functional loss.
- The constellation of movement problems associated with brain injury is often referred to as upper motor neuron dysfunction.
- This term is differentiated from lower motor neuron dysfunction, which describes the weakness and flaccidity that is associated with peripheral nerve damage.

- Primary motor impairments are those deficits that are directly attributable to the brain lesion. Primary motor impairments can be further classified as positive or negative.
- Negative impairments include paralysis (hemiplegia or hemiparesis), sensory loss, fatigue, decreased movement speed, and difficulty organizing available movement into functional motor sequences.
- Spasticity (hypertonicity) and the presence of abnormal reflex activity are the hallmarks of positive impairments associated with stroke.
- Ataxia and intention tremor are positive impairments that are associated with cerebellar pathology.
- Resting tremor is a positive impairment associated with basal ganglia dysfunction such as Parkinson’s disease.

- Secondary motor impairments are preventable deficits that develop over time in response to immobility, inactivity or asymmetries in postural alignment.
- Limitations in joint range of motion (ROM), diminished flexibility between body segments, pain, and edema are common secondary impairments in stroke survivors.

- Flaccid paralysis is a neurological condition characterized by weakness or paralysis and reduced muscle tone without other obvious cause.
- This abnormal condition may be caused by disease or by trauma affecting the nerves associated with the involved muscles.
- Spasticity is a stretch reflex disorder, manifested clinically as an increase in muscle tone that becomes more apparent with more rapid stretching movement. It is a common consequence of lesions that damage upper motor neurons causing upper motor neuron syndrome (UMNS).

MOTOR PLANNING DEFINITION

- Motor planning is the ability to conceive, plan, and carry out a skilled, non-habitual motor act in the correct sequence from beginning to end. Incoming sensory stimuli must be correctly integrated in order to form the basis for appropriate, coordinated motor responses.

Brunnstrom’s Movement Therapy

- The Brunnstrom approach is a widely used movement therapy approach used by clinicians. This approach highly focuses synergic pattern of spastic muscles on the recovery of stroke patients through various stages.
- Assumptions
  - In normal motor development, reflexes become modified into purposeful movements and thus recovery in stroke appears to result development in reverse as reflexes are used to facilitate and learn purposeful movements.
  - Proprioceptive and exteroceptive stimuli can be used to provoke desired motion or tonal changes
  - Recovery of voluntary movement in post stroke proceeds in sequence from mass patterns to discrete movements voluntarily. The stereotyped movements are called limb synergies .
  - Repetition is a must of learned movements.
  - Practice in context of ADL's enhances learning

Brunnstrom's Movement Therapy Principles

- Treatment progresses in a developmental sequence from reflexes to voluntary to functional movements.
- When no motion exists, movement can be facilitated using reflexes, associated reactions, proprioceptive/exteroceptive stimuli to develop muscle tension.
  - Reflex and associated reactions are combined with voluntary effort which produces semi-voluntary movement thus providing sensory feedback and satisfaction.
  - Various stimuli given assist in eliciting movement. Resistance (proprioceptive stimuli) promotes a spread of impulses to other muscles to produce an associated reaction whereas a tactile stimuli facilitates muscles only to stimulated area.

- Even if a partial movement is possible, reversal of movement is stressed within each session.
- Facilitation techniques are dropped a soon as the patient shows voluntary control.
- Emphasis is more on voluntary movement and similar ADL's are encouraged to perform.
- Correct movement, once elicited, should be repeated and practiced.

Brunnstrom's Movement Therapy

Brunnstrom Stages of Recovery for the Affected Arm

Stage I	Flaccidity: no voluntary movement, muscle tone, or reflexive responses
Stage II	Synergies can be elicited reflexively; spasticity is developing
Stage III	Beginning voluntary movement but only in synergy; spasticity may be significant
Stage IV	Spasticity begins to decrease; ability to voluntarily perform movements that deviate slightly from synergy patterns
Stage V	Increased control of isolated voluntary movements, independent of synergy patterns
Stage VI	Isolated motor control; spasticity is minimal
Stage VII	Normal speed and coordination of motor function

For hand, the stages are as follows

Stages	Pattern
1	Muscles are flaccid on the involved side
2	The patient evidences minimal spasticity and little or no active finger flexion is possible.
3	The patient is able to hold on to a handle placed in the hand but unable to release through voluntary finger extension. Reflex extension may be possible
4	The patient is able to release by lateral thumb movement with minimal finger extension or through normal functional synergy. That is, he or she is able to grasp with the fingers while the wrist is extended and able to release the fingers while the wrist is flexed.
5	Voluntary mass extension of digits is possible, and the patient is able to control cylindrical and spherical grasp with limited functional use.
6	The patient demonstrates voluntary extension of fingers, lateral, palmar, and three-point prehension and individual finger movements are possible

The effect of associated reactions on patient's movement

Associated reactions are involuntary movement or patterned reflexive tonal increase in those muscles that are expected to be in contrast to cause movement.

These reactions are seen in affected extremities when other unaffected extremities are resisted or effort is made in affected extremity.

These are evaluated to determine which facilitation method can be used.

basic limb synergies:

- A synergistic muscle is a muscle which works in concert with another muscle to generate movement. They act on movable joints
- Synergistic movement happens when you try to make one movement on your affected side, and you end up making multiple movements.
- Synergy means: stereotype whole limb movement.
- For example, trying to move your affected arm might result in hand and shoulder movements too. While movement is a great sign during stroke recovery, synergistic movement is less than ideal.

basic limb synergies:

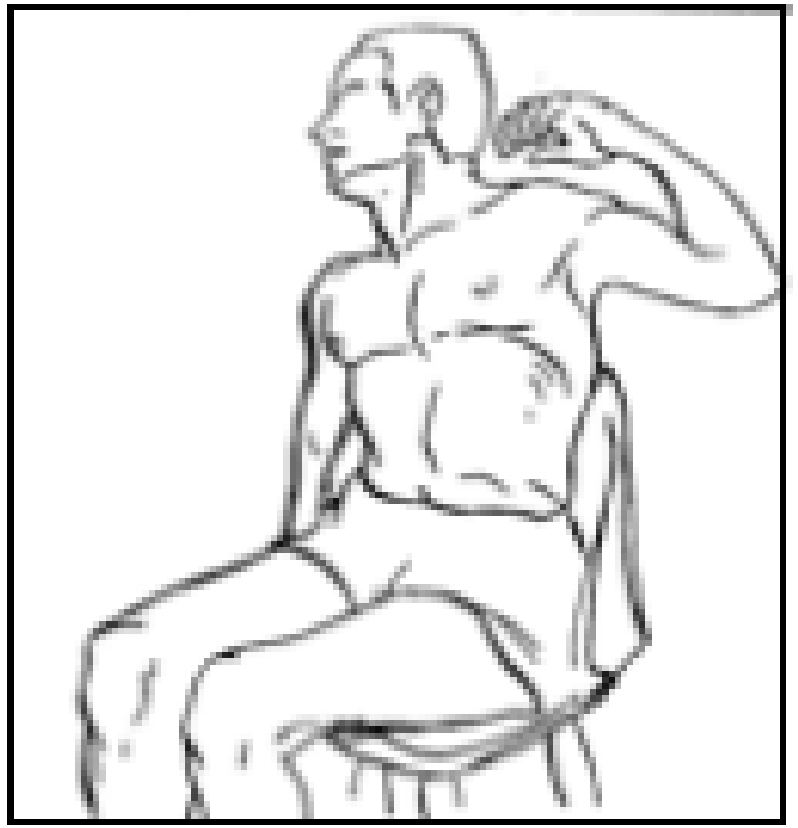
There are two synergies for U.L. and two synergies for L.L.: flexor & extensor.

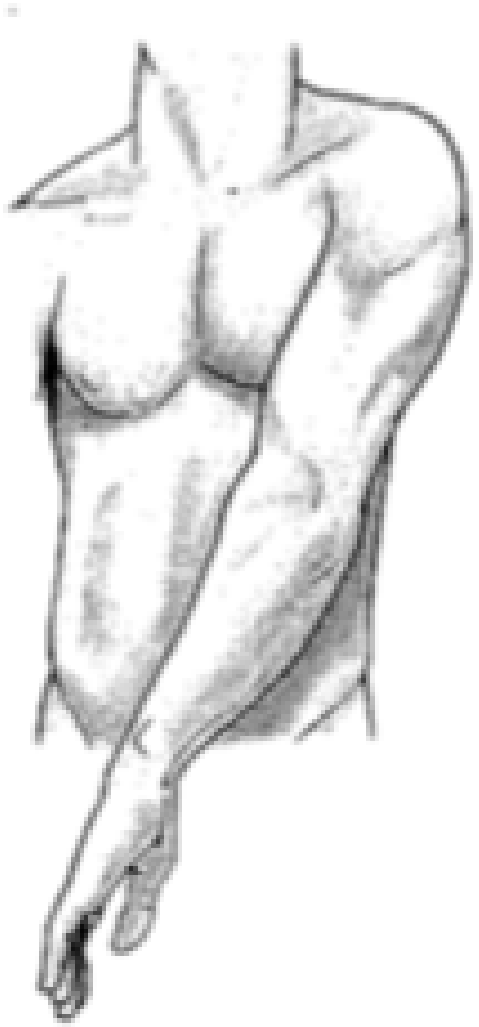
Flexor synergy of U.L:

- It consists of Scapula: retraction & depression, Shoulder: flexion, abduction, external, and rotation, Elbow: flexion to acute angle, Forearm: supination, Wrist & fingers: variable. Most commonly flexed
- The strongest component: elbow flexion
- The weakest component: shoulder abduction & external rotation.

Extensor synergy of U.L:

- It consists of Scapula: protraction, Shoulder: extension, adduction, and internal rotation, Elbow: extension, Forearm: pronation and Wrist & fingers: variable. Most commonly flexed
- The strongest components: adduction (pectoralis major) and pronation.
- The weakest component: elbow extension





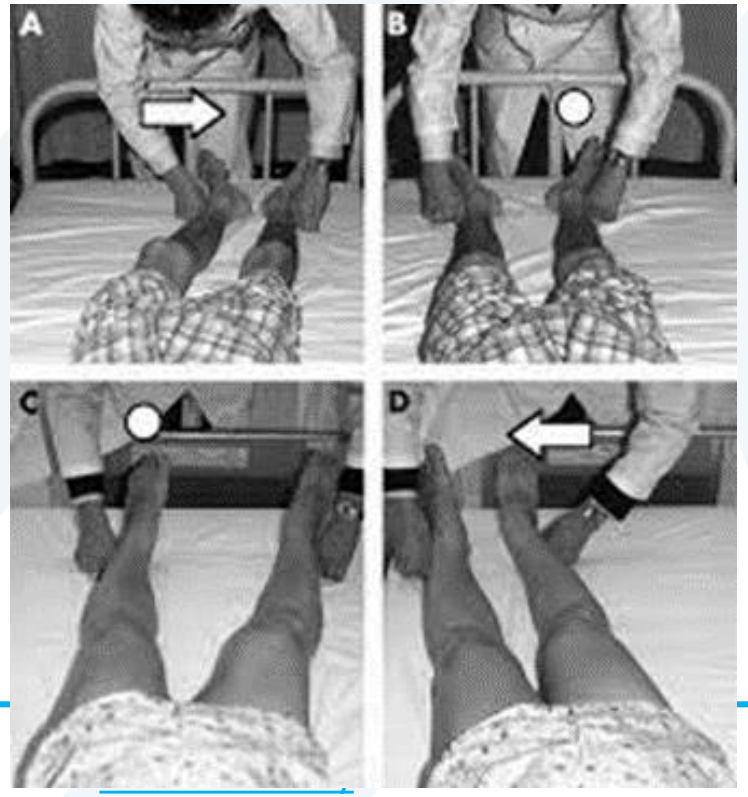
Flexor Synergy of L.L:

- It consists of Hip: flexion, abduction, external rotation, Knee: flexion to about 90°, Ankle: dorsiflexion and inversion, Toes: dorsiflexion.
- Strongest component: hip flexion.
- Weakest component: hip abduction, external, rotation.

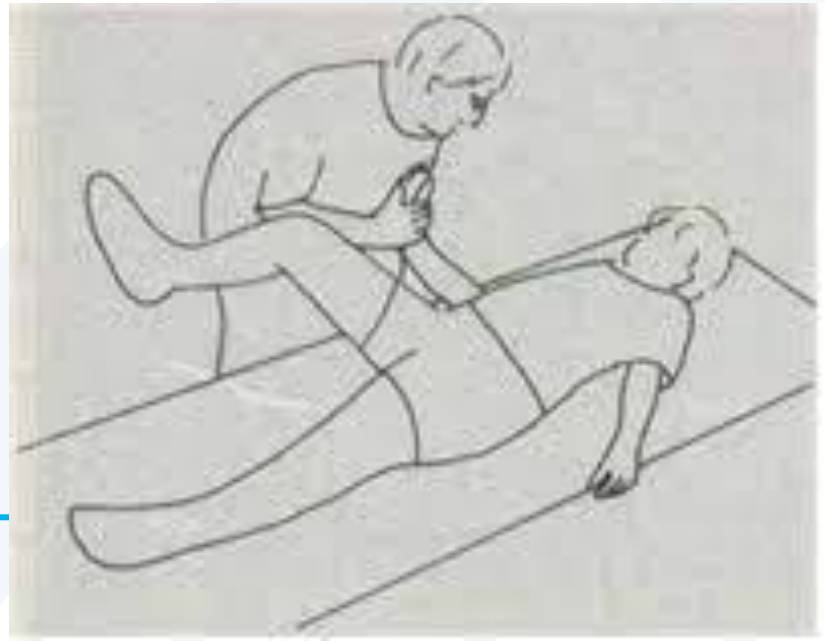
Extensor synergy of L.L:

- It consists of Hip: extension, adduction, internal rotation, Knee: extension, Ankle: planter flexion, inversion, Toes: plantarflexion.
- Strongest components: Hip adduction and Knee: extension.
- Weakest component: hip internal rotation.

Raimeste's Phenomenon: (Resistance to Hip abduction or adduction of noninvolved extremity causes same motion in involved leg)



- Associated reactions are automatic responses of the involved limb resulting from action occurring in some other part of the body
- Resistance to flexion of noninvolved leg causes extension of the involved extremity and resistance to extension of noninvolved side causes flexion of involved extremity.



- Resisted grasp of noninvolved hand causes grasp reaction in the involved hand.
- Flexor movement or tone may be elicited in involved arm when the patient attempts to flex the leg or leg flexion is resisted. This reaction is called **homolateral synkinesis**.
- Souque's Phenomenon - Increased tone of involved arm above horizontal evokes an extension and abduction of fingers.

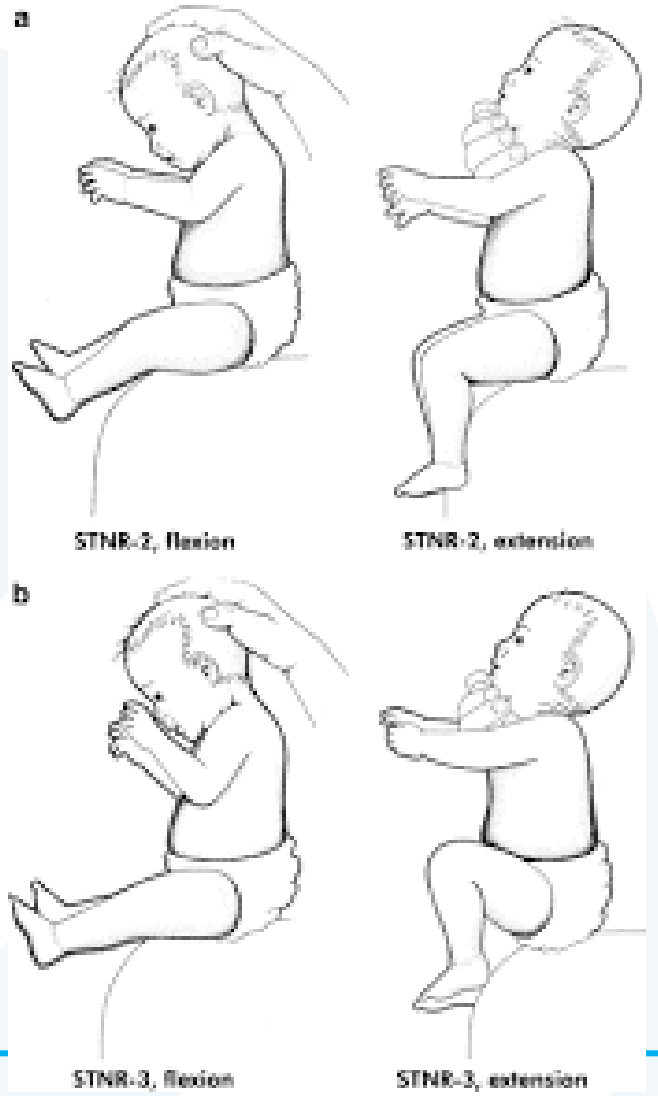
Tonic reflexes:

Symmetric Tonic Neck Reflex (STNR):

- Flexion of the neck results in flexion of the arms and extension of the legs; extension of the neck results in extension of the arms and flexion of the legs.

Asymmetric Tonic Neck Reflex (ATNR):

- Head rotation to the left causes extension of left arm and leg and flexion of right arm and leg; head rotation to the right causes extension of right arm and leg and flexion of left arm and leg


a
STNR-2, flexion
STNR-2, extension
b
STNR-3, flexion
STNR-3, extension

Tonic Lumbar Reflex:

- This is initiated by a change in the position of the upper trunk with respect to the pelvis. Rotation of the trunk to the right results in flexion of the right upper extremity and extension of the right lower extremity; rotation of the trunk to the left results in extension of the right upper extremity and flexion of the right lower extremity

Treatment principles:

(1) When no motion exists, movement is facilitated using reflexes, associated reactions, proprioceptive facilitation, and/or exteroceptive facilitation to develop muscle tension in preparation for voluntary movement.

(2) The responses of the patient from such facilitation combine with the patient's voluntary effort to produces semivoluntary movement.

(3) Proprioceptive and exteroceptive stimuli assist in eliciting the synergies.

(4) When voluntary effort appears:

a) The patient is asked to hold (isometric) the contraction.

b) If successful, he is asked for an eccentric (controlled lengthening) contraction.

c) Finally, a concentric (shortening) contraction.

d) Reversal of the movement between the agonist and antagonist.

(5) Facilitation is reduced or dropped out as quickly as the patient shows voluntary control (primitive reflexes & associated reactions).

(6) Correct movement is repeated.

(7) Practice in the form of ADL.

Benefits of the Brunnstrom approach: The Brunnstrom approach emphasises the ability to recover normal movement by facilitating reflexes, basic muscle synergies and sensory stimulation. This type of treatment will help:

- Increase muscle strength
- Stretch tight muscles
- Regain motor control
- Recover voluntary movement
- Improve functional tasks such as sit to stand, walking, reaching, grasping and hand to mouth
- Improve the sequence of functional activities in order to achieve a specific aim
- Improve posture
- Increase independence

Rood and Proprioceptive Neuromuscular Facilitation Approaches

- Reflecting the view that motor development and motor recovery from stroke followed a hierarchical sequence, these approaches advocated that patients “recapitulate” the movement sequence exhibited by typically developing infants during the first year of life.
- therapy techniques included exercises that required the person to first learn how to maintain stability and then to move, in the prone position on elbows, quadruped positions, and kneeling positions.

- Another hierarchical concept, also influenced by knowledge of infant development, was that stroke survivors recovered motor function in a proximal to distal sequence.
- Hence, therapeutic interventions always began at the pelvic and shoulder girdles. When working to improve upper limb motor function, proximal control over scapular and glenohumeral motions was considered to be a prerequisite for implementing treatment that focused on forearm and hand function. Today, it is understood that survivors of stroke or TBI may demonstrate distal voluntary movements (e.g., some capacity to fl ex the thumb joints) before they have achieved a particular level of proximal control of scapular and glenohumeral motions

- current motor intervention for patients recovering from stroke or brain injury does not follow a proximal to distal sequence. Instead, each patient’s constellation of motor abilities guides the therapist in setting treatment goals

- Like Brunnstrom's model, both the Rood and PNF approaches advocated the use of specific sensory stimuli for facilitation or inhibition of motor "firing" within selected muscles. Stimuli that facilitate the spinal level myotatic reflex, like quick stretch, or vibration over a muscle belly, were used to stimulate the stretch reflex and thus elicit a momentary increase of muscle fibre contraction.

- The physiological principle of reciprocal inhibition (that stimulation to a muscle will simultaneously elicit inhibitory neural signals to its antagonist) was used to relax spastic muscles. For example, a quick stretch to the triceps would elicit a momentary increase of neural signals to elicit contraction of muscle fibres in the elbow extensor muscle and also elicit a momentary decrease of neural " firing" to the muscle fibres of the biceps. The observed result was a temporary decrease in hypertonicity in the biceps and greater ease in passively or actively moving the elbow into extension.
- Generalized inhibitory stimuli included slow, rhythmic vestibular input (as in slow rolling) and various types of relaxing somatosensory stimuli.

- Although these techniques are no longer used in neurorehabilitation as initially prescribed by the Rood and PNF approaches, there are certainly modern correlates to these ideas.
- Functional electrical stimulation (FES) has replaced the facilitation techniques. Medical interventions such as botulinum toxin injections and GABAergic medications and generalized relaxation strategies, as applied through yoga poses, controlled breathing, guided imagery, and meditation, have replaced the reflex-based inhibitory techniques advanced by the Rood and PNF approaches.

- A major contribution by the PNF approach is the use of diagonal patterns of limb movement.
- Before PNF, rehabilitation professionals tended to view movement as occurring only through the three cardinal planes (sagittal, coronal, and transverse).
- Passive movement through diagonal patterns ensures safe and efficient stretch to all muscles, at all joints of the upper limb.
- Active and resisted movements through diagonal patterns provide exercise to groups of muscles in the limbs and trunk that are recruited synergistically by the CNS.
- PNF diagonals and ancillary techniques continue to be used effectively in orthopaedic rehabilitation and athletic training. Their effectiveness as an intervention to improve motor function after brain injury has never been supported by research.

- Rood developed a system of therapeutic exercises enhanced by cutaneous stimulation for patients with neuromuscular dysfunctions. In addition to proprioceptive manoeuvres such as positioning, joint compression, joint distraction and the general use of reflexes, stretch, and resistance, the greatest emphasis is given on exteroceptive applications such as stroking, brushing, icing, warmth, pressure, and vibration in order to achieve optimal muscular action

Tapping

- "Tapping is the use of a light force applied manually over a tendon or muscle belly to facilitate a voluntary contraction".

- Tapping is used to assess reflex activity with a normal response being a brisk muscle contraction. Rood recommended three to five taps over the muscle belly to be facilitated.

Brushing

- Fast brushing, using a battery-operated brush on the skin overlying the muscle, is a therapeutic technique presented originally by Margeret Rood to facilitate movement responses and enhance static holding postural extensors.

- There is limited research in terms of the effectiveness of brushing, its long term use, its continued effects or the required rate or duration of brushing or pressure to be applied.

Cryotherapy-Brief

- Ice can be used to facilitate a muscle response, which uses a combination of coolness and pain sensation to produce the desired response.

Passive Stretching: The types of stretching used include;

- Fast / Quick
- Prolonged
- Maintained

- When we look at the use of stretch for facilitation we employ a fast/quick stretch. The fast/quick stretch produces a relatively short-lived contraction of the agonist's muscle and short-lived inhibition of the antagonist muscle which facilitates a muscle contraction. It achieves its effect via stimulation of the muscle spindle primary endings which results in reflex facilitation of the muscle via the monosynaptic reflex arc.

Joint Compression

- Joint awareness may be improved by joint compression which will lead to enhancing motor control. Receptors in joints and muscles are involved with the awareness of joint position and movement which are stimulated by joint compression. Joint compression can have both facilitatory and inhibitory effects.
- Joint Compression of the joint surfaces facilitates posture extensors which are needed to stabilise the body. Compression can be applied slowly to inhibit muscle control or in jerky manner to facilitate muscle control. The application may be manually and/or by using weight bearing postures.
- Joint compression can be achieved in two ways:
  - Light Compression: Normal body weight being applied through the long axis of the bone which is thought to inhibit (relax) muscle spasticity
  - Heavy Compression: Compression is greater than that applied by body weight which is thought to facilitate co-contraction at the joint undergoing compression

Vibration/Muscle Vibration

- Vibrations of the muscle are thought to increase corticospinal excitability as well as inhibitory neuronal activity in the antagonistic muscle.
- Bishop et al (1974) identified three motor effects achieved through muscle vibration:
  - Sustained contraction of the vibrated muscle via tonic vibration reflex
  - Depression of the other neurons innervating the antagonistic muscles via reciprocal inhibition or antagonistic inhibition
  - Suppression of the monosynaptic stretch reflexes of the vibrated muscle while being vibrated.
- Questions still remain as to whether vibration has any sustained effect on the muscle.

- Muscle Vibration is generally applied to directly to the chosen muscle or tendon and may be applied in two ways; High and Low Frequency.

High Frequency

- The high-frequency vibration is driven from a vibrator that optimally operates at a frequency of 100 - 200 Hz and at an amplitude of 1 – 2 mA. This type of vibration produce facilitation of muscle contraction through what is known as tonic vibration reflex. This facilitatory effect sustained for a brief time after application. Therefore it can be used for stimulating muscles whose primary function is one of tonic holding.

Low Frequency

- The low-frequency stimulation occurring between 5 -50 Hz has an inhibitory effect on muscle through its activation of spindle secondary endings and Golgi tendon organs.
- While Vibration has the potential as a good treatment technique there is still limited evidence on its effectiveness the therapist must be aware of the precautions that must be considered when using it as a treatment option which include:

➢Generates heat at the point of application

➢Can potentially damage skin, particularly at high amplitude

Whole Body Vibration

- Whole body vibration is a relatively new modality which involves the use of vibration through standing on a vibrating platform and has been utilized to improve balance and gait.
- Further studies are needed in the future well-designed trials with a bigger sample size to determine the most effective frequency, amplitude and duration of vibration application in the neurorehabilitation.

Vestibular Stimulation

- The vestibular stimulation technique is a proprioceptive unique sensory system with multi-sensory function. According to the type of stimulus we can use the vestibular system to achieve many treatment alternatives.
- Total body inhibition can be achieved by slow rocking, slow anterior-posterior movement, slow horizontal movement, slow vertical movement and slow linear movement.
- Total body facilitation can be achieved by rolling patterns, a rocking pattern on elbows and extended elbows and crawling.

- Spinning induces tonal responses and causes a *strong facilitation* of movement through the overflow of impulses to higher centres.
- Facilitation of postural extensors is another effect of vestibular stimulation if it is used by *a rapid way anterior-posterior or angular acceleration of the head and body while the child in prone position*.
- Inverted position is commonly used now to achieve a total body inhibition, while it may be used to increase to in certain extensors.
- Vestibular stimulation is **not widely used** in neurological rehabilitation. The management of vestibular dysfunction is recognised as a specialist area within physiotherapy.

Passive Stretching - Slow

- When we look at the use of stretch to normalize tone and maintain soft tissue length we employ a slow, prolonged stretch to maintain or prevent loss of range of motion. While the effects are not entirely clear the prolonged stretch produces inhibition of muscle responses which may help in reducing hypertonus, e.g. Bobath's neuro-developmental technique, inhibitory splinting and casting technique. It appears to have an influence on both the neural components of muscle, via the Golgi Tendon Organs and Muscle Spindles, and the structural components in the long term, via the number and length of sarcomeres.

- Passive stretching may be achieved through a number of methods which include;

Manual Stretching

- Stretch should provide sufficient force to overcome hypertonicity and passively lengthen the muscle.

Weight Bearing

- Weight-bearing has been reported to reduce contracture in the lower limb through the use of Tilt-tables, and standing frames through a prolonged stretch. Angles are key to ensure the knees remain extended during the prolonged stretch as the force exerted on the knee can be quite high.

Splinting

- Splints and casts are external devices designed to apply, distribute or remove forces to or from the body in a controlled manner to perform one or both basic functions of control of body motion and alteration or prevention in the shape of body tissue. Splinting can be used to produce low-force, long duration stretching although there is a dearth of evidence to support this. A wide range of splint have been used to influence swelling, resting posture, spasticity, active and passive ROM.

Serial Casting

- Serial casting is a common technique that is used and most effective in managing spasticity related contracture. Serial casting is a specialised technique to provide increased range of joint motion. The process involves a joint or joints that are tight which are immobilised with a semi-rigid, well-padded cast. Serial casting involves repeated applications of casts, typically every one to two weeks as range of motion is restored.
- The duration of a stretch to reduce both spasticity and to prevent contracture are not yet clear from the research and require further research to determine the most appropriate technique and duration to produce the required effect.

Positioning

- Patients should be given individualized positioning and early mobilization management plans as soon as possible after a neurological impairment to prevent complications and to regain function. It is based on reducing the effects of gravity on alpha motor neuron and consequently inhibiting muscle tone. *Relaxation achieved by this technique is not permanent and unless motor learning or central program adaptation is actualised it is reversible.*

- Positioning is used widely to prevent the development of contracture in neurological conditions and to discourage unwanted reflex activity. After a neurological impairment, muscles can be affected in various ways, causing pain, spasticity, and problems with speed and range of motion. One way to minimize these effects is to properly support, position, and align the body. Proper positioning can be useful to minimize or prevent pain and stiffness that are commonly present post-impairment. It can also regain movement that was lost, or limit future problems with movement. In addition, proper positioning has been shown to increase awareness and protection of the weaker side of the body.

- Some common positions recommended following a stroke:

1. Positioning while lying on your back: Pillows are placed behind the shoulder, head, weaker arm, and hip. The feet are placed in a neutral position.
2. Positioning while lying on the weaker side: When lying on the weaker side, one or two pillows are placed under the head, the weaker shoulder is positioned comfortably on a pillow, the stronger leg is forward on one or two pillows, and the weaker leg is straight out. Pillows are also placed in the back and in front of the body.
3. Positioning while lying on the stronger side: One or two pillows are placed under the head, while the weaker shoulder is placed forward with the weaker arm supported by pillows. The weaker leg is placed toward the back on pillows.
4. Positioning while sitting up: The individual is seated at the centre of the chair or wheelchair, their arms placed forward onto pillows on their lap or on a table. Feet are placed flat on the floor or on footrests with knees bent directly above the feet.

5. Positioning while sitting in bed: Sitting up in bed is recommended for short periods only as it is better to sit in a chair as soon as possible. The individual will sit upright, well supported by pillows. Arms are placed on pillows on either side of the body and legs are extended comfortably.
6. Positioning during transfers: During transfers to a chair or from a chair to another chair, positioning of the weaker shoulder and upper arm is important. The weaker arm should always be supported during transfers, and it is important that no one pull on the arm as it can cause pain in your shoulder that will be difficult to eliminate once created. For getting out of bed, it may be useful to install a bar beside your bed that you can hold onto with your stronger arm to help push yourself up to the standing position.
7. Positioning while standing and walking: While standing up and moving around, slings and supports are used for positioning of the weaker arm.

POSITIONING FOR PERSONS WHO HAVE ACUTE HEMISPHERIC STROKE

Place Logo Here

Left Side Affected

After a stroke people can experience differing physical problems. Careful positioning and placement of pillows may increase comfort and safety. The **left side** affected by the stroke is in **black.** Bed rails not shown.

LYING ON LEFT SIDE

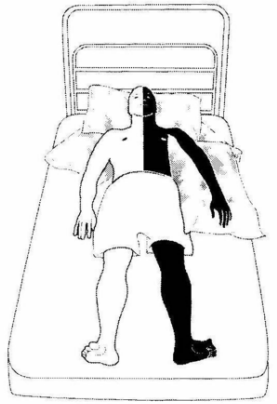
- Use this position only if it does not affect breathing
- 1-2 pillows for the head
- Protract the scapula of the left shoulder, extend wrist & fingers
- Place the right leg forward on 1-2 pillows
- Place pillows in front and behind

LYING ON RIGHT SIDE

- 1-2 pillows for head
- Place the left shoulder forward, scapula protracted with arm supported on pillow
- Left leg backwards on 1-2 pillows
- Place a pillow behind back

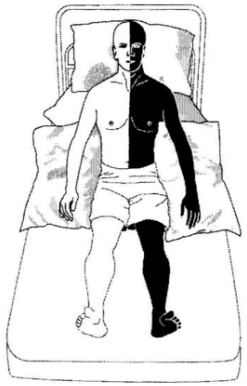
SITTING UP

- Sit well back in the centre of the chair or wheelchair
- Place arms well forward
- The left arm may rest on a table or arm rest
- Feet flat on floor or footrests
- Knees directly above feet



LYING ON BACK

- Head of bed 0-30° unless contraindicated
- Place 3 pillows to support both shoulders and the head
- Left arm on a pillow
- Optional pillow beneath left hip
- Ensure feet are in a neutral position



SITTING IN BED

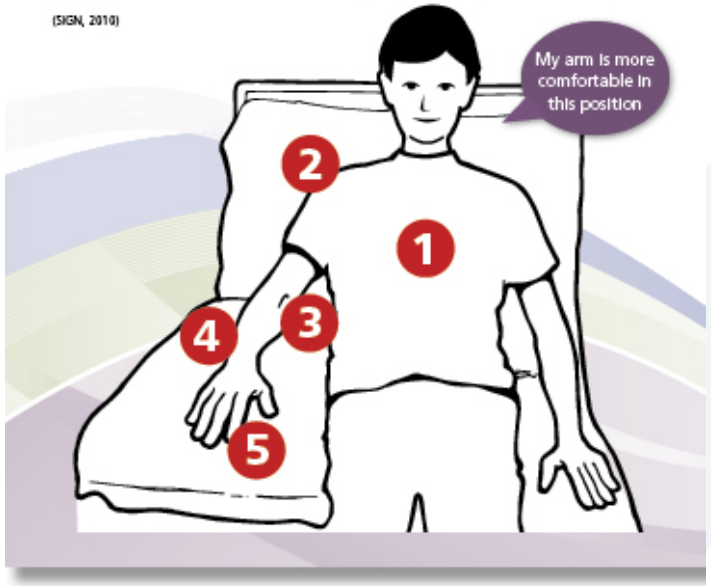
- Sit upright and well supported by pillows
- Place both arms on pillows
- Legs supported for comfort

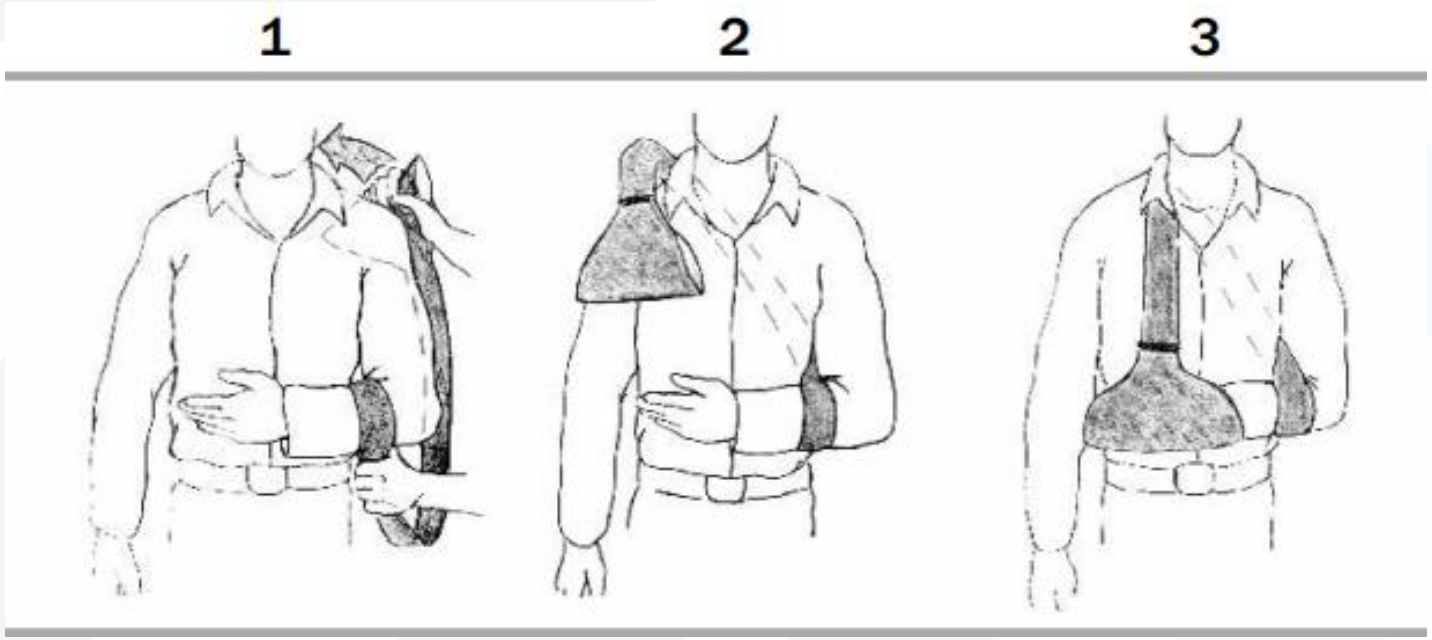
Adopted by APSS Pillar 3, 2007
Reviewed December 2008
Reference: Acknowledgement to Mark Smith, Clinical Specialist Physiotherapist for Stroke, NHS Lothian

Stroke Arm Position Tool

1. **Sit up** straight
2. Stroke **Shoulder** slightly forward
3. Stroke **Elbow** away from the body
4. Stroke **Forearm** slightly forward
5. Palm down and **Fingers** straight

(SIGN, 2010)





Neutral Warmth

- It is one of the most common methods used to inhibit postural tone and muscle activity. Neutral warmth acts through stimulating the thermoreceptors and activating of parasympathetic responses. Usually, 10-20 minutes are sufficient period to produce an effect. The application may be by wrapping body part with towels, hot packs, tepid baths and air splints.

Cryotherapy - Prolonged

- Efferent and afferent neurotransmission is reduced through prolonged use of ice, which is effective for the reduction of spasticity. In order to achieve this, the muscle spindles need to be cooled requiring that ice is applied until there is no longer an excessive reflex response to stretching. Effects can last from 1-2 hours which provide a window of opportunity to work on stretches or exercises that may provide a more long lasting effect. The most common method of prolonged icing that is used is local immersion, which is particularly useful in reducing hand flexor tone.

Massage

- Massage uses pressure to direct venous and lymphatic flow back towards the heart. It is therefore important that the movement is always in this direction so that there is no undue pressure on the closed valves in the veins. These valves prevent backflow of blood by only allowing blood to move in one direction (i.e. toward the heart). As the pressure from the heart pumping subsides and the blood moves back, the valves close and prevent any further back flow.
- Massage may also be used to stretch muscle fibres. In this case, the direction is not as important as the strokes are much shorter and therefore pressure in the wrong direction is not significant enough to cause damage.

Proprioception Neuromuscular Facilitation

- Proprioceptive Neuromuscular Facilitation (PNF) is a set of stretching techniques commonly used in clinical environments to enhance both active and passive range of motion in order to improve motor performance and aid rehabilitation. PNF is considered an optimal stretching method when the aim is to increase range of motion, especially as regards short-term changes.
- PNF helps to restore normal movement by focusing on the developing sequence of movement and how the agonist and antagonist muscles work together to produce volitional movement. PNF uses reflexive movement as a basis for learning more volitional movement. The idea is that one must be able to roll before he can crawl and crawl before he walks.

- PNF focuses on mass movement patterns that are diagonal and resemble functional movement.
- The body does not work in parts, but instead as a whole.
- In order to promote these mass movement patterns, PNF uses a multi-sensory approach, incorporating the auditory, visual and tactile systems.
- PNF allows the patient to understand what normal movement feels like through the use of various senses through use of manual contacts to cue the patient and facilitate movement.

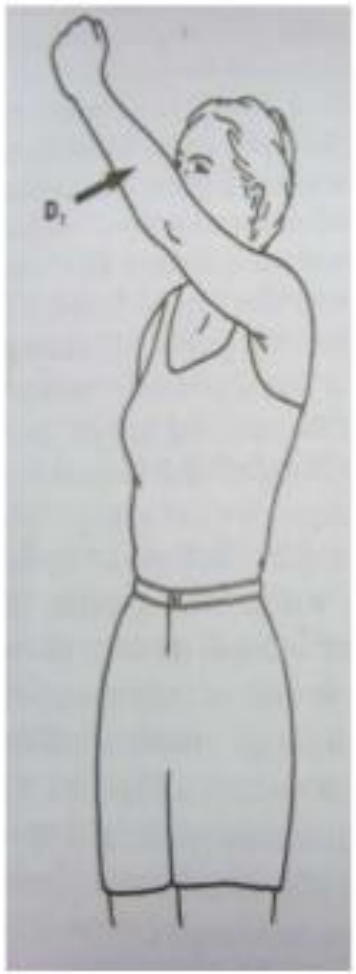
- Primarily, PNF treatment techniques focus on three things:

1. Increase the motor learning of the agonist through repetition of an activity (repeated contractions) and rhythmic initiation.
2. Reverse the motor patterns of the antagonist. Two techniques are slow reversal and rhythmic stabilisation, both of which use an isometric contraction.
3. Finally, learning to relax muscles helps to increase range of motion and decrease spasticity.

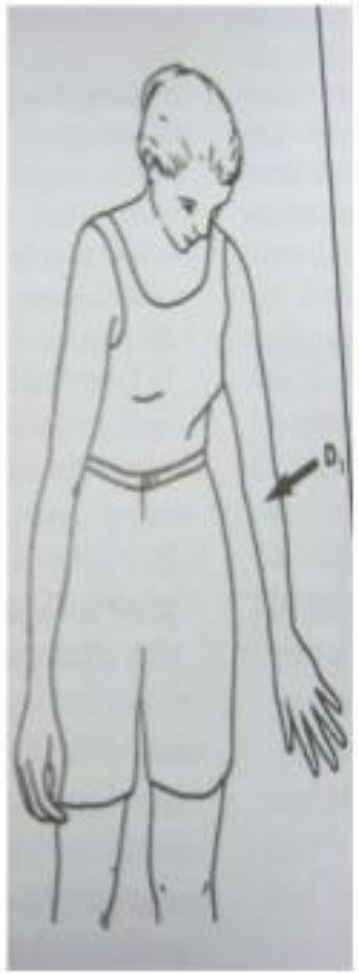
- Proposed mechanisms underlying the PNF stretching response include Autogenic Inhibition and Reciprocal Inhibition which have traditionally been accepted as the neurophysiological explanations for the range of movement gains that PNF stretching achieves over static and ballistic alternatives.

- The patterns of movement associated with PNF are composed of multijoint, multiplanar, diagonal, and rotational movements of the extremities, trunk & neck.
- There are 2 pairs of foundational movements for the upper extremities; UE D1 flexion & extension, UE D2 flexion & extension. There are also 2 pairs of foundational movements for the lower extremities; LE D1 flexion & extension, LE D2 flexion & extension. Various PNF stretching techniques based on Kabat's concept are: Hold Relax, Contract Relax, and Contract Relax Antagonist Contract.

F-ADD-ER



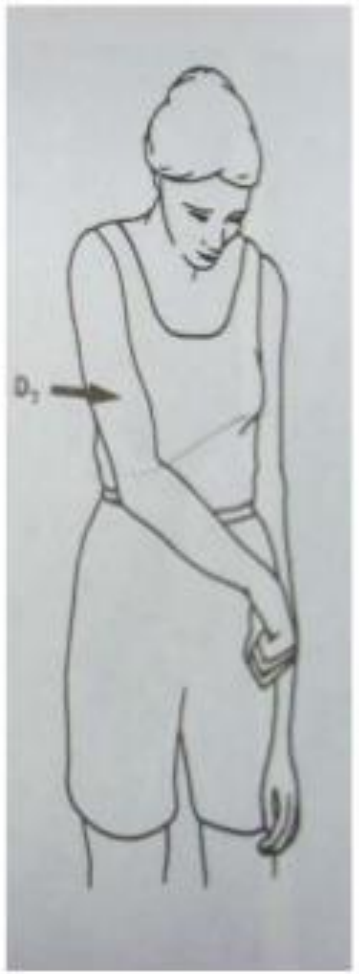
E-ABD-IR



Diagonal One

F-ABD-ER

E-ADD-IR

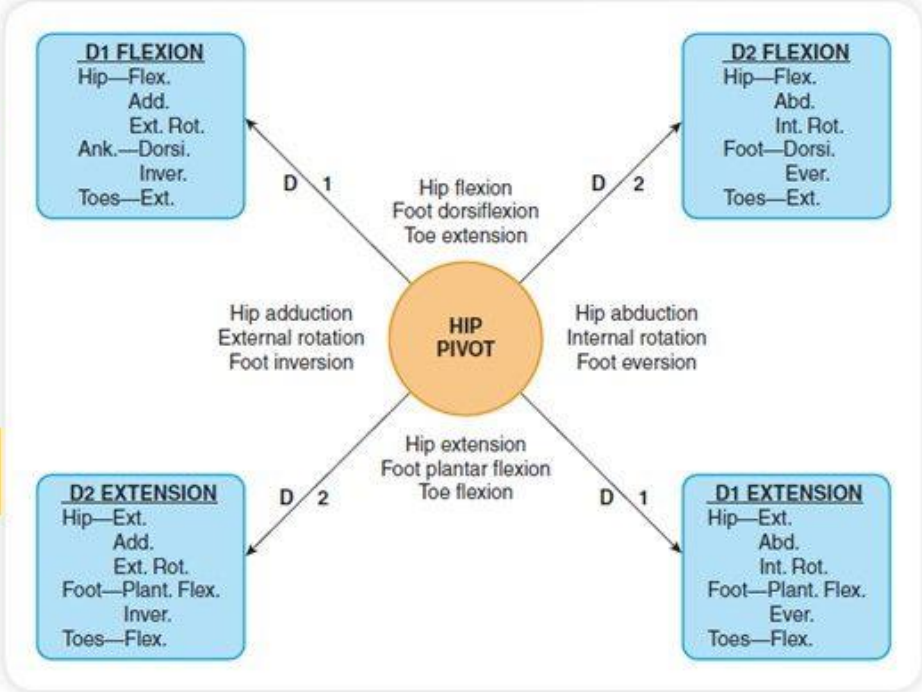


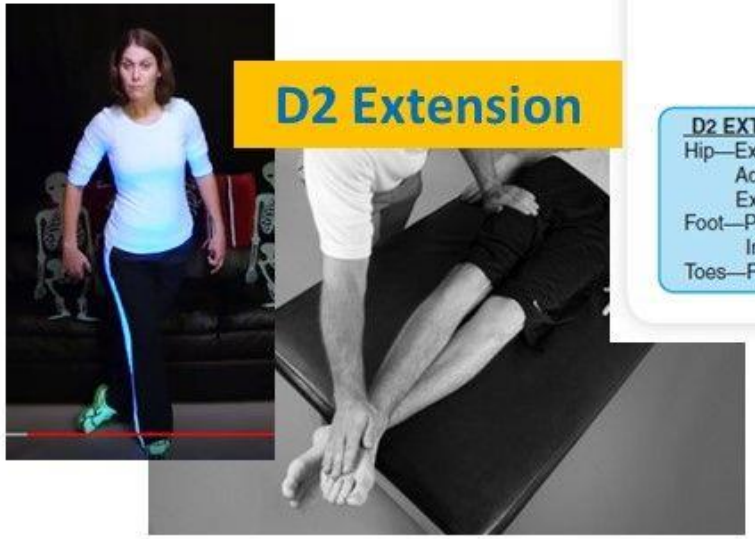
Diagonal Two

Lower Extremity PNF Patterns

D1 Flexion

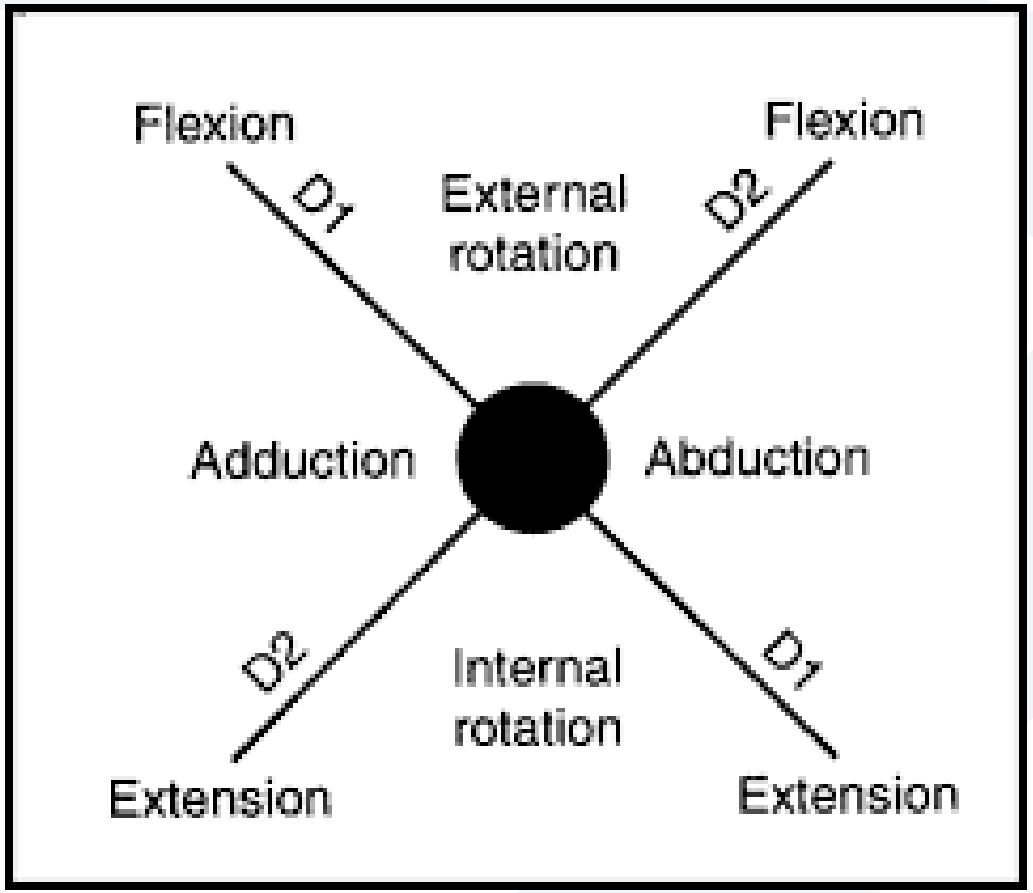
D2 Flexion





D2 Extension

D1 Extension



	D1 Flexion	D1 Extension
Hip	Flexion, adduction, ER	Extension, abduction, IR
Knee	Flexion	Extension
Ankle	Dorsiflexion	Plantarflexion

	D2 Flexion	D2 Extension
Hip	Flexion, abduction, IR	Extension, adduction, ER
Knee	Flexion	Extension
Ankle	Dorsiflexion	Plantarflexion

- Contract Relax: Passive placement of the restricted muscle into a position of stretch followed by an isotonic contraction of the restricted muscle.
- After the contraction period the patient is instructed to relax the restricted muscle that was just contracting and activate the opposing muscle to move the limb into a greater position of stretch.
- Through Golgi tendon organ, the tight muscle is relaxed, and allowed to lengthen.

- Hold Relax: Very similar to the Contract Relax technique. This is utilised when the agonist is too weak to activate properly.
- The patient's restricted muscle is put in a position of stretch followed by an isometric contraction of the restricted muscle. After the allotted time the restricted muscle is passively moved to a position of greater stretch. This technique utilises the autogenic inhibition, which relaxes a muscle after a sustained contraction has been applied to it for longer than 6 seconds.

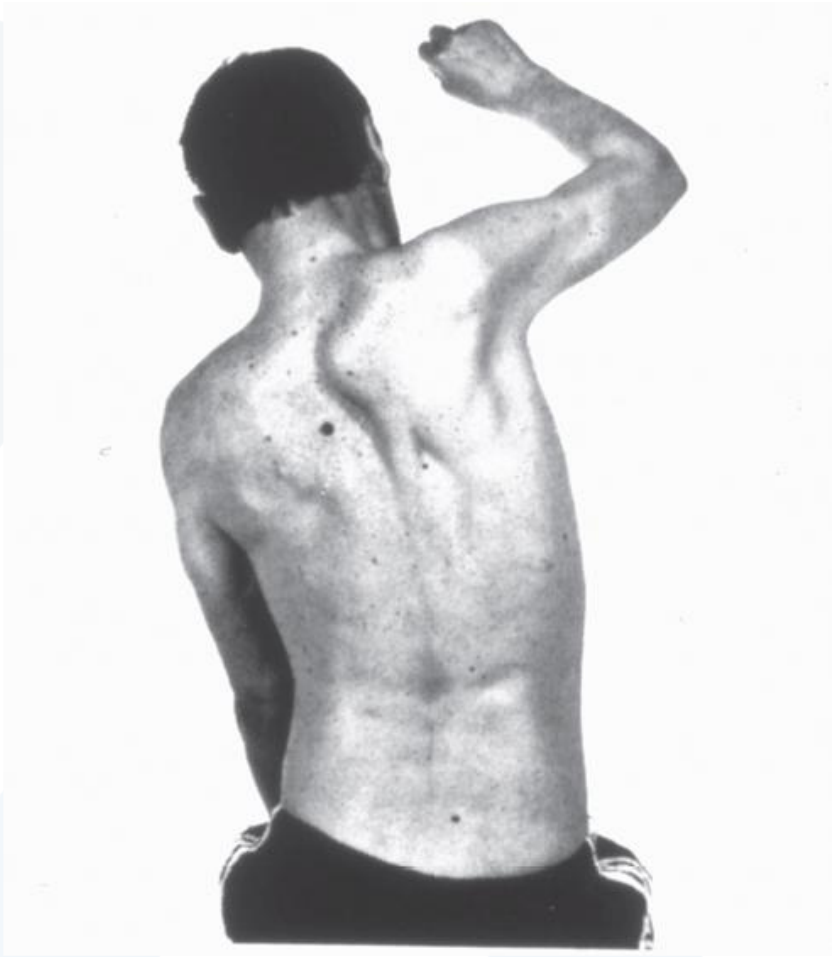
- Contract Relax Agonist, Antagonist Contract: Usually performed by a passive or active stretch of the target muscle(s) to move the limb into a starting position at first, followed by a sub-maximal isometric contraction of the target muscle and finally an active stretch is used to move the limb into a new greater position. This technique uses autogenic and reciprocal inhibition. Reciprocal inhibition is the main cause of the greatest effect of this technique versus the other PNF techniques.

- Rhythmic Initiation: Begins with the therapist moving the patient through the desired movement using passive range of motion, followed by active-assistive, active-resisted range of motion, and finally active range of motion.
- Slow reversals: Utilizes isotonic contractions of first agonists, then antagonists performed against resistance .
- This technique is used to strengthen and build-up endurance of weaker muscles and develop co-ordination and establish the normal reversal of antagonistic muscles in the performance of movement.

Neurodevelopmental Therapy (The Bobath Approach)

- Berta Bobath, a physical therapist, and her husband, Karel Bobath, a psychiatrist and neurophysiologist, began advancing a different set of ideas for enhancing motor recovery in children and adults as early as the 1940s
- Where Brunnstrom's approach capitalized on spasticity and hyperactive reflexes as opportunities to elicit early movement, the Bobaths viewed hypertonicity as an obstacle to a person's ability to move freely. In addition, they recognized that once a person begins to move his paretic limbs in abnormal patterns, it is extremely difficult to break away from these obligatory patterns for flexible movement sequences that meet the contextual demands of activity performance.

- Instead of viewing the synergies as primary impairments that are directly associated with cerebral damage, they conceptualized these abnormal movement patterns as secondary maladaptive strategies.
- “adaptive features” to describe disorders of movement that develop in response to a person’s attempt to move within the constraints of limited mobility, specific weakness, or hypertonicity in specific muscles.



- Neurodevelopmental therapy (NDT) introduced the concept that therapy could “ prevent” the development of abnormal limb synergy patterns by removing mechanical obstacles to movement
- In particular, NDT provides specific guidelines for observing a patient’s postural alignment, predicting how misalignment might impact the kinematics of limb movement, and improving the patient’s postural symmetry and balance.

- The Bobaths were the first to articulate that motor performance problems in stroke survivors are due to factors beyond the activation of individual muscles. They stressed that many stroke survivors have “lost the feeling of normal movement”
- “normal movement” is described as motor programs or flexible attractor states
- In addition, they recognized that postural alignment and postural control provide a critical foundation for functional movement.
- However, outcome studies have not supported the efficacy of the total package of NDT intervention, as compared with other approaches to improving motor control in stroke survivors

- Depending on the extent of neuropathology, all stroke survivors have varying potential for spontaneous recovery and reorganization of neural mechanisms.
- These studies consistently find that brain plasticity is a dynamic process that is influenced by the individual's active efforts to meet environmental and task demands.
- Therefore, a unique pattern of activity with core foundational characteristics emerges whenever the motor program is executed

Applying Principles from Dynamical Systems, Ecological Systems, and Motor Program Theory to Occupational Therapy Practice

- Reduce kinesiological constraints to movement performance such as limited range of motion, excessive effects of gravity, etc.
- Present task-based challenges designed to provide graded practice in using available capacities to achieve functional goals.
- Manipulate affordances/regulatory conditions within therapeutic tasks (and the environmental context) to provide varied and graded opportunities to practice incorporating effective motor programs into performance of functional tasks.
- Provide opportunities for practice and active experimentation with varied strategies in a variety of contexts to develop flexibility and skill in motor performance.

The Bobath approach rests on a number of principles that include:

- Encouragement of normal movement patterns
- Focusing on quality of movement
- Normalisation of tone to facilitate active movement
- Positioning and posture in lying, sitting and standing
- Discouragement of compensatory movements
- Discouragement of muscle strength training
- Promotion of maximum functional recovery to improve quality of independence

Handling techniques are used so that a person does not move with over-exertion and to provide sensory feedback.

- Benefits of Bobath

Bobath encourage a person to move in the most normal and energy efficient way and prevent abnormal movement patterns in order to:

- Normalise tone
- Regain motor control
- Make movements easier to achieve that are precise and goal directed
- Improve posture
- Lengthen tight muscles to help decrease spasticity and reduce contractures
- Improve ability with everyday activities
- Increase independence
- Achieve maximum potential

The Bobath approach also emphasises the importance of early rehabilitation, consistency of practise and a stimulating environment in order to promote recovery.

Constraint-Induced Movement Therapy

- CIMT involves constraint of the non-affected upper extremity in combination with intensive therapy.
- Key Principles from Constraint-Induced Movement Therapy That Can Be Applied to Occupational Therapy for All Stroke Survivors
  - Prevent learned nonuse by teaching patients how to capitalize on emerging abilities to execute specific movements.
  - Design/adapt activities that the person can perform with existing capabilities.
  - Teach the person how to design/adapt activities for functional use of available abilities within natural contexts.

- The restraints commonly used for CIMT includes[11]:

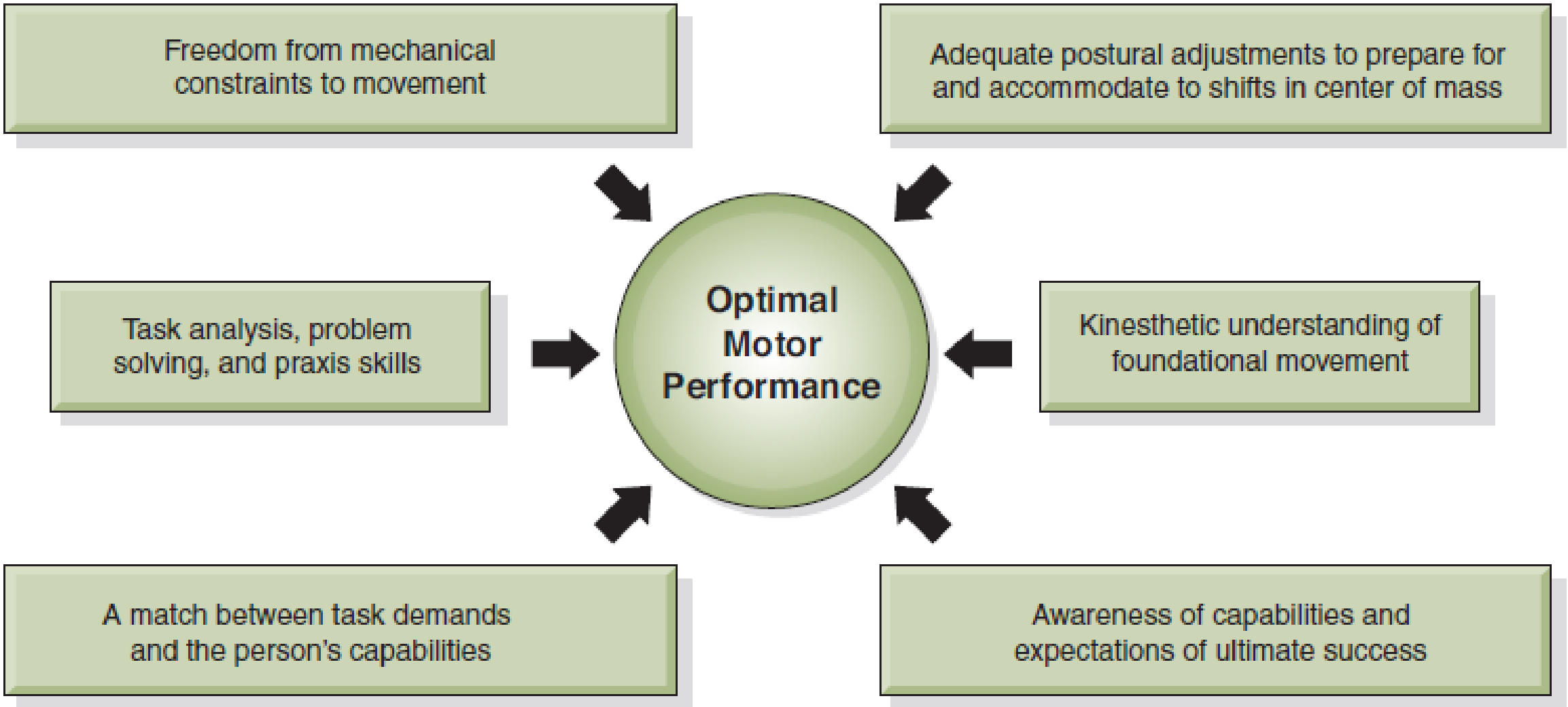
- Sling
- Plaster cast
- Triangular bandage
- Splint
- Sling combined with a resting hand splint
- Half glove
- Mitt

- Requirements for Participation in CIMT
- It was stated by researchers [12] to simply, follow 10 x 10 x 10 eligibility criteria in selecting a patient for CIMT:

- 10 degrees active wrist extension on the affected hand
- 10 degrees active thumb abduction on the affected hand
- 10 degrees active extension of any other two digits on the affected hand
- Also in order to CIMT be more beneficial, it was suggested that [13] :

- Limited spasticity (0,1,1^{+}) according to modified Ashworth scale.
- Ability to move the affected arm 45 degrees of shoulder flexion and abduction, and 90 degrees of elbow flexion and extension.
- Adequate balance.
- Minimal cognitive dysfunction.

MULTIPLE FACTORS CONTRIBUTE TO OPTIMAL MOTOR PERFORMANCE



Mechanical Requirements for Movement Execution

- The most elemental requirements for motor performance are freedom from mechanical constraints:
  - Joint mobility.
  - Fluid dissociation between body segments.
  - Optimal postural alignment.
  - The absence of limiting factors such as edema and pain.
  - The capacity to generate specific movements.

Joint Mobility

- Joint mobility, the capacity for limbs to be moved passively around a joint fulcrum, is necessary for active movement and functional performance.
- Deficits in passive ROM are preventable, secondary, impairments associated with immobility.
- Histologically, soft tissues do not maintain their underlying distensibility (capacity to be stretched to maximum length) unless they are routinely lengthened by antagonist muscles or an external force.

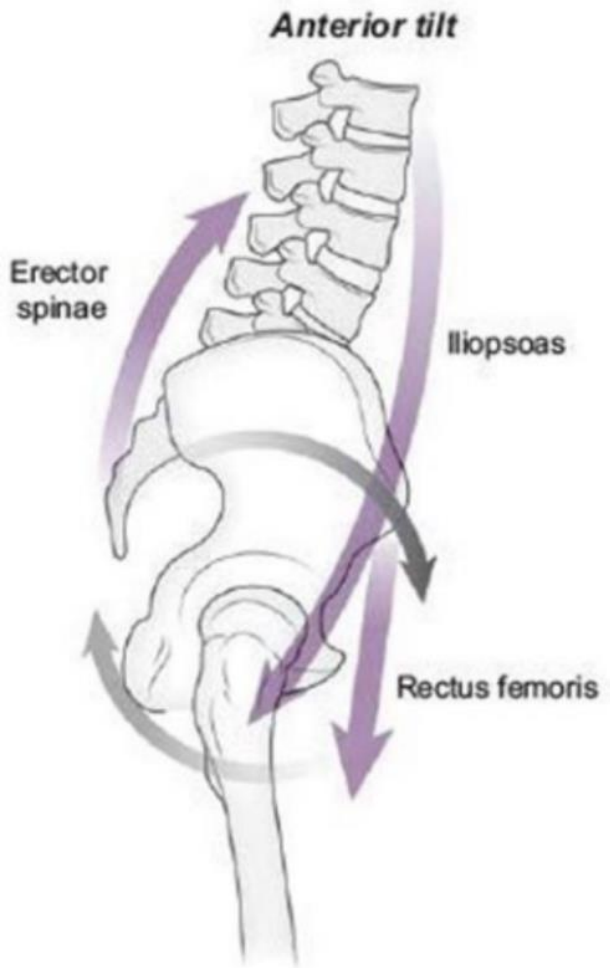
Dissociation

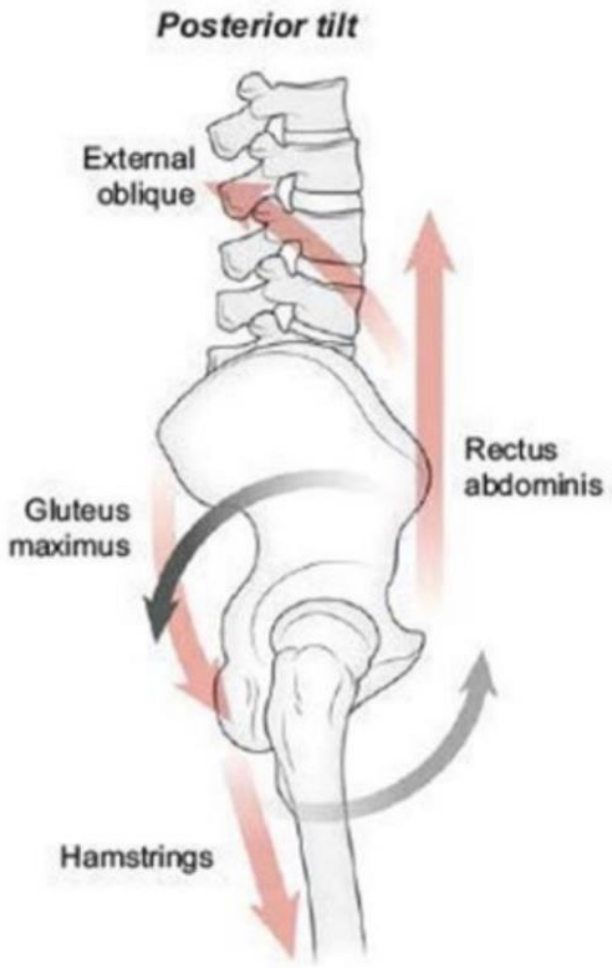
- Dissociation between body segments refers to the underlying potential for adjacent body segments to move independently of one another.
- When applicable to the task or movement desired, every segment within our bodies must have the capacity to move freely, without undue restraint from loss of length of multijoint or single-joint muscles.

Optimal Postural Alignment

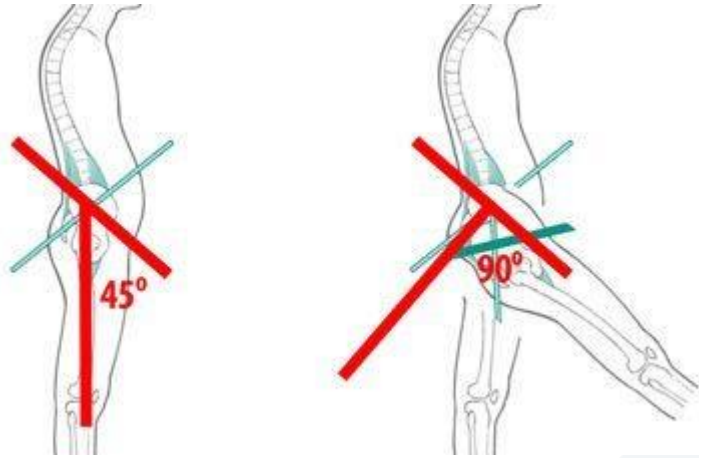
- Optimal postural adjustment allows a person to efficiently maintain balance against the force of gravity, to freely dissociate adjacent body segments, and to move the arms and legs on a stable foundation at the body core.
- that the pelvis serves as a cornerstone to alignment of the trunk and limbs.
- In the sagittal plane, a resting posture of excessive anterior tilt will accentuate lumbar lordosis (with abnormal shortening of extensors and abnormal distension—and weakness—of abdominals).

- A resting posture of excessive posterior tilt will decrease the normal lordotic curve of the lumbar spine (with abnormal shortening of the abdominals and latissimus dorsi and excessive lengthening of the lumbar extensors).
- In terms of function, this will limit the person's capacity to flex the hips, which is crucial when moving from stand to sit and when reaching forward while sitting.
- This posture will also accentuate the kyphotic curve of the thoracic spine, which can impact respiratory capacity and mechanics at the scapula and humerus.

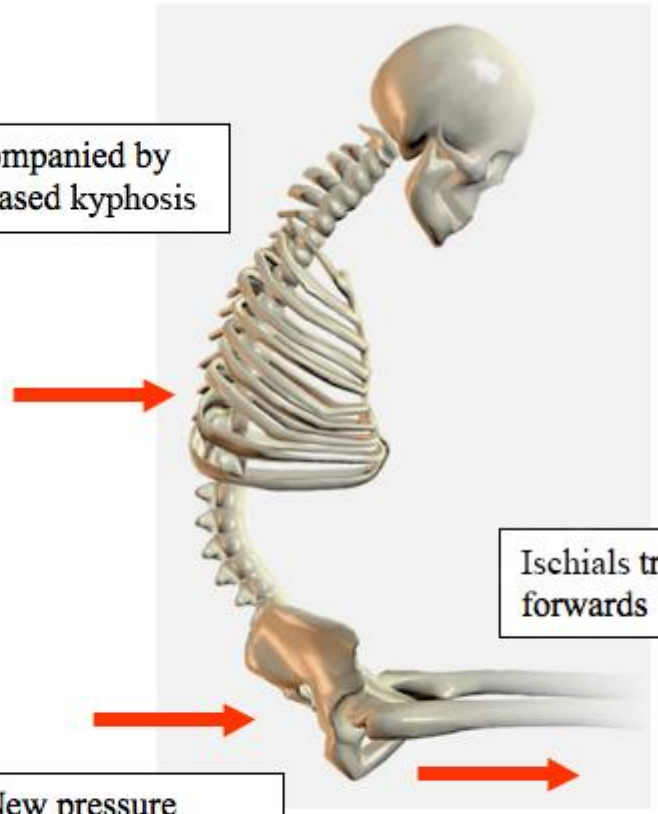


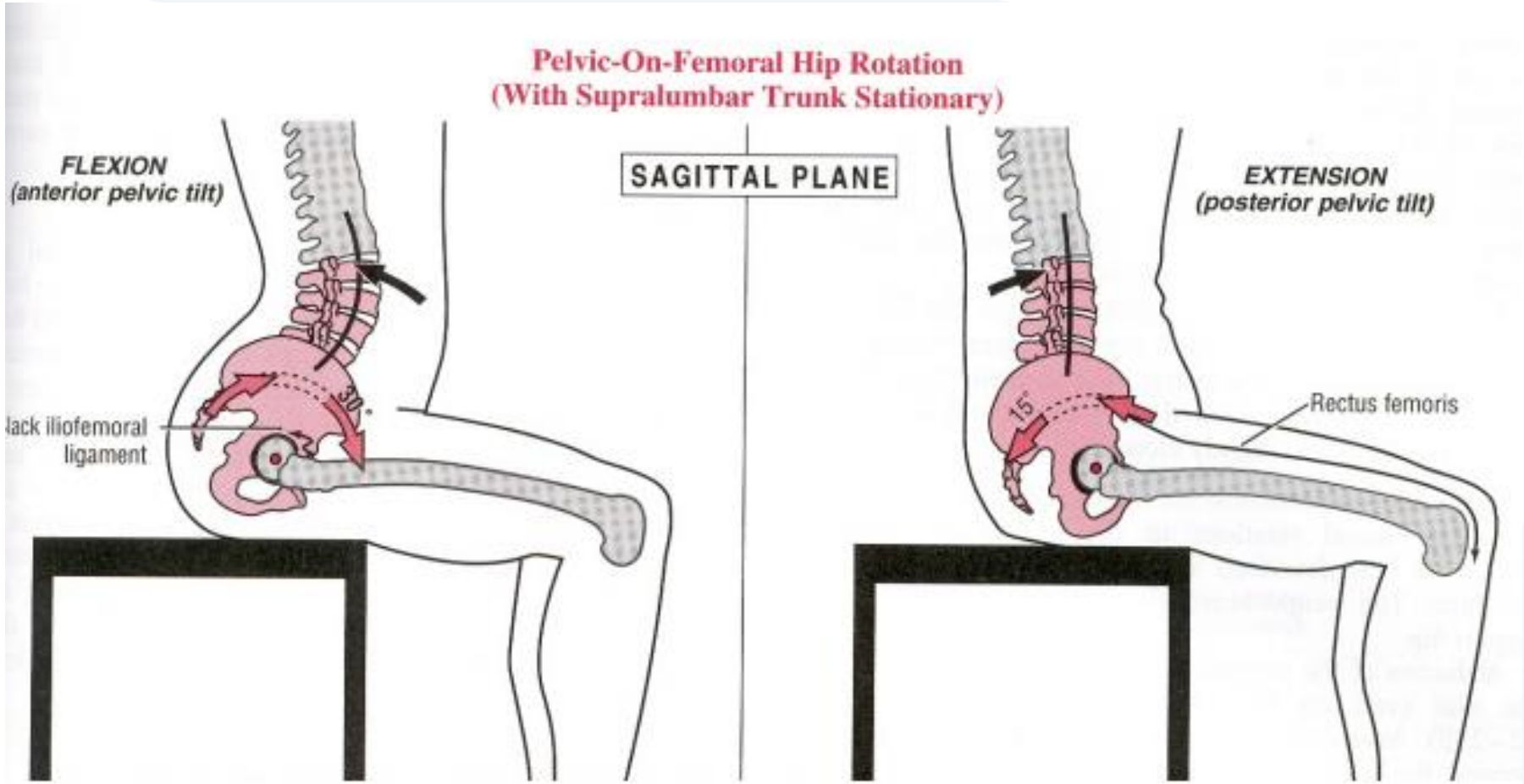


a) pelvic anterior tilt b) pelvic posterior tilt



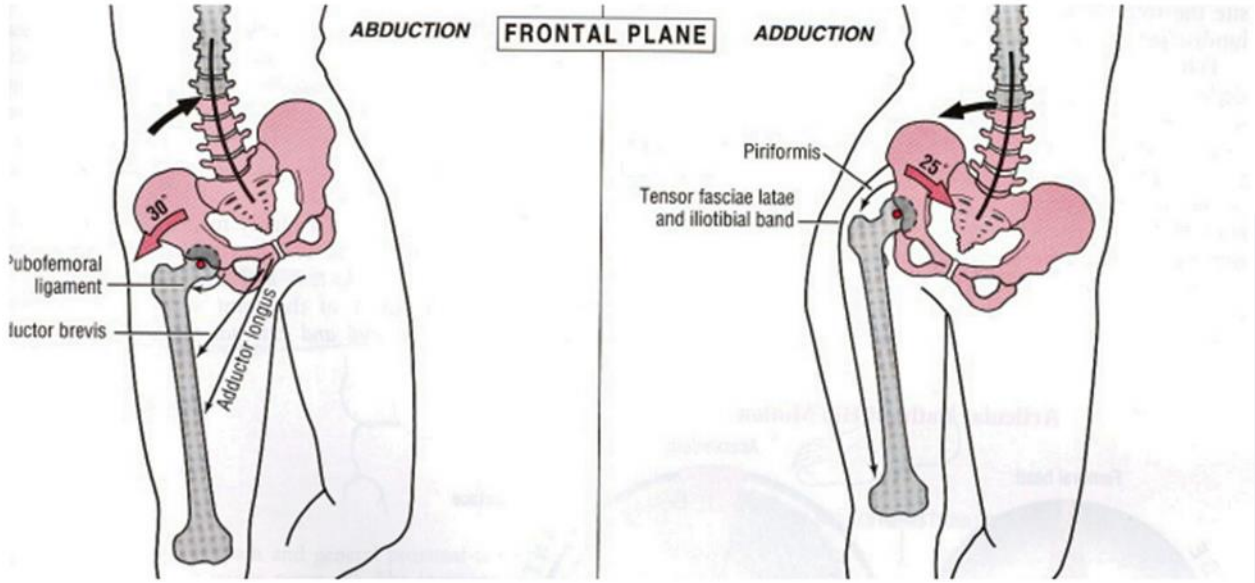
Posterior Pelvic Tilt




Pelvic-On-Femoral Hip Rotation
(With Supralumbar Trunk Stationary)
FLEXION
(anterior pelvic tilt)
SAGITTAL PLANE
EXTENSION
(posterior pelvic tilt)
lack iliofemoral
ligament
30°
15°
Rectus femoris

- In the frontal plane, a resting posture of lateral tilt will accentuate lateral trunk flexion away from the weight-bearing side and lead to asymmetries in posture throughout the scapulae and upper limbs, as well as throughout the lower limbs.
- Based on influences from the NDT approach, many clinicians refer to abnormalities in lateral pelvic tilt as problems in weight bearing. A person with excessive left lateral pelvic tilt demonstrates an abnormal pattern of weight bearing, with most of the body weight supported on the left ischium.

- **Abduction** and **Adduction** in the **Frontal Plane**
- **Right lateral tilt and left lateral tilt**



Freedom from Other Secondary Impairments

- Distal edema, localized pain, and complex pain syndromes are examples of other secondary impairments that will also impede a person’s capacity to use his or her available motor ability in a functional way.

The Capacity to Generate Muscle Contraction

- The capacity to generate muscle contraction determines whether an individual will be able to produce specific movements.

Foundational Movement Strategies

- Normally, when a seated person wants to reach forward to grasp an object, the CNS calls forth a movement pattern that includes anterior pelvic tilt, hip flexion, scapular abduction, and upward rotation, as well as glenohumeral flexion and external rotation. Additionally, wrist extensors contract to establish optimal mechanical efficiency for the finger flexors. Many persons with hemiplegia cannot rely on automatic generation of these complex muscle linkages, and each attempt at movement presents the challenge of coordinating an unmanageable number of degrees of freedom.

- After intervening to reduce mechanical obstacles, the therapist structures therapeutic tasks so that the patient gains practice in implementing a selected motor strategy in a variety of contexts.
- For example, the therapeutic goal may be to develop the linkage between anterior pelvic tilt, hip flexion, and symmetrical trunk extension as a foundational motor program for forward reach in sitting, as well as standing up from a seated position.

- The session may begin with the therapist moving the patient’s pelvis so that the person understands the kinematic model of action.
- The therapist may then ask the patient to sit on a therapy ball, which is rocked forward and backward using anterior and posterior pelvic movement.
- After this, the seemingly unrelated task of reaching for objects from the seated position will emphasize that the patient anteriorly tilt the pelvis by directing attention to “keep your back straight” and “bring your nose over your toes.”
- Following this, the patient will practice standing up and sitting down on a variety of surfaces with an emphasis on the same lumbopelvic interactions previously practiced in different contexts.
- Finally, the patient may practice this same sequence but while holding a variety of objects.

Fig 1: Pelvic tilt technique with Swiss ball

Anterior pelvic tilt

Posterior pelvic tilt

Patient practicing sit to stand with the added challenge of a glass of water in his hand. A. Patient is in posterior pelvic tilt. B. Patient shifts to anterior pelvic tilt and hip flexion in preparation to stand. C. Patient bears weight through both legs as he rises from the seating surface. D. Patient completes the sequence of moving from sit to stand.

Postural Adjustments

- Every time a person moves, his or her body's center of mass (COM) changes its relationship to the base of support (BOS). Postural control mechanisms enable us to maintain balance by ensuring that our body's COM remains within the BOS.
- Sensory processing of visual, vestibular, tactile, and proprioceptive information allows a person to maintain continuous and dynamic awareness about the body's COM and alignment between body segments.

- Muscle contractions of appropriate amplitude and timing allow for predictive and ongoing force production to match the changing influence of gravity during motor performance.
- Sufficient joint mobility and muscle length allow the necessary movements to be generated through their full ROM.

During daily activities, a person's COM can be displaced in three ways:

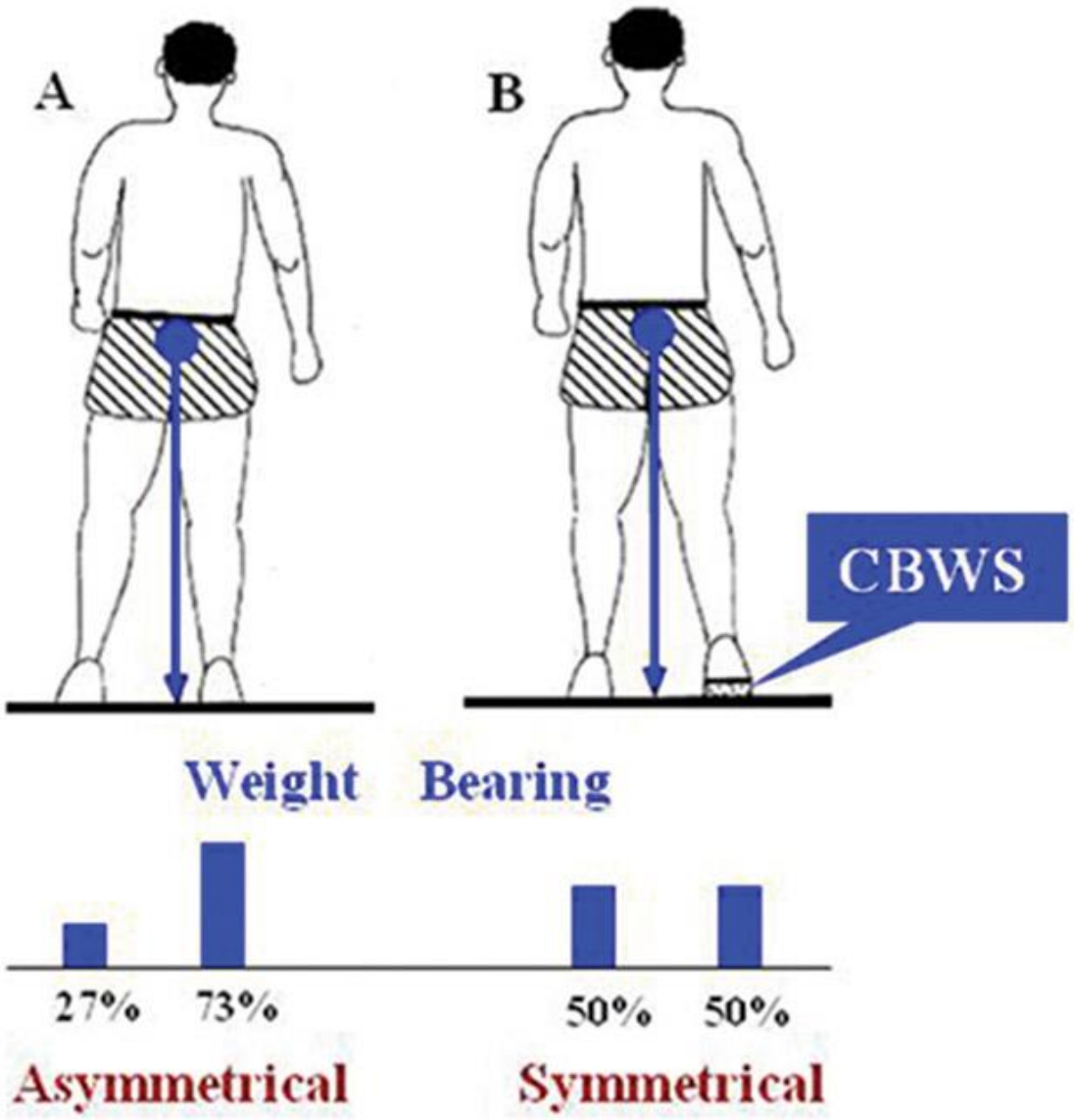
(1) by an external force applied to the body, as occurs during contact sports.

(2) by external movement of the support surface, as occurs when we sit or stand in a moving vehicle.

(3) during performance of activities requiring self-initiated movement of the head, limbs, or trunk

Efficient postural adjustments during self-initiated weight shift in sitting. Notice that, with weight shift to the right, the woman laterally flexes her trunk to the left and abducts her left arm and leg. These postural adjustments ensure that, even as her centre of mass (COM) shifts significantly, her COM will remain safely over her base of support (BOS). Notice also that her head remains erect and her trunk is elongated on the right.

- Individuals with impairments in postural adjustments will be fearful of falling when sitting or standing without support, and, even more so, when attempting to move their limbs.
- When people feel unable to maintain their balance in posturally threatening situations, one such strategy is to constrain movement at selected body parts and thus decrease the number of motor elements, or degrees of freedom.
- A negative consequence is that these patterns lead to soft tissue shortening and difficulty dissociating the scapula and pelvis from adjacent proximal structures. This lack of sufficient mobility at the limb girdles subsequently limits the normal kinematics of upper and lower extremity movement.
- **Postural Assessment Scale for Stroke**


A
B
CBWS
Weight Bearing
27%
73%
50%
50%
Asymmetrical
Symmetrical

Task Analysis, Problem Solving, and Praxis Skills

- In any situation that requires motor action, we automatically “size up” the task and environmental parameters before creating the motor plan that will guide the action.
- In addition to preplanning postural adjustments, we rely on complex interactions between the visual (striate), parietal, premotor, and primary motor cortices to match our arm and hand motions to the task requirements.

- These abilities seem to be dependent on two networks:
- Neural Networks: Enable us to accurately determine which physical properties of the object goal are essential to formulating the specifics of a motor plan. These parameters include information about the object's size, shape, weight, texture, and location.
- Feedforward Control: Control of reach and grasp is anticipatory, just as is control of postural adjustments during task performance. Corrections, based on feedback, are necessary only when errors occur.