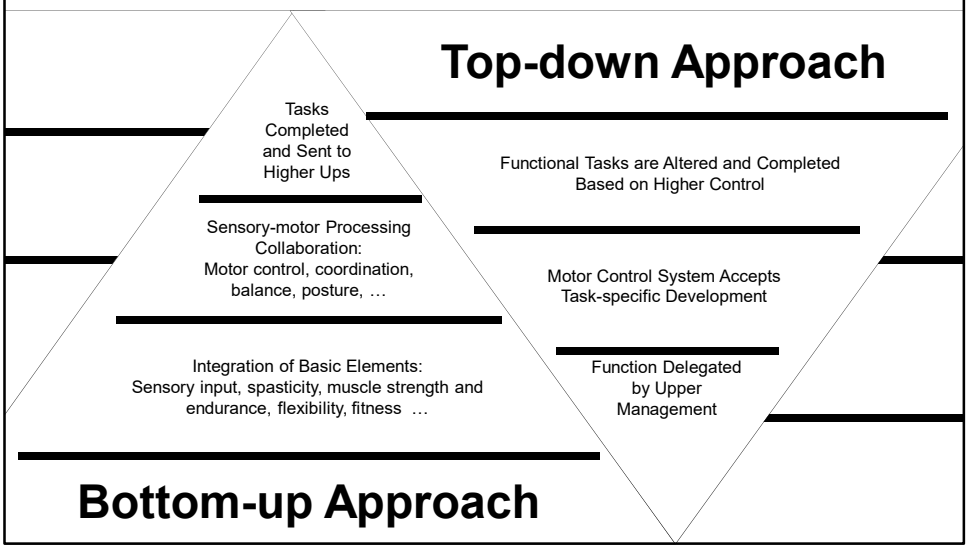
Toward optimal treatment

Advanced Concept in Stroke Rehabilitation

Duck-won Oh
Cheongju University

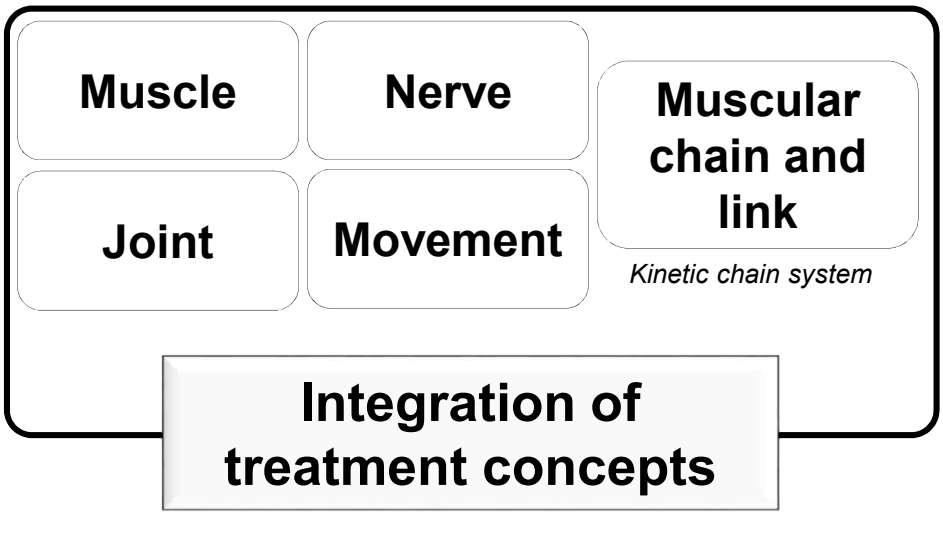
Basic Ideas of Rehabilitation Approaches



Current Keywords on Treatment

- Function-oriented
- Patient-centered
- Evidence-based

Paradigm Shift in the Treatment



Three Elements in Treatment

Alignment

Soft tissue

Function

Disclosing the 'Neuromuscular Control and Reset (NCR)'

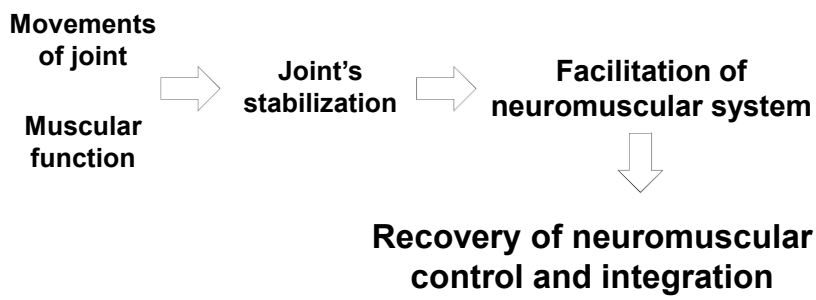
- All organs can functions optimally in **neutral position** (Douglas, 2004).
- Wrong position of the joint occurs chemical disparity and mechanical problem subsequently (Lewit and Janda, 1987).

Disclosing the 'Neuromuscular Control and Reset (NCR)'

- Abnormal position of the joint is more likely to produce decreased stability of the joints and movement impairments, thereby producing joint injury.
- Misalignment of joint causes additional effects to joints in other parts and muscles around the joint, and consequently alters the recognition of movements and postural faulty (Kisner and Colby, 2010).

'Neuromuscular Control and Reset (NCR)'

- **Integrated approach** reflecting current trend
- Critical component of any evaluation and treatment

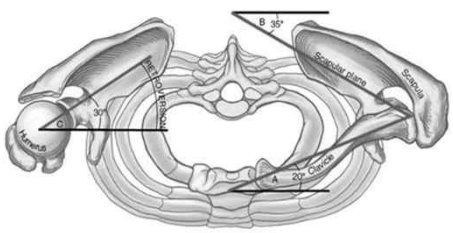


Neutral Position of Joints

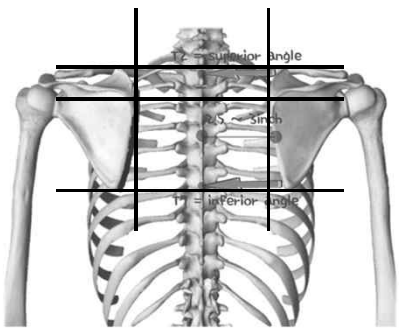
- The position of a joint where the bones that make up the joint are placed in the optimal position for maximal movement (Segen, 2002).
- Good joint alignment, suggesting parallel position of joints' surfaces
- Less resistance and stress on joints during movement
- Optimal function and activity

Neutral Position of Scapula

- Glenoid fossa orients approximately 5° tilt upward in sagittal plane.

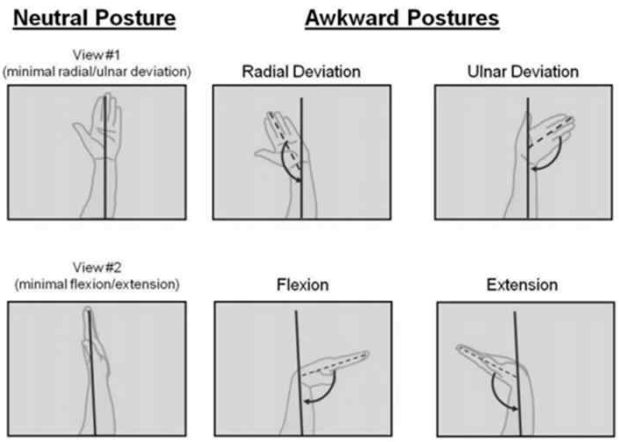


Scapular plane

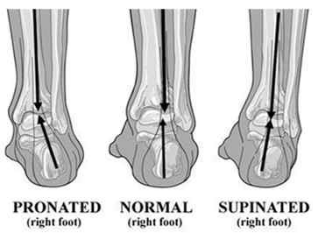


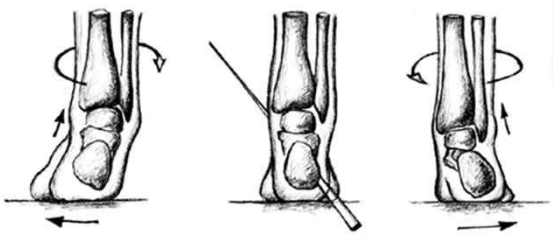
- Superior angle of scapula: T2
- Root of scapular spine: T3
- Inferior angle of scapula: T7

Neutral Position of Wrist Joint

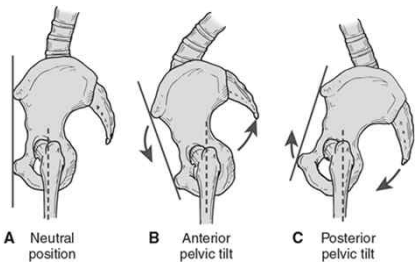


Neutral Position of Ankle Joint





Neutral Position of Pelvis



Influence of pelvic inclination on sit to stand task in stroke patients

Darwish et al., Egypt J Neurol Psychiatr Neurosurg. 2019;55:89

- Abnormal pelvic alignment and movements affect the functional performance of stroke patients during sitting and sit to stand task.

Table 4 Mean values of time of five repetitions sit to stand test in three groups

Variable	Gla (mean ± SD)	GII (mean ± SD)	*P* value	Glb (mean ± SD)	GII (mean ± SD)	*P* value
Time of 5xSTS test (Seconds)	19.77 ± 5.99	9.00 ± 0.94	0.0001*	17.53 ± 4.79	9.00 ± 0.94	0.0001*

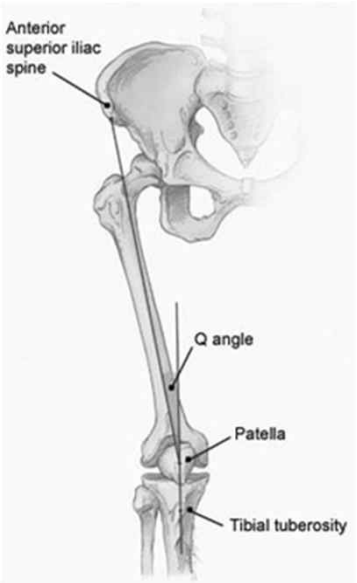
5xSTS five repetitions sit to stand, *SD* Standard deviation, *P* probability, Significant *P** < 0.05, ° Degree

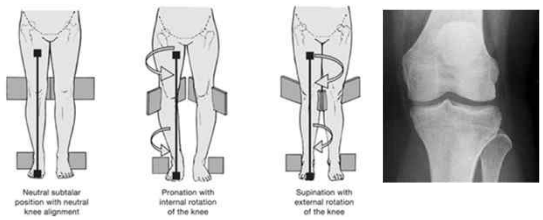
Table 3 Mean values of anterior pelvic tilt angles during initiation and mid of sit to stand task between two tested sides of three groups

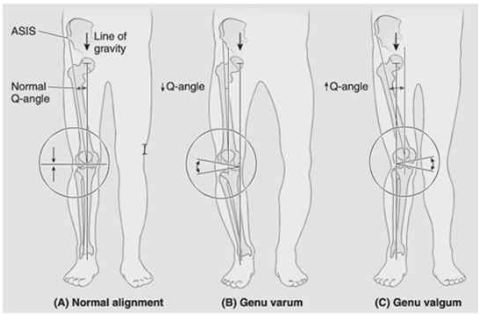
Variables	Pelvic tilt angle during initiation of STS (°)			Pelvic tilt angle during mid of STS (°)		
	Right	Left	*P* value	Right	Left	*P* value
Gla (mean ± SD)	− 11.13 ± 4.85	− 7.87 ± 3.11	0.037*	7.87 ± 4.15	10.73 ± 3.45	0.049*
Glb (mean ± SD)	− 9.20 ± 5.71	− 11.20 ± 4.72	0.305	11.00 ± 4.34	7.60 ± 5.34	0.066
GII (mean ± SD)	− 7.53 ± 4.56	− 6.87 ± 4.96	0.705	14.13 ± 3.9	13.80 ± 3.72	0.814

STS Sit to stand, *SD* Standard deviation, *P* probability, Significant *P** < 0.05, ° Degree

Neutral Position of Knee Joint



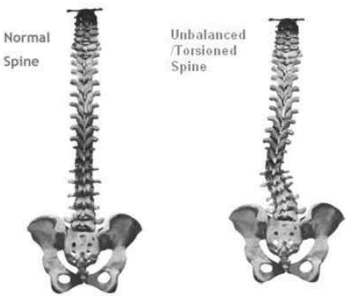




<15° >20° <10°

Malalignment of trunk and pelvis after strok

KZakaria et al., Egypt J Neurol Psychiat Neurosurg. 2010;47(4):599-604



- There was a significant correlation between the degree of spasticity and both lateral trunk deviation and lateral pelvis tilting as well as between duration of illness and abnormal trunk movements.

Muscular Compensation in Ligament Deficiency

Kim et al., PLoS One. 2016;11(1):e0146234

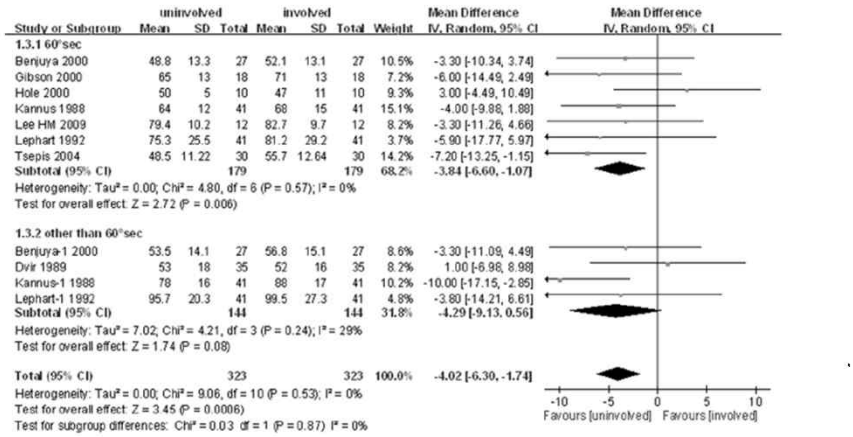


Fig 4. Forest plot demonstrating slight reductions in hamstring-to-quadriceps ratio in ACL deficient compared with uninjured limbs.

Musclar Function

- Joint stability:

  Integrity of a joint when it is placed under a functional load
- Optimal length–tension relationship:
  - ✓ Effect of muscle length and the amount of tension (force) produced
  - ✓ Muscles that are too long or too short can produce adverse stress on the joints
  - ✓ Position where the muscle can generate the most tension with the least effort.

Physical Effects of Stroke

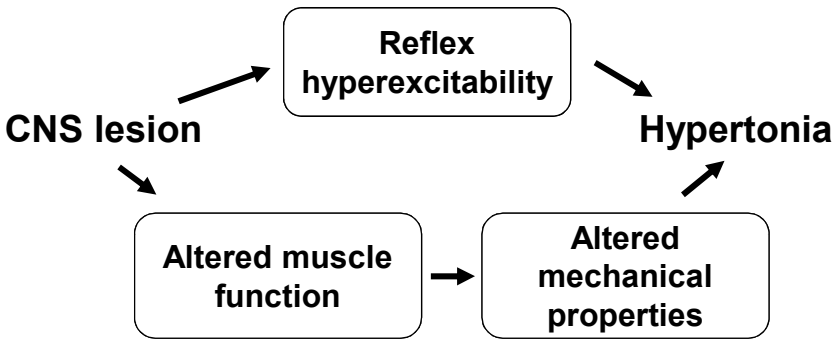
Muscle weakness	**Fatigue**	**Foot drop**
Pain	**Spasticity**	**Contractures**

Changes at sensation

- Feeling less sensitive to touch and temperature
- Feeling more sensitive to stimuli
- Feeling unaware of the position and movement of your limbs

Reflex and Muscle Adaptation to Hypertonia

O'Dwyer et al., *Brain.* 1996;119: 1737-1749



- Reduced activity due to paresis

- Loss of sarcomrere
- modelling of connective tissue
- Altered periarticular connective tissue

Five Factors to Increase Muscle Tone

Janda, Man Med 1991;6:136-139

Limbic dysfunction	• Muscle hypertonicity due to dysfunction of the limbic system • Muscle tension from emotional stress
Impaired function at the segmental (interneuronal) level	• An altered balance between physiologically agonistic and antagonistic muscles • Muscle tension asymmetry in joint dysfunction
Impaired coordination of muscle contraction	• Impaired coordination of muscle contraction • Trigger points (TrPs)
Response to pain irritation	• A defense reaction meant to immobilize an injured part of the body • Splinting spasm from viscera and flexor or nociceptive reflexes
Overuse	• Muscle tightness, involved in "muscle imbalance" syndromes • Active muscle fibers are replaced by non-contractile tissue.

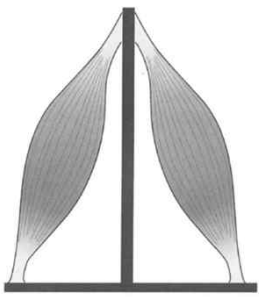
Muscle Balance

- Muscle balance is essential for *optimal recruitment of force-couples* to maintain precise joint motion and ultimately decrease excessive stress placed on the body (Comerford and Mottram, 2001; Janda, 1996; Sahrmann, 2002).
- Muscle balance establishes normal length-tension relationships, which ensure proper length and strength of each muscle around a joint.

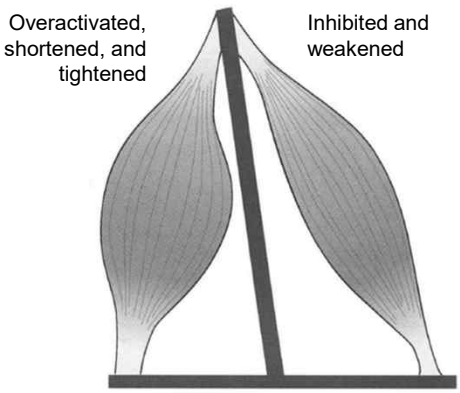
Causes of Muscle Imbalance after Stroke

- Spasticity and pathological synergy
- One-sided movement after stroke
- Keeping a posture for long periods
- Adaptive posture and poor posture
- Lack of physical activities
- Congenital of acquired deformity

Muscle Imbalance



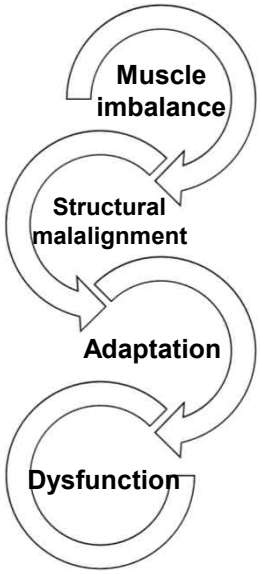
Muscle balance



Muscle imbalance

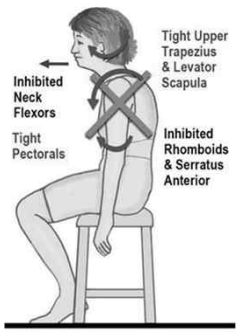
Muscle Imbalance

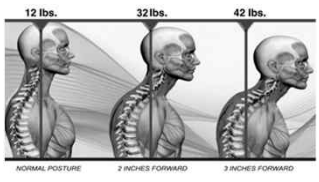
- Muscle imbalance can result in the stabilizing muscles being *less efficient to stabilize joints* as they are pulled out of optimal alignment (Janda, 1993).
- It seems that certain muscles are prone to shortening (tightness), whereas other muscles are susceptible to lengthening and weakness (inhibition) (Janda, 1983).



Compensatory Muscle Imbalance

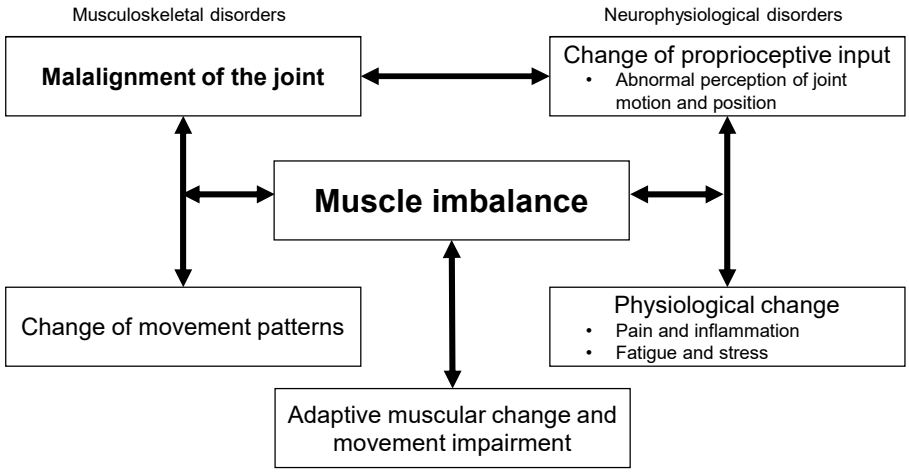
- Altered length-tension relationships
- Altered force production
- Synergistic dominance
- Altered reciprocal inhibition relationships
- Arthrokinetic dysfunction
- Decreased neuromuscular control





Muscle Imbalance and Movement Impairment

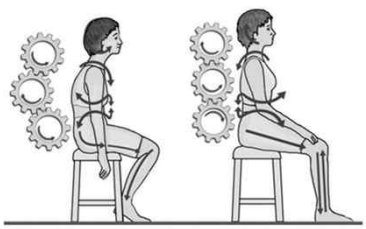
오덕원 등, 한국신경근육재활학회지. 2017;7(2):26-43

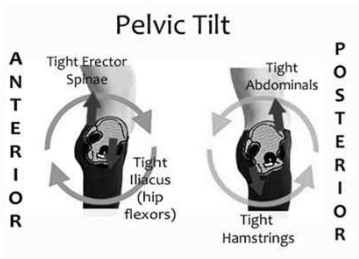


Three Systems of Chain Reaction

1 Articular chain

- Postural chains:
  - ✓ Structural postural chains
  - ✓ Functional postural chains

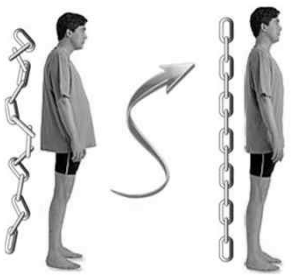


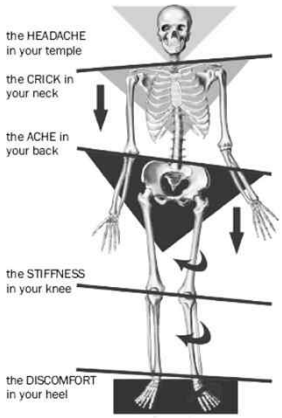


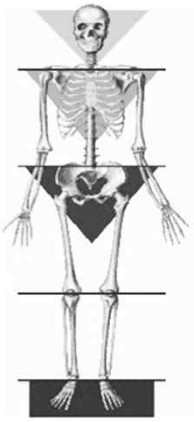
Three Systems of Chain Reaction

1 Articular chain

- Kinetic chains



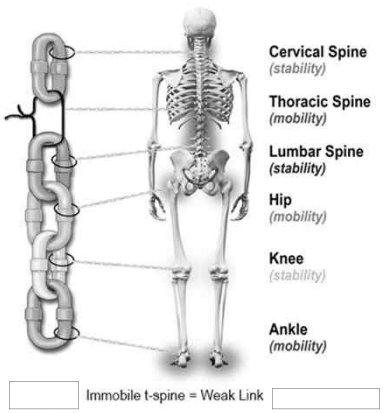




Three Systems of Chain Reaction

1 Articular chain

- Movements always occur toward less resistance of tissue in the joint, and it's adapted by sustained use.

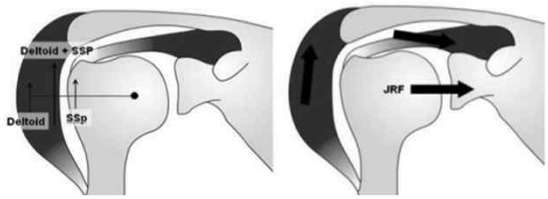


- Injury generates in the weakest part of body during movements.

Three Systems of Chain Reaction

2 Muscular chain

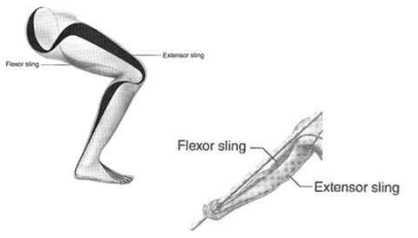
- Synergists chains:
  - ✓ Synergists work together for isolate joint motion.
  - ✓ Force coupling (Parsons et al., 2002)

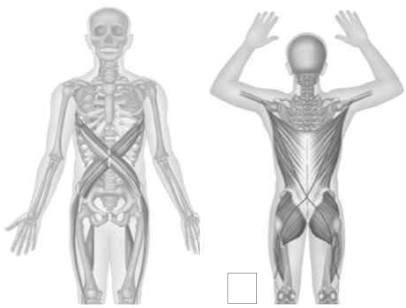


Three Systems of Chain Reaction

2 Muscular chain

- Muscle slings:
  - ✓ Providing movement and stabilization across multiple joints
  - ✓ Extremity flexor and extensor slings
  - ✓ Trunk muscle slings

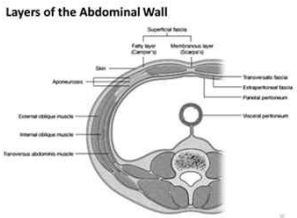


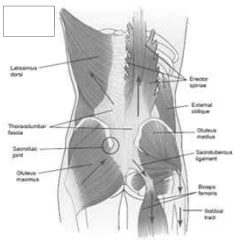


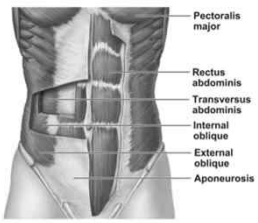
Three Systems of Chain Reaction

2 Muscular chain

- Myofascial chains:
  - ✓ Abdominal fascia
  - ✓ Thoracolumbar fascia







Three Systems of Chain Reaction

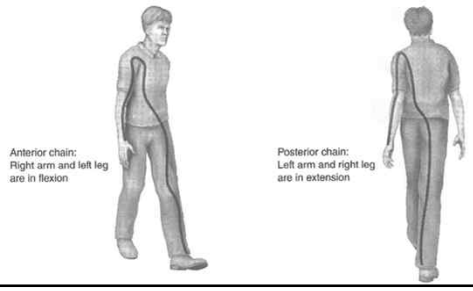
3 Neurological chain

- Protective reflexives
- Sensorimotor chains
  - ✓ Feedback and feedforward mechanisms
  - ✓ Groups of muscles are linked together neurologically for function.

Three Systems of Chain Reaction

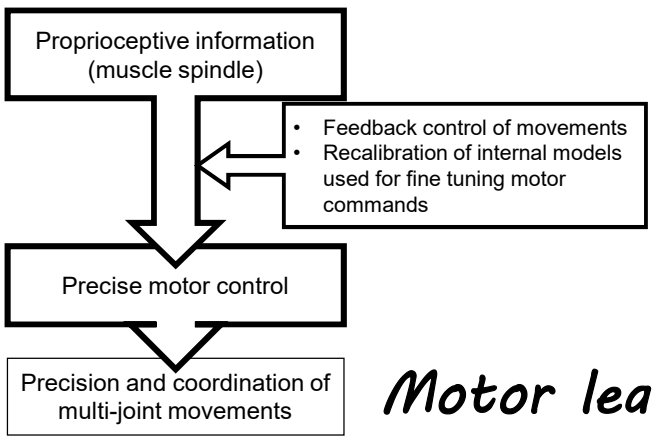
3 Neurological chain

- Neurodevelopmental locomotor patterns
  - ✓ Reciprocal locomotion and coactivation patterns



Proprioception and Motor Control

Björklund, Umea University, 2004



Motor learning

(Ghez and Sainburg 1995; Sainburg et al. 1999; Lackner and DiZio 2000)

Impaired Proprioception and Its Role in Dysfunction

Malalignment of spinal joints

⇩

Muscle imbalance in trunk

⇩

Distortion in sensory-motor processing

- Since soft tissues also are richly innervated with mechanoreceptors, some soft tissue techniques may also be useful in normalizing proprioception (Clark, 2015).
- One way of restoring joint motion is manipulation/mobilization, which is suitable since it can have an immediate and significantly beneficial effect on proprioceptive feedback (Clark, 2015) and result in plastic changes from sensorimotor integration (Haavik, 2012).

Effects on Impaired Proprioception

Page et al., Assessment of Treatment of Muscle Imbalance, 2004

- A lack of proprioception delays the protective muscular responses of reflexive joint stabilization.
- Insufficient afferent information affects CNS processing.

Local effects

- Selective atrophy of Type II muscle fibers probably results from instability rather than pain (Edstrom, 1970)
- Joint damage decreases the excitability of the alpha motor neuron (Hurley, 1997).
- Changes in local muscle firing patterns

Global effects

- Compensatory changes in the feed-forward control of the motor program
- Copers: Increased cocontraction of agonist and antagonist to reinforce joint stability
- Noncopers: Changes in the biomechanics around the joint

What is proper body posture?

- Proper Body Posture or Alignment is a balanced position in which the body's load-bearing joints are aligned.
- It occurs when all the muscles are in well balanced position - front to back, side to side, top to bottom.
- Stress to the joints, muscles, vertebrae, and tissue is minimized.
- Maximal biomechanical efficiency

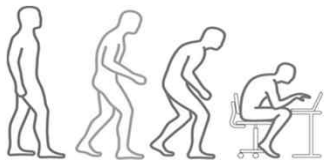
Factors Maintaining Posture

Inert structures supporting the body posture

- Ligaments
- Fascia
- Bones
- Joints

Dynamic structures maintaining the body posture

- Muscles
- Tendinous attachments



Effects of Poor Posture

- A non-neutral spine leads to 'improper posture', which increases stress on spine and causes pain, discomfort and damage.

Causes of poor posture

- Spasticity and synergy
- Anatomical deformities
- Positional Causes
  - ✓ Poor postural habit
  - ✓ Psychological factors, especially depression, loss of self-esteem …
  - ✓ General muscle weakness
  - ✓ Loss of the ability to perceive the position of your body
  - ✓ Loss of flexibility

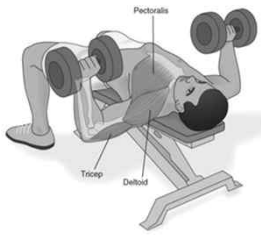
  …..

How do alterations in static posture occur?

- **<u>Habitual movement patterns</u>**
  - ✓ Poor postural habits in daily basis and chronic overloads
  - ✓ Frequently the body does not readjust itself to neutral positioning and continues to move in this imbalanced position, even when not loaded.

Contributions to Postural Change

- **Altered movement patterns from repetitive movement** (Leahy, 1995; Guyer and Ellers, 1990; Hammer, 1999)

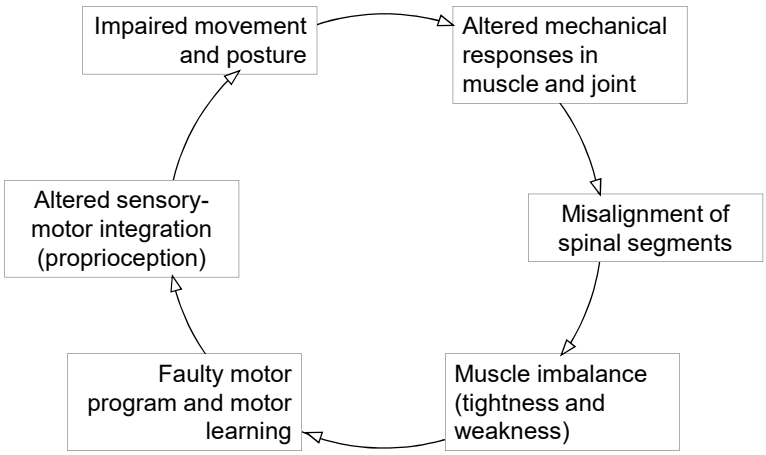


Contributions to Postural Change

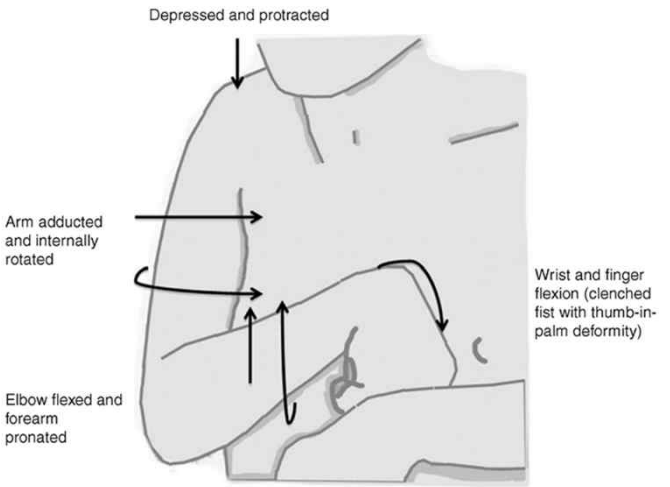
- **Altered movement patterns from injury**
  - ✓ Acute injury may result in chronic muscle imbalances.
  - ✓ Compensation to perform functional activities
- **Altered movement patterns from surgery**

- **Altered movement patterns from incompletely rehabilitated injuries**

Chronic Postural Deformity Cycle

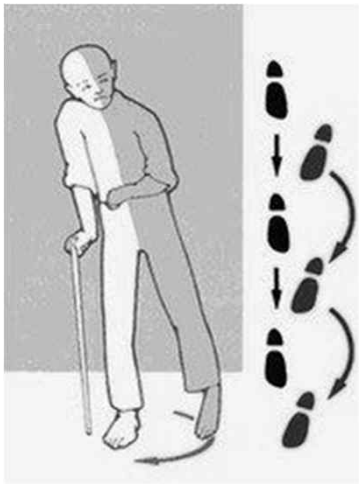


Abnormal Posture after Stroke



Subluxation of shoulder joint

Abnormal Posture after Stroke



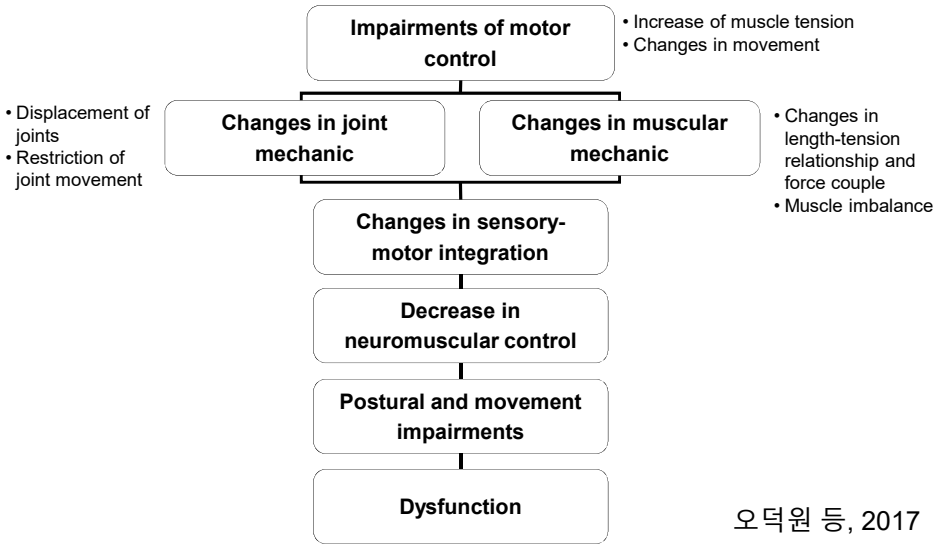
- Circumduction gait:
  - ✓ Hip hiking at the swing of affected leg
  - ✓ Hypertonia of knee extensor and plantar flexor of ankle at swing
  - ✓ Back knee at stance

‘Neuromuscular Control and Reset (NCR)’

오덕원 등, 한국신경근육재활학회지. 2017;7(2):26-43

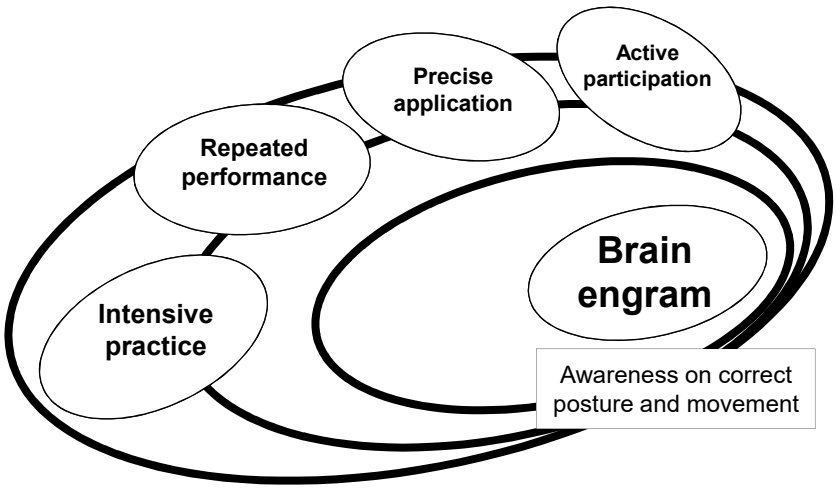
- Aims:
  - ✓ To define the original sources of the symptoms
  - ✓ To provide structured procedure for clinical practice
  - ✓ To allow for the advanced treatment and applied clinical research to manage the symptoms using precise techniques

Model to Explain Dysfunction in the NCR



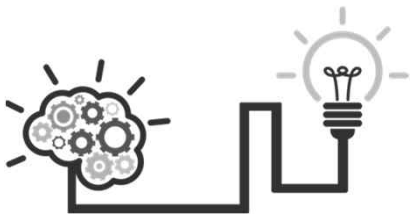
오덕원 등, 2017

Reset of Brain Engram on Posture and Movement



Basic Premise of the NCR Concept

- *Body function can be most effectively performed by the integrative control of neuromuscular system normalizing joint motions and muscle activities.*



Main Ideas of the NCR Concept

오덕원 등, 한국신경근육재활학회지. 2017;7(2):26-43

- Treatment should accept two main ideas:
  - (1) Recovery of normal movement requires comprehensive process *to reset neuromuscular control by correcting joint position and encouraging appropriate muscle activity*.
  - *(2) Optimal motor control can be achieved during functional activities*, considering movement interacted with environment.

Eight Principles of the NCR Concept

원상희 등, 한국신경근육재활학회지. 2017;7(2):44-68

1. Neuromuscular control and muscle function in the neutral position of the joint
2. Influences of kinetic chain reaction on body movement
3. Influences of malalignment of the joint leading to the impairment of joint motion
4. Exact evaluation and treatment

Eight Principles of the NCR Concept

원상희 등, 한국신경근육재활학회지. 2017;7(2):44-68

5. Muscle imbalance resulting in distorted sensory-motor and weakened proprioceptive functions
6. Learning of muscular efforts to stabilize the joint
7. Intensive and repetitive practices based on active participation
8. Performance of functional activities.

Start of Treatment

오덕원 등, 한국신경근육재활학회지. 2017;7(2):26-43

Application of the NCR concept

Correction of joint alignment

- End-range mobilization (Lungdberg et al, 1978)
- Oscillatory technique (Maitland, 1980)
- Use of lateral shift (Mckenzie, 1981)
- Mobilization with movement (Mulligan, 1995)

Improvement of joint stability

- Stabilization exercise (Hides, 2001)

Application of the NCR Techniques

Passive stability
- Correction of joint malalignment
- Alleviation of compression or shear

Muscular function
- Recovery of muscle imbalance
- Active stretching and strengthening

Active stability
- Strengthening of joint stabilizers
- Maintaining the neutral position of a joint

Functional activities
- Facilitation of neuromuscular control
- Coordination and balance trainings

4R Rules in the NCR

1	Reset of joint malalignment (Sluka et al, 2006)	• Restoration of joint alignment • Alleviation of compression or shear
2	Reset of muscle imbalance (Shiple & DiNubile, 1997)	• Recovery of muscle imbalance • Active stretching and strengthening
3	Reset of impaired joint stability (Hides et al, 2008)	• Improved active stability - To reinforce joint stabilizers' function - To maintain neutral position of the joint
4	Reset of impaired sensory-motor control (Wemick et al., 1999)	• Functional training - To facilitate neuromuscular control during activities - To improve coordination and balance function

Ankle Joint Mobilization with Movement in Chronic Stroke

Alamer et al., Degener Neurol Neuromuscul Dis. 2021:11 51–60

ROM	Balance	Gait function
• All of these studies (n= 170 subjects) proved that ankle range of motion of stroke survivors were significantly improved in MWMs groups compared to control groups	• Out of seven studies, six of them (n=198 subjects) mentioned that balance ability of stroke patients was significantly enhanced in MWMs groups relative to the control groups in all outcome measures (BBS, TUG)	• All of the included trials (n=224 subjects) indicated that MWMs had a positive impact on gait function as compared to control groups.

Joint Mobilization and Stretching for Stroke

Cho and Park, J Stroke Cerebrovasc Dis. 2020;29(8):104933

Table 3. *Comparison of spatio-temporal gait variables in pre- and post-intervention in three groups (mean ± SD).*

Classification		Pre-intervention	Post-Intervention	within-group change
Cadence (steps/min)	JMG	82.68 ± 17.95	84.00 ± 17.08	1.31 ± 4.53
	ASG	89.05 ± 16.87	95.94 ± 16.68*	6.89 ± 11.67
	JMASG	87.75 ± 16.42	98.12 ± 20.07*	10.37 ± 10.08[a]
Speed (m/s)	JMG	0.78 ± 0.20	0.81 ± 0.18	0.02 ± 0.06
	ASG	0.84 ± 0.17	0.90 ± 0.16*	0.05 ± 0.08
	JMASG	0.76 ± 0.22	0.88 ± 0.23*	0.12 ± 0.12[a]
Stride length (m)	JMG	1.11 ± 0.13	1.10 ± 0.11	-0.00 ± 0.05
	ASG	1.10 ± 0.19	1.16 ± 0.20*	0.06 ± 0.09
	JMASG	1.04 ± 0.24	1.12 ± 0.19*	0.08 ± 0.11[a]

JMG, joint mobilization group; ASG, active stretching group; JMASG, joint mobilization & active stretching group.
Within group: *$p < 0.05$ when compared with pre intervention values.
Among groups: [a]$p < 0.05$ when compared with the JMG
[b]$p < 0.05$ when compared with the JASG.

Effectiveness of Massage Therapy in Post-Stroke Survivors

Cabanas-Valdés et al., Int J Environ Res Public Health 2021;18(9):4424

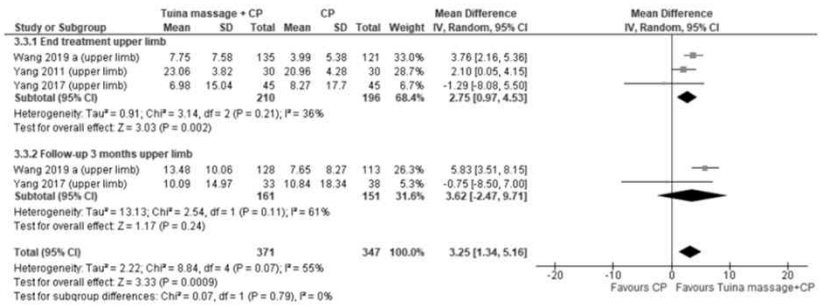
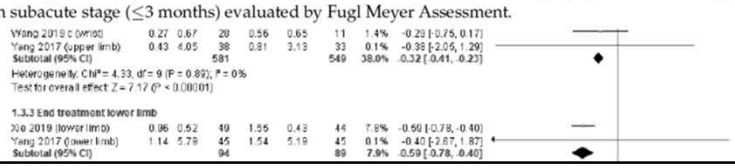


Figure 3. Forest plot of comparison Tuina massage plus conventional physiotherapy (CP) versus CP for upper limb motor function in subacute stage (≤3 months) evaluated by Fugl Meyer Assessment.



Core Exercising for Postural Control in stroke

Gamble et al., Arch Phys Med Rehabil. 2021;102:762-75

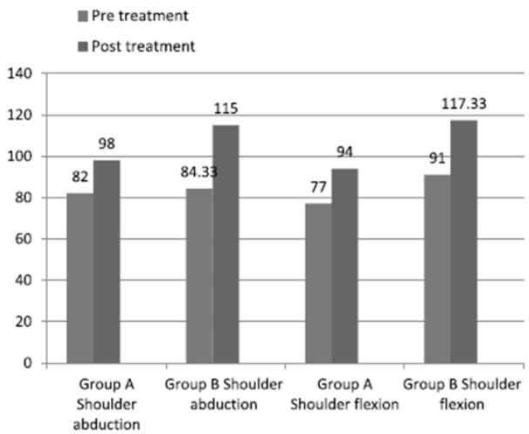


Fig. 4 Mean values of ROM of shoulder abduction and flexion pre- and posttests in both groups

- Core muscle training is similar to conventional physical therapy program in improving upper limb function in hemiparetic patients, and has beneficial effect on improving trunk balance

Joint mobilization added to task-oriented training in chronic stroke

Sabbah et al., Egypt J Neurol Psychiatr Neurosurg. 2020; 56:38

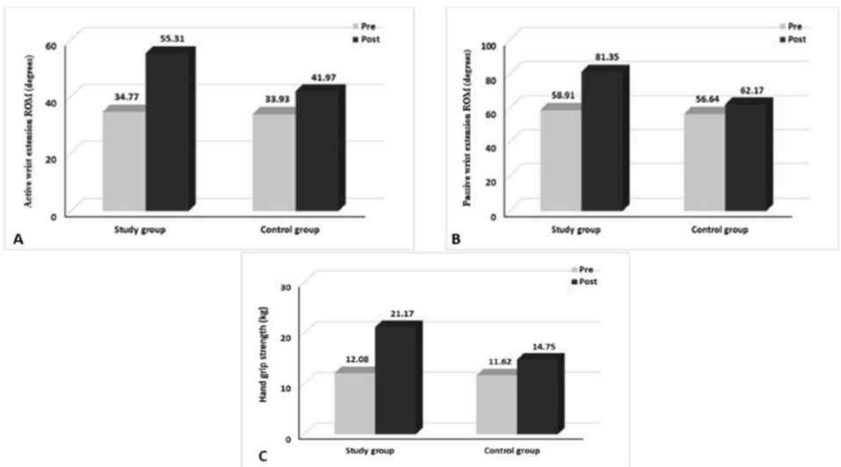


Fig. 1 **a** Mean active wrist extension ROM pre- and post-treatment in both study and control groups. **b** Mean passive wrist extension ROM pre- and post-treatment in both study and control groups. **c** Mean hand grip strength pre- and post-treatment in both study and control groups

‘Neuromuscular Control and Rest (NCR)’

- Appropriate treatment based on accurate procedure of the evaluation
- Influences of the kinetic chain reaction in the body
- Key factors of treatment:
  - To identify the exact origin of physical problems
  - To restore neutral position of the joint
  - To recover normal pattern of movement (Sahrmann, 2002)

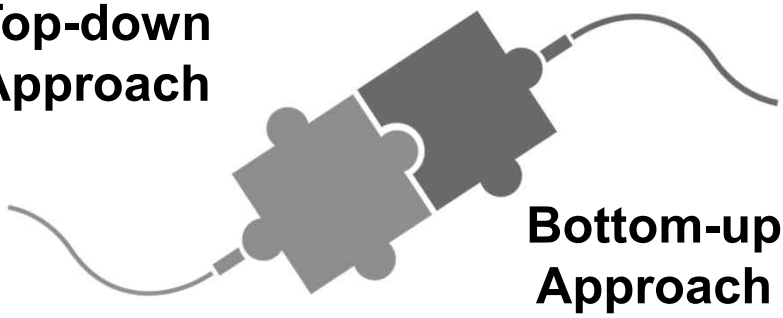
‘Neuromuscular Control and Rest (NCR)’

The **NCR** concept focuses on the alteration of brain engram from movement impairments by getting better neuromuscular control in various activities, facilitating normal function !!!

‘Neuromuscular Control and Rest (NCR)’

Beyond current views …

Top-down Approach



Bottom-up Approach