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Neurodynamics for Motor Recovery after Stroke, a Review Article

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Abstract

Stroke is a leading cause of death and long term disability. In Asia, There are almost 75.2% mortalities related to stroke cases. Stroke results in variety of deficits including motor, sensory, cognitive, language, perceptual deficits and also affect level of consciousness. The main aim of this study is to carry out qualitative analysis of the studies that investigated the effects of neurodynamics in stroke patients. The following Databases were explored including; Research Gate, Google Scholar, PEDRO and PUBMED. Following keywords were used for the searches; e.g. neurodynamics, neural mobilization, upper motor neuron lesions, stroke, peripheral nerve mobilization and neural tension technique. The studies are selected by reviewing their abstracts, methodology, results and conclusion. There were 16 studies selected for the review including, 1 case study, 3 clinical trials, 3 systematic reviews and 9 randomized control trails (RCTs). There was a difference noted in application of the neurodynamic techniques in almost all reviewed studies. Out of 9 RCTs, only 1 study (Jacob Lorentzen) reported that neurodynamics was not effective to reduce spasticity. However it concluded the beneficial effects of neural mobilization to improve range of motion. There was 1 case study which reported that combination of neurodynamics with Botulinum toxin A was effective to reduce pain and increase range of motion. There were 3 systemic reviews which concluded that there was lack of qualitative and quantitative evidence to support the effects of neurodynamics on stroke. There were 3 clinical trials (quasi experimental studies) which supported the effects of neural mobilization technique. This review showed the beneficial effects obtained by the application of neurodynamics to improve range of motion, flexibility, tone reduction, pain intensity, nerve conduction velocity, cerebral cortical activity and post stroke functionality. This review concluded that there is limited evidence to support the effects of neurodynamics in stroke patients and further research is acquired in future.

Keywords: Dynamic neural mobilization; Neural mobilization; Rhythmic neurodynamics; Spasticity; Stork

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Introduction

Stroke is a leading cause of disability [1]. Lack of blood supply to the brain either due to thrombus, embolism or rupture of blood vessels leads to stroke which results in loss of neurological function. Ischemic and haemorrhagic stroke are the two most common types of stroke.

Vascular involvement in stroke

Anterior cerebral artery syndrome: It supplies frontal and parietal lobe. Characteristics of ACA syndrome are urinary incontinence, apraxia and contra lateral loss of motor and sensory function, lower extremity is more affected in ACA syndrome than upper extremity [2].

Middle cerebral artery syndrome: It supplies the lateral part of frontal, temporal and parietal lobe, globus pallidus, internal capsule and caudate nucleus. Characteristics of MCA syndrome are visual field defect, Hemineglectia, spatial disorganization, speech impairment, contra lateral spastic hemiplegia or paresis with the involvement of face and loss of sensory function, MCA syndrome affects upper limb more than lower limb. Raised intracranial pressure in MCA syndrome leads to death [2].

Internal carotid artery syndrome: In this syndrome MCA is more involved than ACA. ICA syndrome cerebral edema occurs which leads to raised intracranial pressure, coma and death [2].

Posterior cerebral artery syndrome: Two posterior cerebral arteries supply occipital and temporal lobe. Characteristics of

PCA syndrome include visual defect, memory loss, topographic disorientation, contra lateral hemiplegia or paresis, thalamic pain and difficulty in reading and writing [2].

Consequences of stroke

Stroke results in sensory, motor, cognitive and perceptual deficit [3]. The common clinical signs and symptoms are contra lateral loss of motor function and sensations, spasticity, clonus, apraxia, aphasia, hemi neglect, thalamic pain, visual defect, disturbance of balance and coordination, ipsilateral pushing, spatial disorganization and memory loss [4]. Middle cerebral artery MCA strokes are most common affecting the contra lateral half of body (opposite upper extremity and lower extremity) [5]. 20 percent of stroke patients (MCA) fail to restore the function of affected UE [6]. In upper limb spasticity develops in adductors and medial rotators of the shoulder joint, flexors of elbow, flexors of wrist and finger and pronators of forearm 6. Abnormal synergies develop with spasticity. Isolated movement of the limb gets impossible due to development of synergy e. g. in upper extremity UE flexion, abduction and lateral rotation of the shoulder joint get limited. Patient fails to perform the functional task in response to environmental demands [6].

Stages of motor recovery

In stroke motor recovery occurs in 6 stages.

Stage 1: Flaccid paralysis occurs. Movement of the limb is not possible.

Stage 2: (early synergy) Obligatory synergies develop, movement occur within synergistic pattern, movement out of synergy get impossible as muscles are strongly linked together. Synergies allow no or minimal voluntary movement.

Stage 3: Voluntary control of synergies starts to develop with marked spasticity.

Stage 4: Movement out of synergy emerges and spasticity starts to decrease.

Stage 5: Synergy and spasticity decline and voluntary movements become more dominant.

Stage 6: Normal movement patterns develop [7].

Pathophysiology of stroke

Loss of blood supply to the brain disturb the energy metabolism which leads to release of neurotransmitters, influx of calcium ion occurs which results in the release of nitric oxide and cascade of events start resulting in cell death. In stroke, co-contraction of agonist and antagonist muscle occurs at supraspinal level [8]. Spasticity is common in stroke and is a disorder of stretch reflex which occurs due to defect at three levels; muscular, spinal and supraspinal level [9]. At neural level, it occurs due to loss of inhibition conducted by dorsal reticulospinal tract and increased excitation conducted by medial reticulospinal tract. At spinal level, it occurs due to exaggeration of stretch reflex either due to increased excitability of muscle spindle or abnormal management of sensory input to spinal cord and at muscular level, it occurs due to prolong period of immobilization. Prevalence of spasticity ranges from 30 to 80 % [10].

Assessment scales

Physiotherapy assessment scales for the stroke include; Fugl Meyer assessment scale for upper and lower extremity performance. It is a 33 items tool with maximum score of 226 for upper and lower extremity. It validity is 0.96 [11].

Wolf motor function test is used for upper extremity functional task performance. It is 16 items tool. Its reliability is 0.88-0.98 [12]. Berg balance scale for balance in older population. There are 14 functional tasks which include unsupported sitting for 2 min and standing with feet together for 2 min, standing with eyes closed, transfer from one chair to another. Scoring is done from 0 to 4. 4 indicate normal function and 0 indicates inability to do task. Full score is 56. Its reliability is high (r = 0.95) [13, 14].

Performance oriented mobility assessment Tinetti scale for balance and gait. There are 13 items for balance and 9 items for gait in this scale. It is 3 point ordinal scale in which scoring is done from 0 to 2 with maximum score of 28. Its reliability is 0.80-0.93 [15].

Motor assessment scale for motor function. 7 points ordinal scale is used, 8 items are used to assess motor performance; scoring is done from 0 to 6 with maximum score of 54. Its reliability is 0.89 and validity is 0.54 [16].

Action research arm test to assess upper extremity dexterity and coordination. Timed up and go test for balance assessment. It is used to determine fall risk. It requires both static and dynamic balance. If individual takes ≥12 sec to complete the test than they has increased risk of fall. Its reliability is 0.92-0.99 [17].

Functional reach test to assess balance in elderly population [18]. Individual is asked to stand in fixed position and reach forward, than distance is measured. In Modified version of Functional Reach Test (FRT); test can be performed in sitting position it is designed for those individuals who are unable to stand.

Dynamic Post urography is used to assess postural control in upright position either with static or dynamic balance [19]. And Modified ash worth scale and Modified Tardieu scale for spasticity.

Physiotherapy treatment option for stroke

Physiotherapy treatment of stroke includes, local facilitation technique (stretching, taping, and strengthening exercises), proprioceptive neuromuscular facilitation (hold relax, rhythmic initiation, contract relax), constraint induced movement therapy, active range of motion exercises, electrical stimulation, neurodynamics, icing, cognitive relaxation technique, balance and gait training.

Effect of neurodynamics in stroke patients

In neurodynamics sequence of movement restore electrical signals to nerve by reducing axonal transport, increase nerve conduction velocity by reducing pressure on nerve, which results in increased flexibility and function of the upper and lower extremity [20-23]. Neurodynamics indirectly stimulate the nervous system through peripheral nerve mobilization [24]. Explored studies suggest that neurodynamics (nerve mobilization) can be useful for the rehabilitation of patients with nervous system lesion but still

there is limited evidence to support it and more research needs to be done [25]. The effects of neurodynamics in stroke patients may depend on the time after stroke, since the level of spasticity, synergistic pattern and ability to perform functional task may vary over time. Thus the rationale of this study is to analyze previous studies to determine the contribution of neurodynamics as treatment option for the stroke cases.

Studies conducted from 2008 to 2018 are included in this review. The following Databases were explored including; Research Gate, Google Scholar, PEDRO and PUBMED. Following keywords were used for the searches; e.g. neurodynamics, neural mobilization, upper motor neuron lesions, stroke, peripheral nerve mobilization and neural tension technique. The studies are selected by reviewing their abstracts, methodology, results and conclusion. Randomized control trail, case studies and quasi experimental studies done in the past were studied to determine the effects of neurodynamics on following outcome measure; quality of life, spasticity, range of motion, gait, balance, functional recovery, sensory and motor performance, coordination and activities of daily living.

Inclusion criteria for this study include; (a) both male and female. (b) Acute, sub-acute and chronic cases of stroke. (c) Original studies with human participants, case studies and systematic reviews. (d) Intervention; neurodynamics on stroke. (e) Outcome; the effect of neurodynamics on gait, balance, functional recovery, range of motion, spasticity and coordination as outcome measures. Exclusion criteria include; (a) Studies with neurological problems other than stroke (e.g. cerebral palsy, traumatic brain injury). (b) Original studies on animal subjects. (c) Studies published in no indexed journals, commentaries and dissertations. Descriptive statistical analysis was done on the data and results were presented as mean and standard deviation.

The analysis of the reviewed articles indicated that the amount and quality of literature to support the effect of neurodynamics for stroke patients is limited. There were total 332 hemiplegic stroke patients which were included in previous studies done from 2010 to 2018. Mean and standard deviation of age of the patients (years) was 60.25 ± 7. [26], height (cm) was 161.05±8.57, weight (kg) was 64.51±7.84 and MMSE-K (score) was 26±2.09 (**Table 1**).

There were 16 studies selected for the review including, 1 case study, 3 clinical trials, 3 systematic reviews and 9 randomized control trails (RCTs) which determined the effects of neurodynamics on following outcome measure; quality of life, spasticity, range of motion, gait, balance, functional recovery, sensory and motor performance, coordination and activities of daily living. There was a difference noted in application of the neurodynamics techniques in almost all reviewed studies like dynamic neural mobilization, rhythmic neurodynamics and peripheral nerve mobilization. In few studies Neurodynamics was combined with other different techniques like strengthening, static stretching, contract relax, vibration and Botulinum toxin A.

Table 1. Demographic characteristic of stroke patients.

Characteristics	Mean± standard deviation
Age of patient (years)	60.25±7.26
Height (cm)	161.05±8.57
Weight (kg)	64.51±7.84
MMSE-K (score)	26±2.09

Richard F. Ellis in 2008 carried out a systematic review, 10 studies were included in this review. This study determined that limited evidence is available to support the effect of neural mobilization in stroke patients [26]. Tomasz-Wanly in 2010 carried out a randomized control trial on chronic stroke patients and determined that neuromobilizations with proprioceptive neuromuscular facilitation is effective on upper limb sensory deficit in chronic stroke patients [27]. Go doi J in 2010 carried out a clinical trial on 5 stroke patients, patients with modified ashworth scale 1 and 1+ were included and pre and post assessment was done with Modified ashworth scale and electromyography this study concluded that neural mobilization was effective in reducing myoelectric activity in bicep muscle in stroke patients [28].

Jessica Castilo in 2011 carried out a clinical trial on 6 stroke patients, patients with modified ashworth scale 1 and 2 were included and pre and post assessment was done with EMG. This study concluded that Upper Limb Neurodynamics Test was effective to improve electrical signals to spastic muscles [29]. Yong-Jeong Kim in 2011 carried out a clinical trial on 11 hemiplegic stroke patients, Neural mobilization, Static stretching and Contract relax were applied for 30 min and assessment was done with ROM and sit and reach test to assess hamstring flexibility, TUG and 10 min walk test to assess gait. This study concluded that neural mobilization, static stretching and contract relax were effective to improve hamstring flexibility and gait [30].

Jorge H. Villafane et al in 2012 carried out a case study on 76 years old stroke patient with severe spasticity; botulinum toxin type A combined with Neurodynamics was applied. Assessment was done at baseline, 3rd and 9th month with Numeric rating scale, Modified ashworth scale and anxiety and depression scale. This study concluded that treatment was effective for pain relief and improvement of joint ranges of motion. The patient also showed decreased anxiety and depression after the treatment [31]. Jakob Lorentzen et al in 2012 carried out a randomized control trial RCT on stroke 10 patients. Neural tension technique NTT was applied for 20 minutes and assessment was done with Modified ashworth scale and goniometry. This study Concluded that NTT was effective to increase ROM but not effective to reduce spasticity than random passive movement [32].

LIU Zhongshu in 2013 carried out a randomized control trial RCT on 49 stroke patients, who were randomly assigned to observational (neural mobilization with conventional treatment) n=25 and control group (conventional treatment) n=24. Neural mobilization with conventional treatment was applied and assessment was done with Berg balance scale, Fugl Meyer assessment scale, Composite spasticity scale, ADLs and Modified barthel index. This study concluded that neural mobilization with conventional treatment was effective to reduce ankle spasticity, improve motor function and ADLs [33].

SHI Jia-jia in 2013 carried out a randomized control trial RCT on 40 hemiplegic patients. Neural mobilization with conventional drugs and rehabilitation training was applied and assessment was done with Fugl Meyer assessment scale, electromyography

and 10 m walk test before and after the intervention. This study concluded that neural mobilization with conventional drugs and rehabilitation training was effective to improve lower limb function.

Hyun-Kyu Cha in 2014 carried out a randomized control trial RCT on 20 hemiplegic stroke patients [34]. Sciatic nerve mobilization with functional training was applied to subject group and just functional training was applied to control group for 4 weeks. This study concluded that neural mobilization with conventional treatment was more effective than conventional treatment alone to improve the function of lower extremity.

Yunhyeok Shinu in 2015 determined the effect of sciatic nerve mobilization on Performance of lower extremity in chronic stroke patients [35]. It is a randomized control trial RCT, 16 hemiplegic stroke patients were included. Sciatic nerve mobilization was applied and assessment was done with digital inclinometer, hand-held dynamometer, and the 10-meter walk test for hamstring flexibility, lower limb strength, and gait performance respectively This study indicated that nerve mobilization was more effective than static stretching in chronic stroke.

Kelson-Carvelhedo in 2016 determined the effect of muscle strengthening, neural mobilization and vibration in stroke patients [36]. It is a randomized control trial RCT, 40 subjects were included. Intervention was applied and assessment was done with Berg balance scale and timed up and go test. This study concluded that three techniques showed improvement in balance than conventional treatment. Alan Carlos et al in 2016 concluded the beneficial effects of neural mobilization to reduce muscle tone, increase range of motion and function in stroke patients [37]. Six studies were selected, one was reviewed.

Raid Saleem et al in 2017 concluded that limited evidence to support the benefit of neural mobilization 12 studies was reviewed [38]. Jeong Kang et al in 2017 determined the effect of rhythmic neurodynamics on nerve conduction velocity [39]. It is a randomized control trial RCT; an intervention was applied for 2 week. Pre-test and post-test assessment was done with nerve conduction study. This study concluded that Rhythmic Neurodynamics improved the nerve conduction velocity and upper extremity function more than the general neurodynamics.

Kang JI et al in 2018 determined the effect of dynamic neural mobilization on cerebral cortical activity in brain [40]. It is a randomized control trial RCT; interventions were applied for 4 weeks and assessment was done with electroencephalography. Dynamic neural mobilization was more effective than conventional neural mobilization at increasing the β-waves and decreasing μ-rhythms in C3 and C4 areas of cerebral cortex (primary motor areas).

Out of 16 studies included in this review; 7 studies determined the effects of neurodynamics on upper extremity, 6 studies determined the effects of neurodynamics on lower extremity and 3 studies determined the effects of neurodynamics on both upper and lower extremity. Out of 16 studies; 4 studies determined the effects of neurodynamics on spasticity in upper extremity. Out of 9 RCTs, methodological quality of the 3 studies (Yunhyeok Shinu 2015, Hyun-Kyu Cha 2014 and LIU Zhongshu 2013) was moderate and 6 studies were limited as determined by PEDro score.

Out of 9 RCTs, only 1 study (Jacob Lorentzen) reported that neurodynamics was not effective to reduce spasticity. However it concluded the beneficial effects of neural mobilization to improve range of motion. There was 1 case study which reported that combination of neurodynamics with Botulinum toxin A was effective to reduce pain and increase range of motion. There were 3 systemic reviews which concluded that there was lack of qualitative and quantitative evidence to support the effects of neurodynamics on stroke. There were 3 clinical trials (quasi experimental studies) which supported the effects of neural mobilization technique. Different terminologies were used synonymously with neurodynamics like peripheral nerve mobilization, nerve mobilization, neural mobilization, rhythmic neurodynamics, neural tension technique and dynamic neural mobilization. Evidence supported that neurodynamics were effective for the motor recovery of patients with hemiplegia. It stimulates nervous system through indirect mechanism.

Literature suggested that neurodynamics improved passive range of motion much better than active range of motion. This analysis showed that blinding of the subject was not done in any of the study included in this review. Groups were not similar at the baseline in all the studies which showed biasness. Only few studies had proper long term follow up. There were 5 Korean studies, 2 Chinese studies and few studies were in other native languages. Studies which were not translated into English were omitted.

Despite the methodological limitations of studies included in this review such as study design, subject blinding and sample size calculation, beneficial effects of neurodynamics in stroke patients were observed. Future studies should concentrate on the analysis of neural reorganization after stroke which can be done by giving due importance to muscle tone, sensory and motor control, musculoskeletal involvement and functional independence. Future research should determine the effect of neurodynamics for the recovery of stroke subjects in elaboration with large sample size with a homogenous population. Neurodynamics protocols should be properly defined.

Conclusion

This review showed the beneficial effects obtained by the application of neurodynamics to improve range of motion, flexibility, tone reduction, pain intensity, nerve conduction velocity, cerebral cortical activity and post stroke functionality. The qualitative analysis of the studies concluded that there is limited evidence to support the effects of neurodynamics in stroke patients and further research is acquired in future.

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