

Effectiveness of dynamic neuromuscular stabilisation for improving trunk control in hemiplegic stroke: A scoping mini review

Raghumahanti Raghuveer ^{1,2 *}, Ekta Chitkara ¹ and Parul Raj Agarwal ³

¹ Department of Physiotherapy, Faculty of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Sector-43, Faridabad, Haryana 121004, India.

² School of Physiotherapy, Gandhi Institute of Technology and Management, Gandhinagar, Rushikonda, Visakhapatnam, Andhra Pradesh 530045, India.

³ College of Physiotherapy, Heritage Institute of Medical Sciences, NH2, GT Road Bypass, Bhadwar, Varanasi, Uttar Pradesh 221311, India.

* Correspondence: raghuneuro@yahoo.com; Tel.: +91-8126506769

Received: 11 April 2022; **Accepted:** 17 August 2022; **Published:** 23 November 2022

Edited by: Kheng Seang Lim (University of Malaya, Malaysia)

Reviewed by: Tze Yang Chung (University of Malaya, Malaysia); Irene Looi (Seberang Jaya Hospital, Malaysia)

<https://doi.org/10.31117/neuroscirn.v5i4.160>

ABSTRACT: Stroke is one of the leading causes of mortality and morbidity in the adult population, resulting in significant cognitive and sensorimotor impairments affecting one-half of the body in most patients. The limitations that are attributed to trunk impairment affect the postural and respiratory functions due to either spasticity or weakness of trunk muscles, including the diaphragm. Physiotherapy is effective in interdisciplinary stroke management, with approaches utilising the principles of plasticity. This review focused on briefing the pathomechanical aspects of trunk impairment in hemiplegic stroke. The proposed mechanisms of Dynamic Neuromuscular Stabilization (DNS) as a treatment for hemiplegic stroke were analysed, and the existing research evidence for the efficacy of DNS in improving trunk control among stroke participants was critically reviewed. The findings substantiate the need for high-quality trials, emphasising study design, subset size, reflective outcomes, and regulated follow-ups.

Keywords: Dynamic neuromuscular stabilisation; stroke rehabilitation; reflex diaphragmatic activation; trunk control; trunk stabilisation

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1.0 INTRODUCTION

A stroke or cerebrovascular accident is a neurological condition developing suddenly due to impaired blood supply to the fully developed brain lasting more than 24 hours ([Förster et al., 2008](#)). The common pathology is either a blockage or rupture of a blood vessel supplying the brain, and 80% of strokes are ischemic ([Sridharan et al., 2009](#)). Most strokes present as hemiplegia (paralysis

of muscles in one half of the body with or without facial weakness) or hemiparesis (weakness of muscles in one half of the body) and are often used synonymously for stroke.

1.1 Trunk impairment in stroke

Hemiparesis includes weakness in one-half of the body involving the trunk, but trunk control is observed to be

impaired bilaterally ([Fujiwara et al., 2001](#); [Tsuji et al., 2003](#)). Trunk control maintains the stability of the spine and facilitates limb mobility. This ability of the trunk to maintain the centre of gravity within the base of support is impaired in stroke ([Karthikbabu et al., 2011](#)) and is reflected in increased lateral sway and hip elevation seen with circumduction gait ([Balaban & Tok, 2014](#); [Raghuveer et al., 2021](#)), abnormal gait pattern, abnormal postural control and a reduced ability to perform a motor task ([Brown et al., 2002](#)). These can be attributed to motor impairments, including weakness, spasticity, loss of dexterity, and sensory impairments, including loss of balance, proprioception, and postural control deficits ([Bower et al., 2015](#)). Quantitative analysis using Electromyography showed reductions in the activity of the lateral muscles, delay in onset, and a decrease in the activation of muscle pairs which can reflect in abnormal recordings for outcomes including motor and functional deficits ([Dickstein et al., 2004](#)). The extent of trunk impairment can be studied to predict the outcome of functional activities after stroke ([Duarte et al., 2002](#); [Verheyden et al., 2004](#)). There is a dearth of available evidence showing improvements in trunk function after utilising rehabilitation protocols, and most interventional studies on hemiplegic stroke emphasise upper limbs and lower limbs function ([Karthikbabu et al., 2011](#)). Furthermore, studies targeting core muscles of the trunk to gain stability and function are limited.

1.2 Treatment for trunk impairment in stroke

Most of the studies on trunk muscle training for improving trunk function showed favourable results in both sub-acute and chronic stroke patients, with a duration of intervention ranging between two to eight weeks. Rehabilitative approaches targeting trunk function in stroke included specific trunk training exercises (TTE), trunk training exercises with a modality, Bobath approach/Neurodevelopmental Treatment (NDT), abdominal hollowing, abdominal bracing, and conventional therapy ([Cabanas-Valdés et al., 2013](#); [Lee et al., 2020](#)). NDT is the most studied approach for improving trunk function in hemiplegic stroke. There is a moderate level of evidence for NDT when compared with any other intervention on shoulder joint stability, balance, weight-bearing on the paretic leg, coordination, and walking distance (outcomes requiring significant contribution of the trunk), and insufficient evidence for muscle tone, brain activity, walking ability and extended activities of daily living ([Veerbeek et al., 2014](#)). Other strategies, including TTE, have improved trunk function in both sub-acute and chronic stroke patients by improving trunk control ability ([Mudie et al.,](#)

[2002](#)) and have moderate evidence showing its effectiveness when given in combination with physiotherapy during rehabilitation sessions ([Cabanas-Valdés et al., 2013](#)). The improvements were attributed to gains in muscle strength in both sub-acute and chronic stroke patients, thereby enhancing trunk control and balance ([Mudie et al., 2002](#)). However, high-quality trials must be conducted to conclude these interventions' effectiveness firmly.

1.3 Dynamic neuromuscular stabilisation

In stroke, weak recruitment of lumbopelvic core muscles can be attributed to low intra-abdominal pressure generation due to a weaker hemidiaphragm ([Frank et al., 2013](#), [Similowski et al., 1996](#)). Rehabilitation approaches utilising strengthening core muscles, including abdominals, lumbar extensors, and pelvic muscles, were helpful in improving the stability of lumbar posture by facilitating tonic and postural muscles ([Marshall & Murphy, 2005](#); [Yu & Park, 2013](#)). Dynamic Neuromuscular Stabilisation (DNS) was developed on the principles of developmental kinesiology and reflex-mediated core stabilisation concepts by Pavel Kolar in 2013. This approach offers a set of exercises based on ideal natural developmental patterns, which are repeated to activate the whole spine by facilitating the spinal stabilisation system, restoring the intra-abdominal pressure, and optimising movement efficiency ([Milić, 2020](#)). DNS facilitates the core stabilisers, primarily the diaphragm, obliques, and transverse abdominus, reflexively, utilising ontogenic patterns, which are helpful in individuals with reduced somatosensory function or impaired movement awareness ([Frank et al., 2013](#)). Postural stability is improved by subconscious activation of the postural core muscles through the facilitation of motor control strategies for posture and balance ([Lee et al., 2018](#)).

Most of the studies using DNS strategies targeted sports conditions, and the outcomes were strength, endurance, motor control, and stability in athletes and professional sportspeople. The training principles of sport can be transferred to subjects with cerebral stroke as the primary and secondary impairments following a stroke resulting from neuromuscular dysfunction. Gordon ([2004](#)) stated the importance of sports exercises in improving neuromuscular control in patients with cerebral stroke ([Gordon et al., 2004](#)). Further, Eng ([2010](#)) described the effects of fitness and mobility exercises (FAME) in chronic stroke and concluded that FAME in stroke improves motor function, cardiovascular function, and cognitive function ([Eng, 2010](#)).

2.0 METHODOLOGY

To provide an overview of the previous research on the effects of DNS in improving trunk function in hemiplegic stroke, the literature was searched in PubMed, Google scholar, Pedro, and Scopus databases. The Boolean operators "AND" or "OR" were used for the following keywords "Dynamic Neuromuscular Stabilisation", "Reflex Mediated Trunk Activation", "Trunk Exercises in Hemiplegic Stroke", "Motor stability Exercises in Hemiplegia", "DNS", "Trunk Muscle Facilitation in Ontogenic Pattern", "Core stability training", "Reflex mediated DNS". The articles obtained in the preliminary search were screened for duplicate titles and inclusion. Studies comparing the effectiveness of DNS as an intervention in participants with stroke were considered for inclusion. Among the studies whose outcomes did not measure trunk control or trunk function, or trunk impairment were excluded.

3.0 RESULTS

Research on DNS in stroke or apoplexy is sparse, with only five articles (**Figure 1**) studying the effects of DNS as an intervention with a variable duration on outcomes of hemiplegic stroke (**Table 1**). All these studies reflect positively on the impact of the approach for improving function in stroke, but the result is far from conclusive due to the following reasons.

The existing literature lacks well-designed RCTs that can clarify the effects of DNS in hemiplegic stroke. Available studies had small sample sizes totalling 124 stroke patients in 5 studies who were treated with DNS. Of the five studies, 3 were RCT study designs, one was a semi-experimental study, and one was a case-control study.

Even though the intervention in the experimental groups in all studies was based on DNS principles, they differed while delivering the exercise in terms of the type of exercise, time, progression, number of sessions, and duration of treatment (**Table 1**). The sample size of the studies was small, ranging from a minimum of 5 subjects ([Yoon & You, 2017](#)) to a maximum of 16 subjects ([Yoon et al., 2020](#)) per group; hence, The effectiveness of DNS to be superior to any other type of intervention cannot be generalised. A follow-up measure to study the carry-over effects of the exercise was not included in any of the studies.

Raghuveer et al. ([2021](#)), in their study, used 20 DNS positions mentioned in the DNS Brochure published by the DNS school Prague. The patients were educated on DNS by exercising three basic developmental patterns and progressed at the rate of 3-4 new positions every

next week so that they would have completed all 20 developmental patterns by the sixth week ([Raghuveer et al., 2021](#)). In contrast, some studies used predetermined positions for their research; the supine position was used to educate the patient about synkinesis descent of the diaphragm, raise the Intra-abdominal pressure and facilitate the core. The patients were then made to perform unilateral and bilateral upper and lower extremity movements along with the diaphragm descent, and once the patient perceived the correct pattern, prone, quadruped, sitting, and standing positions were used for the same ([Lee et al., 2020](#); [Yoon et al., 2020](#)).

In addition, Benfiry and colleagues used eight weeks of DNS exercises occupying 90 minutes a day up to 3 sessions per week. They included three levels, Level 1 (Simple - 1st and 2nd week), Level 2 (Moderate - 3rd and 4th week), and Level 3 (Advance - 5th to 8th week) based on the patient's ability to gradually lift their centre of gravity from dependent (supine) to independent position (quadruped, sit and stand) ([Benfiry et al., 2018](#)). Yoon and You reported a case-control study on five stroke patients who practised DNS exercises for 20 minutes thrice before recording core muscle activation by SEMG and muscle thickness by ultrasonography. This was done to measure the immediate effect of a single set of DNS exercises ([Yoon & You, 2017](#)).

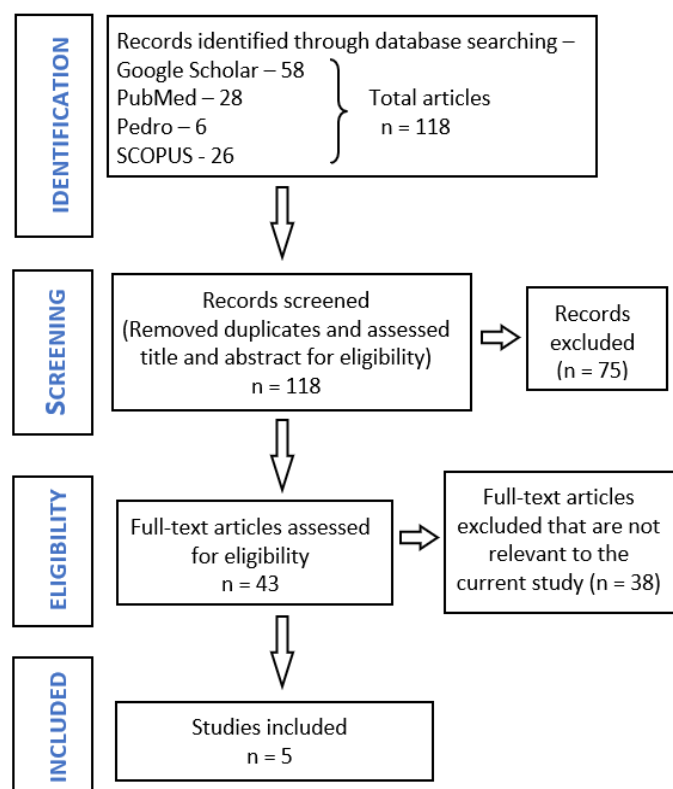


Figure 1. The search strategy used in the study.

Table 1. Summary of research showing the effect of DNS on trunk impairment in hemiplegic stroke

Author/ Reference	No. of participants	Study design	Duration of intervention	DNS intervention	Outcome measures	Control group/ Comparator	Results
Raghuveer et al., 2021)	30 Sub-acute and chronic hemiplegic stroke patients	RCT	6 weeks	15 patients treated with 20 DNS exercises	TIS, MRS, SS-QOL, 10 MWT (Walking Ability)	15 patients treated with NDT exercise for trunk	Both treatments were equally effective for within-group differences; trunk impairment and quality of life showed more improvement in the DNS group.
Yoon et al., 2020)	31 Sub-acute hemiplegic stroke patients	RCT	4 weeks	16 patients received DNS exercises for 30 minutes a day for 3 sessions per week.	FVC, FEV1, MIP, MEP, FSS, FIM	15 patients received NDT exercises	Both therapies were effective within their groups; the DNS group showed better improvements
Lee et al., 2018	28 Chronic Hemiparetic stroke patients	RCT	4 weeks	14 patients received 20 sessions of DNS exercises for 5 days a week over 4 weeks	APA time was denoted by surface electromyography recording of EO, TrA/IO, ES and AD muscles, TIS BBS, FES	14 patients received conventional core stabilisation exercises (CCS)	DNS was superior to CCS in improving APA control, balance, and fear of falls.
Benfiry et al., 2018	30 Chronic stroke patients	Semi Experimental Study, Random sampling	8 weeks	15 patients received DNS exercises for 90 mins per day for 3 days a week	SF-36, BBS	15 patients in the control group performed everyday activities but did not receive any exercise	DNS was effective in bringing improvements in performance and Quality of Life.
Yoon & You, 2017	5 hemiparetic strokes and 5 healthy adults	Case-control Study design	-	All 10 subjects performed DNS exercises for 20 minutes and practised 3 times before recording.	SEMG of TrA, IO, EO, RA. Ultrasound imaging for abdominal thickness	All 10 subjects performed the NDT exercise for 20 minutes and practised 3 times before recording	DNS showed greater activation of TrA/IO

RCT: Randomized Control Trial, DNS: Dynamic Neuromuscular Stabilization, TIS: Trunk Impairment Scale, MRS: Modified Rankin Scale, SS-QOL: Stroke Specific Quality Of Life, 10-MWT: 10 Minute Walk Test, NDT: Neurodevelopmental Therapy, FVC: Forced Vital Capacity, FEV1: Forced Expiratory Volume in first Second, MIP: Maximum Inspiratory Pressure, MEP: Maximum Expiratory Pressure, FSS: Fatigue Severity Scale, FIM: Functional Independence Measure, APA: Anticipatory Postural Adjustments, EO: External Oblique, TrA: Transverse Abdominus, IO: Internal Oblique, AD: Abdominals, BBS: Berg Balance Scale, FES: Functional Electrical Stimulation, SF-36: Short Form 36 Health Survey Questionnaire, SEMG: Surface Electromyography, RA: Rectus Abdominis

4.0 DISCUSSION

DNS was developed on the premise that gross motor development is pre-programmed in the nervous system, which is genetically modulated and predictable in growing children, especially during the initial years of growth. Progress in these patterns of movements happens as the central nervous system (CNS) matures, and new movement strategies non-existent previously can be seen in control of the child. The child develops the ability to maintain posture and perform voluntary motor actions efficiently. This suggests that every child has these inborn central movement patterns, which automatically integrate into volition at the appropriate developmental sequence as the CNS matures (Frank et al., 2015). There is mutual synchrony between the maturation of CNS and the anatomical and structural development of the musculoskeletal system. Motor patterns evolve as the brain matures and becomes integrated as a voluntary function. The synchrony is affected by CNS lesions, leading to impaired muscle function, altered joint sense, abnormal development, and postural dysfunction (Milić, 2020).

DNS assessment includes special movement-based tests to identify abnormal postural movement or compensation. Then patients are trained in an ontogenic movement pattern by being instructed to perform: 1) Perceive the ideal respiratory movement pattern to subconsciously descend the diaphragm symmetrically to facilitate its stabilising role by increasing the intra-abdominal pressure; 2) Holding the activated core to perform dynamic movements; and 3) Facilitation of limb movements through centration at the joints improves mobility, reinforcing stability. These

movements are further progressed using assistance and resistance by modalities like resistance bands and physio balls (Benfiry et al., 2018). The patient implicitly learns to activate the core and trunk muscles for performing all DNS exercises and will use the learned patterns for activities of daily living.

Even though all studies point out that DNS strategies were useful, further studies, including blinding, adequate sample size, and quantitative outcomes, will help to determine the clinical efficiency of DNS as a compelling novel intervention.

5.0 CONCLUSION

Further to this review, the authors believe that DNS is an important novel approach for treating patients with hemiplegic stroke. There is limited evidence on the effectiveness of DNS for improving trunk control following a stroke. Future studies are warranted to consider standardised study designs with adequate sample sizes and other temporal specifications for establishing the evidence for using DNS as an intervention in stroke rehabilitation.

Acknowledgements: The authors self-funded the study and did not receive a grant from any sources.

Author Contributions: RR participated in the study concept and design, specifying the question, identifying relevant references, and writing the manuscript; EC and PRA supervised the review process and participated in reading and checking the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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