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Effectiveness of diaphragm activation using reflex mediated dynamic neuromuscular stabilization on trunk function in hemiplegia

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ABSTRACT

Introduction: Trunk muscle strength is impaired multidirectionally in hemiplegic patients and its identification plays a crucial role in planning treatment strategies in rehabilitation. Neurodevelopmental treatment (NDT) is commonly used to improve postural core stability but requires conscious effort by the patient. Dynamic Neuro Muscular Stabilization (DNS) utilizes the subconscious stimulation of trunk to reflexively mediate the diaphragm and other core stabilization muscles, which is extremely effective for individuals with, reduced somatosensory or movement awareness. *Materials and Methods:* Aim of this study is to find out effects of training utilizing conscious and subconscious activation of diaphragm by NDT and DNS strategies over 6-weeks on trunk function in Hemiplegics. This prospective randomized comparison study was conducted with Thirty hemiplegic subjects who were randomly allocated into two groups, Group A- NDT Group and Group B- DNS Group with 15 in each group (n=15). Trunk Impairment Scale (TIS), Modified Rankin Scale (MRS), Stroke specific Quality of life (SSQOL) and walking ability (WA) were measured as Pre-test and post-test scores. *Results:* Analyzed data showed significant improvements with in both the groups for all variables with $P<0.05$. Between group comparisons showed significant improvements in TIS and SSQOL and non-significant differences for MRS and WA. *Conclusion:* The study findings conclude that DNS, a reflex mediated diaphragmatic and core muscle activation can be more useful in improving trunk function when compared with conscious activation by NDT in subjects with Hemiplegia.

Keywords: Neurodevelopmental Therapy, Dynamic Neuromuscular Stabilization, Stroke Rehabilitation, Hemiplegia, Diaphragm stabilization, core stabilization.

1. INTRODUCTION

Stroke or Cerebrovascular accident is the leading cause of death and disability in adults. It results from disruption of blood circulation in the brain (Forster et al., 2008). Prevalence of stroke in India increased by 12.2% along with 53% increase in Disability-Adjusted Life Years (DALYS) between 1990-2016 (Dandona et al., 2017). In majority of individuals, disability following a stroke may be due to motor impairments like spasticity, muscle weakness, loss of dexterity, and sensory impairments like loss of proprioception, body awareness, incoordination, balance deficits and postural impairment (Bower et al., 2015). Trunk function is integral to maintain the stability of spine for effective limb mobility. Trunk impairment in stroke affects the ability to maintain the Centre of Gravity within the Base of Support while providing controlled mobility and skillful movement (Karthikbabu et al., 2011). Furthermore, weakness in one half of the trunk leads to abnormal postural stability and gait impairment (Balaban, 2014). Hemiplegics compensate for the trunk weakness with excessive lateral sway, elevating the involved hip and circumductory gait.

Due to its importance in maintaining stability, Trunk control is a prerequisite to gain before mobility of limbs was to be achieved. Hence extent of impairment in trunk control can be understood to predict the outcome for functional activities after stroke (Duarte et al., 2002; Hsieh et al., 2002; Verheyden et al., 2007). Neuro-Developmental Therapy (NDT) or Bobath approach is one of the most used rehabilitation concepts for the treatment of cerebral palsy children and a regularly used model for adults with hemiplegia following stroke (Cherry, 1993). NDT emphasizes on the role of patients to be active participants who performs the activities with assistance of the therapist. The therapist uses key points of control on the patient's body to facilitate the desired movement pattern (Bobath, 1990). NDT approach is commonly used to train trunk muscle weakness with exercises initially performed with in the BOS and progressing to outside the BOS. These activities follow the principles of motor learning and plasticity.

Activities for trunk involve conscious activation of abdominals and pelvic stabilizers to facilitate deep core muscles (Gjelsvik, 2008). Studies showed that NDT approach can improve proximal stabilization, thereby improving postural control in cerebral palsy subjects, but the effects are not well studied in Hemiplegics. Furthermore, as the approach requires conscious activation of postural stabilizers by the patients, it is ineffective if cognitive or somatosensory impairments coexist along with motor impairments (Hafsteinsdottir et al., 2005). Hence approaches utilizing subconscious or reflex mediated core muscle activation with implicit strategies must be studied for their efficacy.

Dynamic Neuromuscular Stabilization (DNS) was developed on the principles of developmental kinesiology and reflex mediated core stabilization concepts. This approach facilitates the core stabilizers primarily the Diaphragm, obliques and Transverse Abdominus reflexively utilizing ontogenic patterns which are helpful in individuals with reduced somatosensory function or impaired movement awareness (Frank et al., 2013). Hence to bridge the gaps in objective evidence for effectiveness of both NDT and DNS approaches, the present study was undertaken to examine the therapeutic effects of these approaches on Trunk impairment, Disability, Quality of life and Walking ability in individuals with Hemiplegic stroke.

2. MATERIALS AND METHODS

This study was performed on hemiplegics recruited from multiple outpatient rehabilitation centres between 2020-2021 and informed consent was obtained from the subjects prior to the study. Participants were randomly allocated to two groups of 15 each (n=15) using lottery method.

Ethical considerations

Information of all patients remained confidential and informed consent was obtained prior to the study. The study protocol was approved by the institutional ethics committee of Manav Rachna International Institute of Research and Studies (EC/2020-21/004).

Procedure

Inclusion criteria for stroke participants was as follows: 1) first time stroke patients who were clinically stable and are able to attend outpatient department for treatment (mean months 2.31 $\pm$ 0.73), 2) patients who were able to understand and follow commands well MMSE > 24(MMSE scores 25.47$\pm$ 0.66) and 3) Modified Rankin Score <4 (Mean score 2.82$\pm$0.28). Patients with cognitive impairment, hemianopia, history of surgical procedures and uncontrolled hypertension were excluded from the study.

Trunk Impairment Scale (TIS), Modified Rankin Scale (MRS), Stroke Specific Quality of Life (SS-QOL) and 10-Meter Walk Test (10 MWT) for Walking Ability were recorded on base line and after 6 weeks on a pretest-posttest basis as outcomes. NDT exercises were designed based on the functional limitations of the subjects and included, stretching and functional training for latissimus dorsi, exercises for abdominals and oblique muscles, placing exercises for facilitation of trunk extension, dissociated movements for

the pelvis and hip, facilitation of lumbar spine stabilizers and multidirectional functional reach activities for the shoulder. All the exercises follow the principles of Bobath approach with active patient participation, performing repeated functional movement still near normal patterns are achieved, progression from passive to assisted to active movement and achieving ability to hold positions (Muhammed et al., 2016).

DNS protocol consisted of 20 developmental pattern exercises utilizing reflex mediated facilitation of diaphragm by the therapist placing both thumbs on the chest zones and encouraging normal breathing pattern and holding the descent of diaphragm to activate its stabilizing role (Frank et al., 2013; Lim et al., 2016). The spine, ribcage, pelvis and scapula are positioned in alignment by activating the core stabilizers. For the first week, 3 developmental patterns were used for education of correct breathing-stabilization and for next 5 weeks, new three to four patterns were introduced from the DNS posters. By the sixth week, the participants have practised all patterns from the DNS poster (Frank et al., Davidek et al., 2018). The subjects practised the DNS exercises in their home and were received the illustrated booklet for reference. Stretching exercises, mat activities, functional training and active range of motion exercises were given to subjects in both the groups.

Data analysis

Data was collected on the baseline pre-intervention and the last day of the 6th-week post-intervention. Mean and Standard Deviation scores of the groups were used for comparisons. SPSS version 22.0 was used for analysis. Data analysis included descriptive characteristics of the subjects, Within-group comparisons, and Between-group comparisons. Wilcoxon-Signed Rank test and Mann Whitney U test were applied for within and between-group comparisons of TIS, MRS and SS-QOL. Students Paired and unpaired t-tests were used for with-in and between-group comparisons of 10 MWT. Data was analysed at 95% CI and $P< 0.05$ was considered as significant.

3. RESULTS

Multiple baseline characteristics of the patients in both the groups show homogeneity with non-significant differences at the baseline (Table 1). Comparison of pre and post readings suggests significant differences within both the groups with improvements in mean and SD values of the primary and secondary outcome measures. The analysis of MRS, TIS, SS-QOL and 10-MWT showed a significant reduction in disability, Trunk Impairment, Quality of life and walking ability in 6th week when compared with pre-intervention in both NDT and DNS groups with $p <0.05$ (Table 2 & chart 1 -8).

Table 1 Shows baseline characteristics of the study population in both groups.

	NDT	DNS	P-Value
Age* (In Years)	59.73 ± 7.51	59.27 ± 9.07	0.879
Gender			
Males, n (%)	12 (80)	12 (80)	1.000
Females, n (%)	3 (20)	3 (20)	
Type of stroke			
Ischemic, n (%)	13(86.7)	11(73.3)	0.369
Haemorrhagic, n (%)	2(13.3)	4(26.7)	
Duration of stroke			
Mean Duration	3.93 ± 1.2	3.8 + 1.73	0.255
Side of stroke			
Right, n (%)	8 (53.3)	6 (40)	0.472
left, n (%)	7 (46.7)	9 (60)	

∗Represents continuous variable with normal distribution, expressed as mean ± SD; other values are expressed as n (%); NDT (Neurodevelopmental Therapy) and DNS (Dynamic Neuromuscular Stabilization).

Table 2 within-group comparison for effects of NDT and DNS

	NDT GROUP			DNS GROUP		
Outcome Measures	Pre-Scores	Post scores	P-value	Pre-Scores	Post scores	P-value
MRS	2.87±0.52	1.78±0.49	<0.05	3.13+0.61	1.84±0.64	<0.05

TIS	14.42±3.41	17.89±4.28	<0.05	14.87±4.76	18.8±5.53	<0.05
SS-QOL	146.26±20.66	178.73±18.40	<0.05	151.4±17.9	188.8±22.9	<0.05
10-MWT	0.22±0.48	0.67±0.6	<0.05	0.28±0.39	0.72±0.58	<0.05

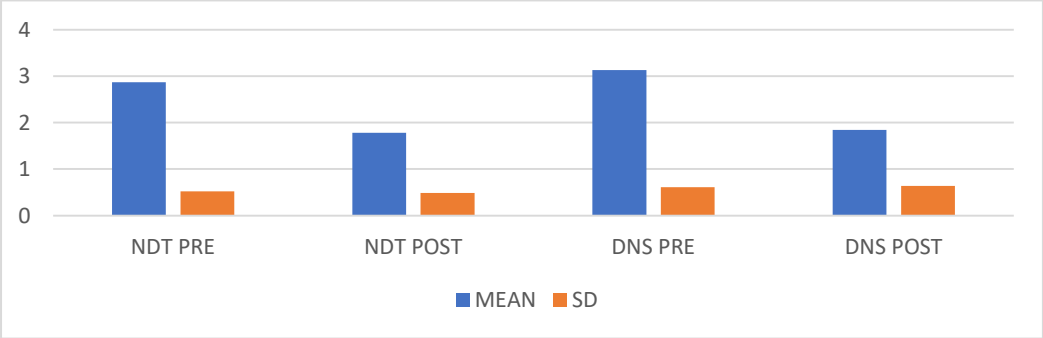

Chart 1 comparison of Pre and Post values of Modified Rankin Scale with in NDT and DNS groups:

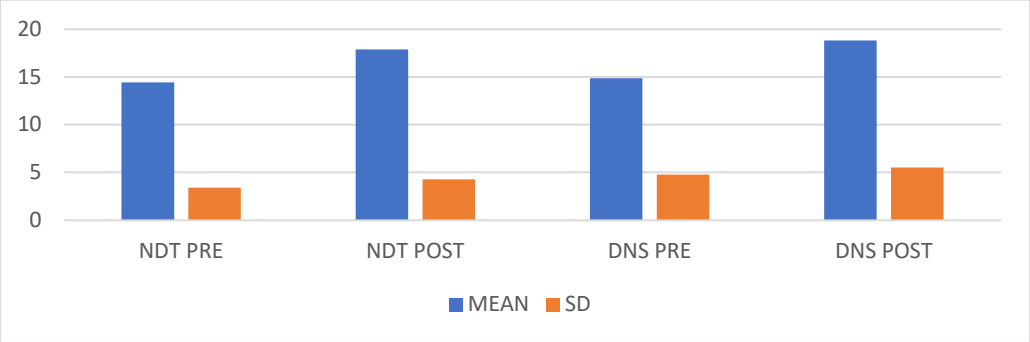

Chart 2 comparison of Pre and Post values of Trunk Impairment Scale with in NDT and DNS groups:

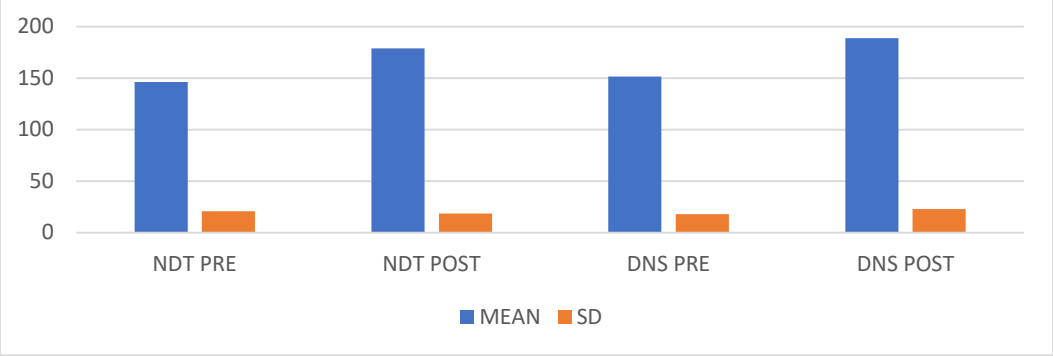

Chart 3 comparison of Pre and Post values of SS-QOL with in NDT and DNS groups:

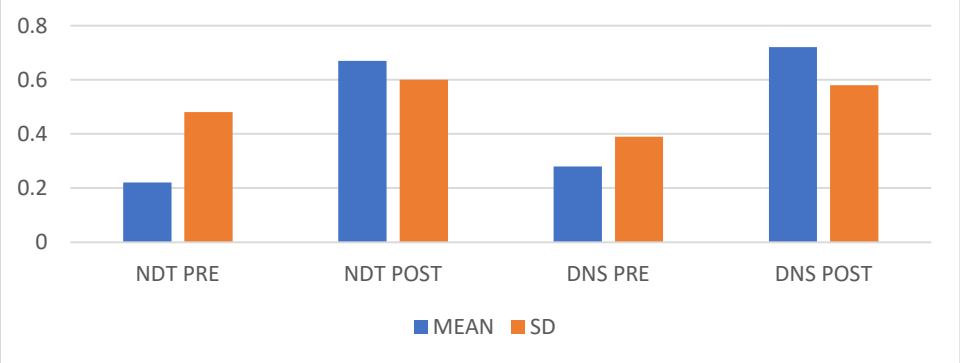

Chart 4 comparison of Pre and Post values of 10MWT with in NDT and DNS groups

Comparison of post interventional readings between the groups showed significant differences for TIS and SS-QOL with $p<0.05$. MRS and 10-MWT elicited non-significant differences with $p>0.05$ (Table-3).

Table 3 Between-Group comparison for effects of NDT and DNS

	NDT	DNS	t- value/ Z-value	P value
Post-Treatment				
MRS	1.78±0.49	1.84±0.64	-1.619	.105
TIS	17.89±4.28	18.8±5.53	-3.686	0.001
SS-QOL	178.73±18.40	188.8±22.9	-2.077	0.038
10-MWT	0.67±0.6	0.72±0.68	-0.686	.492

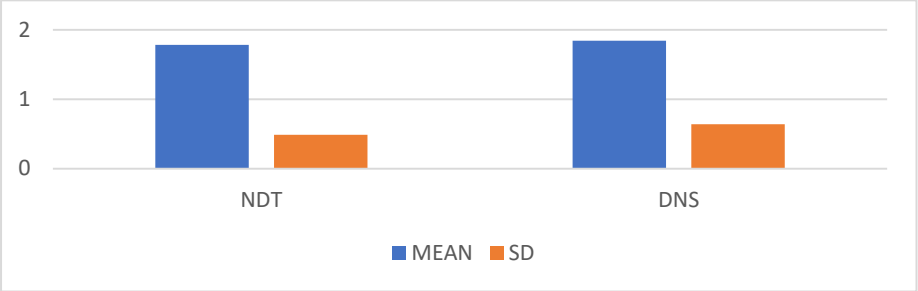

Chart 5 Comparison of mean and SD of post scores of Modified Rankin Scale between the groups.

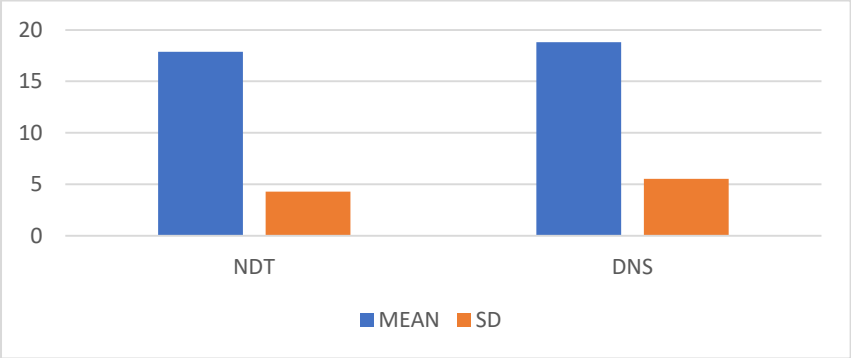

Chart 6 Comparison of mean and SD of post scores of Trunk Impairment Scale between the groups.

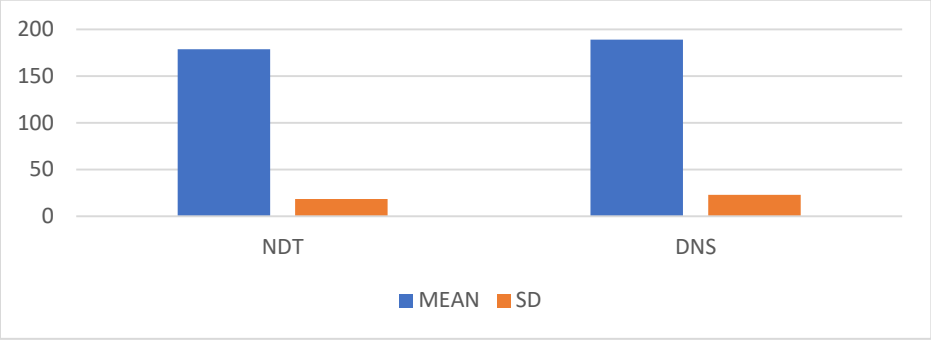

Chart 7 Comparison of mean and SD of post scores of SS-QOL scale between the groups.

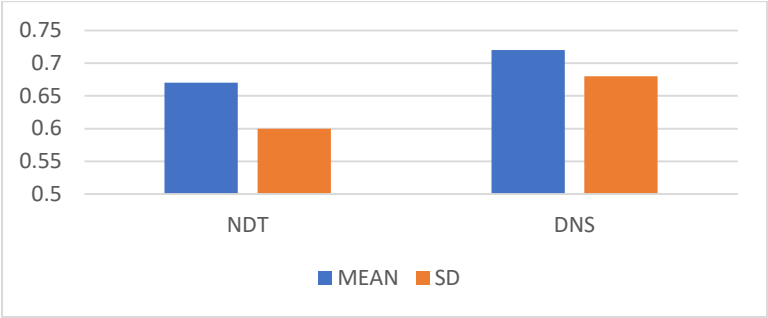

Chart 8 Comparison of mean and SD of post scores of 10-minute walk test between the groups.

4. DISCUSSION

This study was aimed to explore the effects of reflex mediated DNS strategies in improving trunk function in hemiplegics. Thirty subjects were recruited after screening and randomly divided into two groups of 15 each. Group A received NDT intervention and for 6 weeks. Group B received DNS intervention and Standard Physiotherapy exercises. Data were collected before and after the 6-week protocol. The result showed that both the strategies were effective in improving tone and functions within their groups with significant differences between baseline and post interventional scores after a 6-week intervention. Comparison between baseline and post-treatment scores revealed marked improvements in both groups for all outcome measures.

NDT group

NDT group showed significant improvements in Trunk Impairment, Disability, Quality of life and walking ability among hemiplegia subjects following a six-week NDT and Physiotherapy exercise program. NDT Exercises were determined according to the functional expectations of the patient and modified in accordance with their functional level (Raine, 2006; Raine, 2007). Activities performed within and outside the base of support facilitated the postural mechanisms by improving cortical activation and plasticity. Further, NDT approach emphasises on performing movements near to normal, hence quality of movement improved as the subject regained trunk control. This was in accordance with the findings of Muhammed et al., (2016), who observed similar improvements in their study. As proximal stability improved, the subjects were able to gain control and perform meaningful voluntary activities with their limbs (O'Sullivan & Schmitz, 2007). This improved the overall disability and walking ability of the subjects. As the subject is independent in performing his activities of daily living with time, the quality of life improved for them. This is supported by the findings in the study by Grabowska-Fudala, (2017) who found significant improvements in SS-QOL among stroke subjects following therapy.

DNS group

The results of the present study showed significant improvements in Trunk Impairment, Disability, Quality of life and walking ability among hemiplegia subjects following a six-week DNS and Physiotherapy exercise program. This approach was developed primarily emphasising on the dual role of diaphragm as a respiratory as well as a core stabilizer. The onto genic development of postural control is due to reflex mediated facilitation of diaphragm and core stabilizers in various developmental positions that the child adapts during his growth (Yoon, 2017). The intra-abdominal pressure is vital for the lumbopelvic spinal core to activate. Hemiplegia following a stroke leads to abnormal activation or weakness of the trunk muscles followed by inhibition of diaphragm activation as a core stabilizer (Frank, 2013). Improvements in TIS following a six-week DNS protocol can be attribute to facilitation of postural muscles in various developmental positions and re-activation of diaphragm to improve the Intra- abdominal pressure to activate the core. Once improvements in trunk activation are achieved, subjects were able to control their posture during dynamic tasks there by improving the disability, Quality of life and walking abilities (Kobesova, 2014).

Improvements in the outcomes for both the groups can also be attribute to the standard physiotherapy exercises which included stretching of tight muscles of upper and lower limbs, mat exercises for stability, functional training for ADL and Active Range of motion exercises for limbs (Maček, 2020). Between groups comparisons showed significant improvements in DNS group for TIS and SS-QOL when compared with NDT group. Utilizing 20 developmental positions for training, activation of core by reflex mediated facilitation of diaphragm and easier understanding of the subconscious movement might have benefitted the DNS group when compared with NDT which utilised a structured practice (Mohammad Rahimi, 2020). On-significant improvements in Walking ability and Disability can be attributed to improved trunk control in both the groups causing better stance of the affected limb and

swing of the unaffected limb during 10 MWT. As the subject became functional, the disability decreased in both the groups (Yu, 2013; Chung, 2013).

5. CONCLUSION

Based on the findings of the present study, it can be concluded that Dynamic Neuromuscular Stabilization, a reflex mediated diaphragmatic and core muscle activation using developmental positions based on ontogenesis can be useful in improving trunk function when compared with conscious activation by Neurodevelopmental Therapy in subjects with hemiplegic stroke.

Consent for Publication

All authors declare that they have provided consent for publishing the study.

Authors' contributions

All authors contributed to the design of the study, data collection, analysis and writing of the manuscript. All authors read and approved the final manuscript.

Ethical Approval

The study was approved by the Ethics committee of the institutional ethics committee of the university - EC/2020-21/004.

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Conflict of Interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are presented in the paper.

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