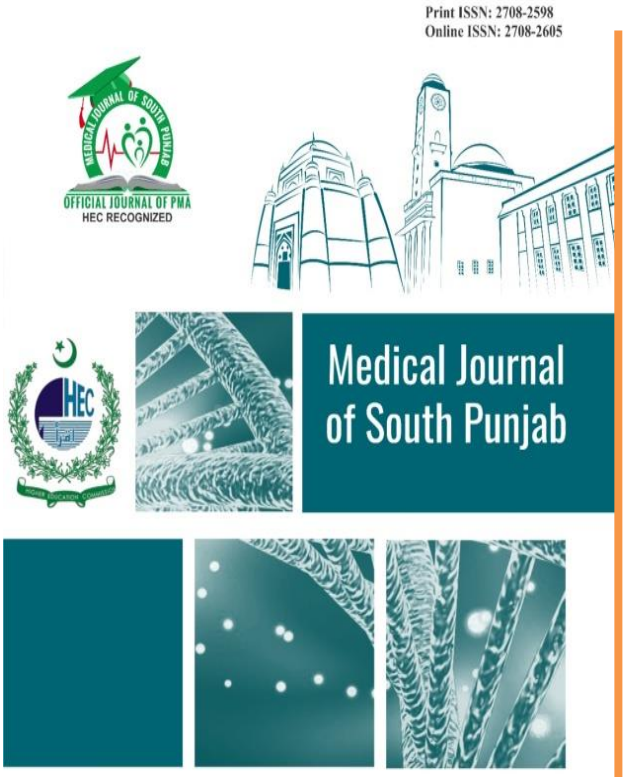
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Authors and Affiliation:
Isbah Siddique[1*], Sajid Rashid[2],
[1-2] TIMES University Multan, Pakistan
Corresponding Author Email:
isbahsiddiq55@gmail.com

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Original Article

Comparison of proprioceptive neuromuscular facilitation and neurodevelopmental treatment on trunk control, balance and gait in children with spastic diplegic cerebral palsy: a randomized controlled trial

Isbah Siddique[1*], Sajid Rashid[2],
[1-2] TIMES University Multan, Pakistan
Corresponding Author Email: isbahsiddiq55@gmail.com

ABSTRACT

Objective: To evaluate the effects of Proprioceptive Neuromuscular Facilitation (PNF) and Neurodevelopmental Treatment (NDT) on trunk control, balance and gait in children with spastic diplegic cerebral palsy (CDCP).

Methods: This randomized controlled trial was conducted at Irus Clinic, Multan, Pakistan & Time. The children aged between 4-12 years with spastic diplegic cerebral palsy (GMFCS I to III) were randomly divided into two groups, Group A of PNF techniques and conventional therapy (n=33) and Group B of NDT facilitation and conventional therapy (n=33). 45 minute sessions were held 3 to 4 times per week for 4 months for both groups. Trunk Control Measurement Scale (TCMS), Pediatric Balance Scale (PBS), Timed Up and Go test (TUG), and 10-Meter Walk Test (10MWT) were assessed before and after intervention. For within group comparisons paired t test and Wilcoxon signed rank test were used and for between group comparisons independent samples t test and Mann Whitney-U test were used.

Results: There were significant within-group improvements in all outcome measures for both groups ($p<0.001$). Between-group analysis revealed that the PNF group demonstrated significantly greater improvements in TCMS change scores (10.545±2.181 vs 4.970±1.334, $p<0.001$), PBS ($U=26.500$, $p<0.001$), TUG ($U=27.500$, $p<0.001$), and 10MWT ($U=1.500$, $p<0.001$) compared to the NDT group.

Conclusion: PNF was more effective in improving children with spastic diplegic cerebral palsy's trunk control, balance and gait speed when compared with NT.

Keywords: Balance, Cerebral palsy, Gait, Neurodevelopmental treatment, Proprioceptive neuromuscular facilitation, Trunk control

1. INTRODUCTION

Cerebral palsy (CP) is the most frequent motor disability in children, occurring in 2-3.5 per 1000 live births worldwide and is most commonly the spastic diplegia subtype.[1] Spastic diplegic cerebral palsy results in bilateral lower extremity spasticity along with poor trunk control, lack of balance and inefficient gait patterns that greatly impact the functional independence and participation of children in their daily activities.[2] Proper trunk control is also one of the most important prerequisites for postural stability, and directly affects balance performance and gait efficiency in these children.[3,4] Children are classified into five levels of function according to the Gross Motor Function Classification System (GMFCS) and most of those in levels I to III are able to remain ambulatory but have motor impairments that vary in severity and need specific rehabilitation interventions.[5]

A variety of neurorehabilitation techniques have been used to treat children with cerebral palsy for trunk control, balance and gait impairments.[6,7] Proprioceptive Neuromuscular Facilitation (PNF) is a technique that activates and facilitates the neuromuscular system through the use of diagonal and spiral movement patterns, manual resistance and facilitation to increase neuromuscular control, strength and coordination.[8,9] PNF has been demonstrated to enhance trunk stability and functional mobility in neurological populations, with the use of motor learning principles, through the use of proprioceptive input.[10,11] Neurodevelopmental Treatment (NDT), or the 'Bobath approach' is a technique that aims to inhibit abnormal postural patterns, allow movement to occur through key points of control and encourage task-oriented functional activities.[12,13] Although widely used, there is now some uncertainty about the superiority of the outcomes of NDT compared with alternative treatments in childhood rehabilitation.[14,15] PNF and NDT are commonly applied in clinical practice, but there is little evidence that compares the efficacy of both approaches in trunk control, balance and gait together in children with spastic diplegia.[10,16]

The purpose of this study was to assess the impact of PNF and NDT, to compare the effects of these techniques on trunk control, balance, and gait speed, and to identify which technique leads to improved functioning across the various outcome measures.

2. METHODOLOGY

This was a Randomized Controlled Trial carried out at Physical Therapy Department of Irus Clinic Multan, Pakistan for duration of 4 months from recruitment of the study participants up to intervention and data analysis.

In G*Power software the sample size was calculated for a two-tailed independent samples t-test, with no prior study directly comparing PNF with NDT in trunk control, balance and gait simultaneously in spastic diplegia it was assumed that the effect size d = 0.5.[10] The number of participants needed for each group was 30 with a significance level (α) of 0.10 and a statistical power ($1-\beta$) of 0.60. Enrollment was 66 children (33 per group) with a 10% attrition.

Simple random sampling technique used and participants were divided into 2 equal groups using computer generated random numbers in closed opaque envelopes, Group A (PNF + conventional therapy) (n=33) and Group B (NDT + conventional therapy) (n=33). All baseline/Post intervention assessments were performed by a trained assessor who was blinded to group allocation. Inclusion criteria: Children (gender not specified) aged 4-12 years with a confirmed diagnosis of spastic diplegic cerebral palsy, GMFCS level I, II or III, capacity to follow simple verbal instructions, capacity to sit unsupported for a minimum of 30 seconds, and parent/guardian consent.

Exclusion criteria: Any orthopaedic surgery within 12 months of enrolment, uncontrolled epilepsy, fixed musculoskeletal deformities

which prevent participation, visual or auditory loss which would affect testing.

Group A (PNF + conventional therapy) was given 15 minutes of bilateral PNF technique for pelvic and trunk patterns.[8,11] Techniques included anterior elevation and posterior depression pelvic patterns to promote trunk flexor activation, posterior elevation and anterior depression pelvic patterns for trunk extensor activation, rhythmic stabilisation at the pelvis to promote co-contraction and dynamic trunk stability, slow reversals and combination of isotonics through pelvic patterns to facilitate coordination, and bridging with manual PNF resistance for strengthening the hip extensors and trunk stabilisers.[9,10,17] Group B (NDT + conventional therapy) were treated with 15 minutes of trunk and pelvic facilitation.[12,13] Techniques consisted of inhibiting abnormal postural tone (key points of control at trunk and pelvis and shoulder girdle) and facilitating trunk righting and equilibrium reactions (weight shifting in sitting and standing); facilitating trunk rotation and dissociation; facilitating weight shifting and alignment at the pelvis in various positions; and facilitating task-oriented movement (NDT handling combined with functional tasks, such as reaching, sit-to-stand and stepping).[13,18,19] The two groups participated in 45 minute sessions, 3-4 times a week for 4 months. The exercises used in the conventional physical therapy for both groups included passive stretching, active-assisted range of motion exercises, and functional mobility exercises.[6,18].

Age, gender, weight, height, and duration of cerebral palsy were recorded. The trunk control was assessed with the Trunk Control Measurement Scale (TCMS), which is a valid clinical assessment scale ranging from 0 to 58 and has high ICC ranging from 0.91 to 0.99,[11] with the higher scores representing better trunk control.[12] The Pediatric Balance Scale (PBS) was used to assess balance, with a score range of 0 - 56, with higher scores representing better balance, and the Timed Up and Go test (TUG) was timed in seconds, with lower times representing better balance performance.[13] The 10-Meter Walk Test (10MWT) was used to assess gait speed, which is expressed as metres per second, with higher scores representing faster walking speed. All outcomes were assessed at pre- and post-intervention 4 months.[14]

SPSS version 26.0 was used for data analysis. Descriptive statistics, namely mean, standard deviation, frequency and percentage were used to summarise participants' characteristics while the Shapiro-Wilk test (n<50 per group) was used to assess normality. A paired samples t-test was used to compare pre- and post-intervention scores for normally distributed data (TCMS) while a Wilcoxon signed-rank test was used for non-normally distributed data (PBS, TUG, 10MWT). Independent samples t-test or Mann-Whitney U test was used to analyze the differences between groups for the change scores. Independent samples t-test, Mann-Whitney U test, and chi-square test were used to test baseline comparability. Results with a p-value of <0.05 were considered statistically significant.

3. RESULTS

Forty children in each group (Group A: PNF, n=33; and Group B: NDT, n=33) were randomly selected. No participants dropped out of the 4-month intervention (Figure 1).

The baseline information of the participants is presented in Table 1. The mean ages were 37.36±2.608 years in Group A and 7.64±2.343 years in Group B which was not statistically significant (p=0.654) and ranged between 4-12 years. Gender distribution was comparable, with 16 (48.5%) males and 17 (51.5%) females in Group A and 18 (54.5%) males and 15 (45.5%) females in Group B (p=0.623). Mean weight (24.891±8.469 vs 26.161±7.321 kg, p=0.524), height (116.427±15.149 vs 117.873±12.665 cm, p=0.680), and duration of cerebral palsy (3.645±2.250 vs 3.621±1.617 years, p=0.961) were also comparable between

groups. Baseline TCMS (28.58±6.960 vs 30.00±6.447, p=0.392), PBS (31.00±6.815 vs 31.30±7.856, p=0.621), TUG (23.858±5.795 vs 24.033±7.234, p=0.985), and 10MWT (0.565±0.180 vs 0.564±0.190, p=0.980) were also comparable, confirming adequate randomisation.

Table 1: Baseline characteristics of participants (n=66)

Variable	Group A (PNF) n=33	Group B (NDT) n=33	p-value
Age (years), mean±SD	7.36±2.608	7.64±2.343	0.654[a]
Gender, male/female, n (%)	16 (48.5)/17 (51.5)	18 (54.5)/15 (45.5)	0.623[b]
Weight (kg), mean±SD	24.891±8.469	26.161±7.321	0.524[a]
Height (cm), mean±SD	116.427±15.149	117.873±12.665	0.680[a]
Duration of CP (years), mean±SD	3.645±2.250	3.621±1.617	0.961[a]
TCMS, mean±SD	28.58±6.960	30.00±6.447	0.392[a]
PBS, mean±SD	31.00±6.815	31.30±7.856	0.621[c]
TUG (seconds), mean±SD	23.858±5.795	24.033±7.234	0.985[c]
10MWT (m/s), mean±SD	0.565±0.180	0.564±0.190	0.980[c]

Table-2: Within-group pre- and post-intervention comparisons

Outcome	Group	Pre, mean±SD	Post, mean±SD	p-value
TCMS	Group A (PNF)	28.58±6.960	39.12±7.47	<0.001[a]
	Group B (NDT)	30.00±6.447	34.97±6.99	<0.001[a]
PBS	Group A (PNF)	31.00±6.815	40.58±7.28	<0.001[b]
	Group B (NDT)	31.30±7.856	36.55±7.96	<0.001[b]
TUG (sec)	Group A (PNF)	23.858±5.795	17.685±5.9	<0.001[b]
	Group B (NDT)	24.033±7.234	20.782±7.0	<0.001[b]
10MWT (m/s)	Group A (PNF)	0.565±0.180	0.796±0.17	<0.001[b]
	Group B (NDT)	0.564±0.190	0.665±0.19	<0.001[b]

Table 3: Between-group comparison of change scores

Outcome	Group A (PNF) Change, mean±SD	Group B (NDT) Change, mean±SD	p-value
TCMS	10.545±2.181	4.970±1.334	<0.001[a]
PBS	9.58±2.291	5.24±1.501	<0.001[b]
TUG (sec)	-6.173±1.856	-3.252±1.394	<0.001[b]
10MWT (m/s)	0.231±0.047	0.101±0.048	<0.001[b]

4. DISCUSSION

This was a randomized controlled trial in which the effects of PNF and NDT were compared regarding trunk control, balance and gait speed in children with spastic diplegic cerebral palsy. All outcome measures showed significant within-group improvements following both interventions at 4-months; however, PNF showed statistically and clinically greater improvements than NDT on all parameters assessed.

The results of the present study are consistent with those of previous studies that have shown that PNF can improve trunk stability by promoting the activation of trunk muscles via facilitation with diagonal patterns and manual resistance, as evidenced by the larger mean change in the TCMS score for this group compared to the MEMS score (10.545 vs 4.970).[8,10] PNF techniques can directly activate the trunk flexors and extensors in pelvic patterns and offer proprioceptive feedback to the system that is important for motor learning and neuromuscular adaptation due to resistance.[9,17] The facilitation aspects of NDT trunk control, on the other hand, with the focus on inhibition of abnormal tone and guided handling, might not offer as strong of a strengthening stimulus as the resistance approach of PNF.[12,14] The results of this study are in line with El-Kafy et al. who showed that the trunk control of children with cerebral palsy significantly improves following PNF based interventions.[8,10]

Results of PBS (U=26.500, p<0.001) and TUG (U=27.500, p<0.001) showed that there were significantly greater improvements in balance outcomes in the PNF group; indicating that this approach may be a better stimulus to enhance balance. The improvement in the PBS

scores for the PNF group (mean change 9.58) versus the NDT group (mean change 5.24) might be related to the rhythmic stabilisation and co-contraction activities that are inherent to PNF techniques, that specifically work on the anticipatory postural adjustments associated with balance control.[11],[17] Likewise, the PNF group experienced a greater reduction in TUG (6.173 vs 3.252 seconds), suggesting that the PNF group had improved functional mobility and dynamic balance, which is similar to the results of Kofotolis and Kellis who reported better balance results with PNF than traditional methods.[20]

The biggest difference between groups was for gait speed (10MWT) and this was statistically significant with the PNF group having a mean increase of 0.231 m/s and the NDT group a mean increase of 0.101 m/s ($U=1.500$, $Z=-6.979$, $p<0.001$). This is a clinically significant difference, since there is evidence that an improvement in gait speed is linked to better ambulation and independence in community settings with children with cerebral palsy.[21] The superiority of PNF in enhancing gait speed could be attributed to the use of pelvic patterns and bridging exercises that focus on strengthening hip extensors and trunk stabilisers, which play a crucial role during stance phase of gait and/or forward propulsion.[11],[22] The findings are similar to the study carried out by Gunjan et al about the significant improvement in gait parameters in children with spastic diplegia after PNF-based pelvic exercises.[11]

The results of this study have important implications for clinical practice in paediatric neurorehabilitation. Although NDT is by far the most common method for managing CP throughout the world, the results of this study support the use of PNF when there are goals for trunk control, balance, and gait speed improvement.[12],[14] The sequences and elements of PNF techniques, the parameters of resistance, may also lead to more standardised type of treatment than NDT which is more dependent on therapist.[15],[17] Future research may merit combined approaches using elements of both PNF and NDT approaches.[9]

5. CONCLUSION

Proprioceptive Neuromuscular Facilitation (PNF) and Neurodevelopmental Treatment (NDT) were found to be beneficial for trunk control, balance and gait speed in children with spastic diplegic cerebral palsy. In paediatric neurorehabilitation, however, functional improvements were significantly higher with PNF than with NDT on all the outcome measures and this may be the preferred intervention.

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