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Research Article

"Effect Of Chest Proprioceptive Neuromuscular Facilitation On Peak Expiratory Flow Rate And Level Of Fatigue In Children With Spastic Cerebral Palsy"

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ABSTRACT

BACKGROUND: Patients with Spastic CP often experience respiratory complications due to impaired lung function. Fatigue prevalence appears significantly higher in adults with CP compared to the general population. Techniques such as Proprioceptive Neuromuscular Facilitation (PNF) targeting respiratory muscles have been found effective in enhancing lung performance. The current study focused on evaluating the impact of chest PNF on Peak Expiratory Flow Rate (PEFR) and fatigue levels in children diagnosed with Spastic CP.
METHODS: A randomized controlled trial was conducted involving 32 children with Spastic CP. Participants were divided into two groups: Group A (n=16), which received respiratory Proprioceptive Neuromuscular Facilitation (PNF) combined with conventional therapy, and Group B (n=16), which received only conventional therapy. Group A's sessions were held for 60 minutes three times a week over a period of 8 weeks, while Group B underwent conventional therapy for 30 minutes per session during the same time frame. The outcome measures, including PEFR and the Modified Borg Scale, were recorded at baseline, the 4th week, and the 8th week of the intervention.
RESULTS: A comparison of average pre- and post-intervention values revealed statistically significant differences ($p<0.05$) between the two groups. All measured variables showed greater improvements in Group A compared to Group B ($p<0.05$), indicating the superior efficacy of combining respiratory PNF with conventional therapy.
CONCLUSION: Adding respiratory Proprioceptive Neuromuscular Facilitation (PNF) to conventional therapy was found to be more effective in enhancing Peak Expiratory Flow Rate (PEFR) and reducing fatigue levels in children with diplegic cerebral palsy than conventional therapy alone.

KEYWORDS: Cerebral Palsy, Spastic, Diplegic, Therapy, Rehabilitation, Respiratory Proprioceptive Neuromuscular Facilitation, Peak expiratory flow rate.

INTRODUCTION

Cerebral Palsy (CP) refers to "a group of permanent disorders affecting the development of movement and posture, which result in activity limitations due to non-progressive disturbances in the developing fetal or infant brain" (Rosenbaum et al., 2007). Spastic CP is specifically defined by the presence of hypertonia, where resistance to movement increases as the speed of the movement increases and varies depending on the direction—indicative of resistance to stretch (Bax et al., 2005; Scholtes et al., 2006). Around 85% of children diagnosed with CP present with some form of spastic CP, making it the most common subtype, with a prevalence rate of 1.16 per 1,000 live births (Boulet et al., 2009).

Respiratory complications are frequently observed in children with CP and are a leading cause of hospitalizations or mortality within this group. Several studies have linked respiratory problems in these individuals to reduced mobility of the chest wall. Poorly coordinated breathing patterns are common, leading to impaired breathing capacity and difficulty in taking deep breaths (Calberg et al., 2007).
Peak Expiratory Flow Rate (PEFR) is a measure of the highest airflow achieved during a forced exhalation, beginning with a full breath. This is typically expressed in liters per minute (L/min). Research shows that the average PEFR for children with CP is approximately -121 L/min, significantly lower than the 200-550 L/min range observed in healthy children. PEFR is mainly determined by factors such as large airway flow, lung elasticity, muscle strength, and the effort exerted by the individual. It serves as an essential metric for evaluating lung function and helps identify the underlying causes of respiratory issues in children with CP (Gorter et al., 2011).
Fatigue is another prevalent issue, with reports indicating that 18% of adults with CP experience higher fatigue levels compared to the general population. Furthermore, many children with CP are insufficiently engaged in physical activities, which may exacerbate this condition (Dos Santos et al., 2011).
Proprioceptive Neuromuscular Facilitation (PNF) exercises involve the use of large-scale, diagonal, and spiral movements of the lower rib cage, which are known to enhance pulmonary function in young adults. These exercises influence the rate and depth of breathing. By applying tactile and proprioceptive stimuli during respiratory exercises, PNF techniques can help restore normal breathing patterns, increase chest wall mobility, and enhance chest expansion (Cabral et al., 2008).
Recent studies suggest that incorporating PNF techniques targeting respiratory muscles can improve chest wall expansion and overall lung function in individuals with CP. Consequently, there is a pressing need to evaluate the effectiveness of chest PNF in improving Peak Expiratory Flow Rate (PEFR) and reducing fatigue in children with spastic CP.

MATERIALS AND METHODS

STUDY DESIGN

This experimental study was carried out at the Institution for Children with Disabilities and Challenges, Delhi, and Ved Special School, Delhi.

RANDOMIZATION AND ALLOCATION

A total of 32 participants were selected using simple random sampling. The entire study protocol was explained to all participants, and informed consent was obtained before any assessments were conducted.

1. **INCLUSION CRITERIA** Participants included children diagnosed with CP by a pediatric neurologist, based on their medical history and brain MRI. Eligible participants were classified under levels I, II, or III of the Gross Motor Function Classification System (GMFCS) and were cognitively and cooperatively capable of undergoing all required measurements. Other inclusion criteria were the absence of any psychiatric or neurological disorders apart from CP, voluntary participation with signed consent, and an age range of 7-12 years (middle childhood). All children were evaluated using the Child Behavior Checklist for ages 6-18 and had an IQ within the average range (90-109).
2. **EXCLUSION CRITERIA** Exclusion criteria included the following: recent surgery within the past year, previous participation in a PNF exercise group within six months, and the presence of unrelated neurological or orthopedic conditions. All participants underwent a basic assessment and were randomly allocated to two groups: Group A, which received conventional therapy along with chest PNF, and Group B, which received conventional therapy only. Baseline measurements were recorded before starting the intervention.

INTERVENTION

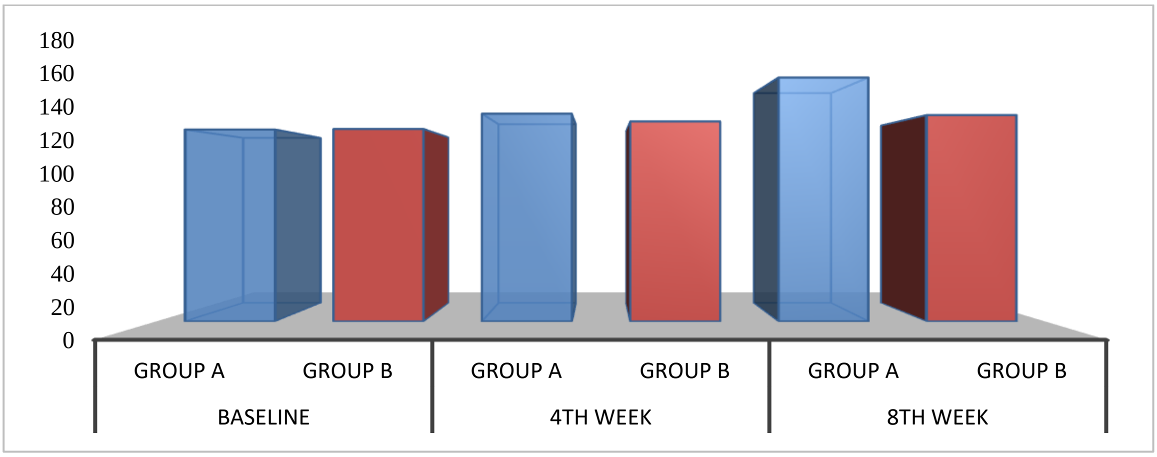
GROUP A - Participants in this group attended 60-minute sessions, three times per week, for a total of 24 sessions over 8 weeks. This program included 30 minutes of PNF exercises in addition to the exercises provided to Group B.
Intercostal stretch: Firm downward pressure was applied along the upper edges of the ribs bilaterally using the therapist's fingers. The pressure was applied during expiration and maintained as the patient continued to breathe. This stretch was applied for 10 breaths at the 2nd, 3rd, 4th, 5th, and 6th intercostal spaces on both sides.
Vertebral pressure high: While the patient lay in a supine position, the therapist applied firm manual pressure over the T2-T5 thoracic vertebrae. This stretch was performed three times, with the pressure maintained for five breaths.
Anterior stretch by posterior basal lift: The therapist placed their hands bilaterally around the lower ribs of the patient and applied a gentle upward lift. This stretch was performed three times, with the position maintained for five breaths.
Group B [Conventional Therapy] - Participants in Group B performed standard exercises, which included pursed-lip breathing, relaxed diaphragmatic breathing, and thoracic mobility exercises. Baseline

measurements for both groups were taken prior to the intervention. Data was subsequently collected at three intervals: baseline, the 4th week, and the 8th week.

DATA ANALYSIS AND RESULTS

Table 1 Comparison PEFR between the group A AND B.

Between the groups	groups	Mean	Std. Deviation	t-value	p-value
Baseline	Group A	130.81	17.26	0.068	0.946
	Group B	131.19	13.90		
4th Week	Group A	141.62	16.83	0.994	0.328
	Group B	136.31	13.17		
8th Week	Group A	166.25	13.59	5.31	0.001*
	Group B	140.62	13.68		

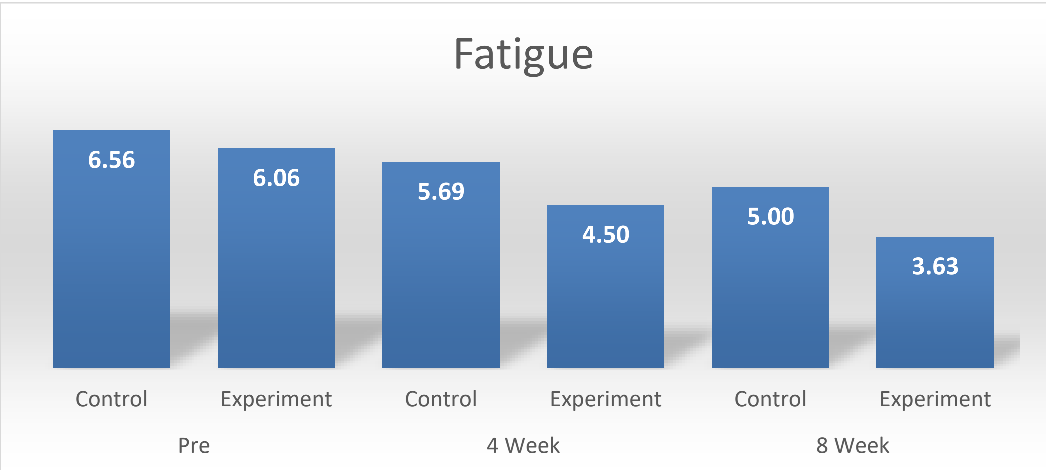


The table 2 compares the means and standard deviations of a measurement between Group A and Group B at three different time points: Baseline, 4th Week, and 8th Week. At the 8th Week, PEFR value of Group A's mean increases to 166.25 (SD = 13.59) compared to Group B's mean of 140.63 (SD = 13.68), with a t-value of 5.31 and a p-value of 0.001, indicating a statistically significant difference between the groups at this time point.

Table.2. Comparison of fatigue score between the groups

Fatigue	Groups	Mean	Std. Deviation	t-value	p-value
Pre	Control	6.56	1.26	1.28	0.212^NS
	Experiment	6.06	0.93		
4 Week	Control	5.69	1.20	3.39	0.002*
	Experiment	4.50	0.73		
8 Week	Control	5.00	1.10	4.04	0.001*
	Experiment	3.63	0.81		

NS=Not Significant *=Significant at 0.05 level



The table 3 compares the means and standard deviations of fatigue between Group A and Group B at three different time points: Baseline, 4th Week, and 8th Week. At the 8th Week, PEFR value of Group A's mean decreases to 3.63compared to Group B's mean of 5.00with a t-value of 4.04 and a p-value of 0.001, indicating Significant difference was found between the groups in terms of fatigue from baseline to 8 weeks.

DISCUSSION

The findings of this study indicate that an eight-week exercise program can have a positive impact on reducing fatigue levels in ambulatory children with spastic CP. Proprioceptive Neuromuscular Facilitation (PNF) exercises have been shown to lower fatigue in children with spastic cerebral palsy [Currow et al., 2009][8].

PNF involves a low-impact exercise regimen aimed at strengthening targeted muscle groups without overexerting the body. It highlights the importance of utilizing muscles without unnecessary stress on the joints and strengthens the connection between the mind and body by coordinating movement with breathing. This approach is particularly beneficial for children who experience chronic fatigue [Saether et al., 2010][9].

PNF is effective in improving neuromuscular coordination and muscle balance, helping to achieve optimal strength. The beneficial impact of this intervention on fatigue can be attributed to three key elements: breathing exercises, exercises to improve ribcage mobility, and strengthening of the lumbopelvic region. First, PNF strengthens the intercostal muscles, enabling a more efficient ribcage movement pattern. Second, enhanced flexibility allows for greater efficiency in ribcage motion. Finally, strengthening exercises improve the functionality of intercostal muscles and lung capacity. These improvements collectively enhance ventilation efficiency, leading to better oxygenation of blood, improved local circulation, increased muscle oxidative capacity, and reduced energy expenditure [Bertoli et al., 2010][10].

PNF exercises have proven to be an effective method for enhancing physical endurance, mobility, respiratory muscle strength, and overall quality of life. They also contribute to a reduction in fatigue levels. By improving stamina and respiratory efficiency, these exercises offer a holistic approach to reducing exhaustion in children with spastic CP [Verschuren et al., 2017][11].

Pulmonary rehabilitation interventions typically require a minimum duration of four weeks to show meaningful effects [Chen et al., 2013][12]. In this context, respiratory PNF exercises carried out over an eight-week period have been found to improve exercise tolerance, increase chest expansion at both the nipple and xiphisternal levels, and reduce fatigue scores in children with spastic CP [Bodyw et al., 2018][13].

Kyochul Seo and Misuk Cho investigated respiratory PNF patterns in healthy young adults and observed significant improvements in pulmonary function parameters. While numerous studies have supported the efficacy of respiratory PNF in enhancing pulmonary function, a review by Gupta S. and Mishra K. concluded that PNF respiratory exercises outperform pursed-lip breathing and diaphragmatic breathing techniques.

The current study demonstrated a notable improvement in post-intervention PEFR values, highlighting the effort-dependent nature of this parameter. These results align with the findings of Mistry HM and Kamble RV (2021), who explored the immediate effects of PNF in patients with COPD. Additionally, the mean difference in PEFR observed in the present study surpassed their findings, likely due to the higher number of treatment sessions conducted in this research.

CONCLUSION

Respiratory Proprioceptive Neuromuscular Facilitation (PNF) in addition to conventional therapy is more effective in improving PEFR and reducing fatigue in children with diplegic cerebral palsy than the conventional therapy alone.

LIMITATIONS AND FUTURE SCOPE

Due to the time-constraints of a master’s research study, it was deemed valuable to consider if a short intense treatment had an immediate effect, before investigating any potential long-term benefits. This Research did not carry out a long-term follow-up after the acute initial post intervention/control follow up. Although we acknowledge this is a limitation in the study design, and future research should include more long-term follow up.

The long-term effects on pulmonary morbidity, prevention of further complication was not addressed in the current study and could be the basis of future trials.

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