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Original Article

Effects of Proprioceptive Neuromuscular Fascilitation on the Shoulder Range of Motion, Arm Circumference and Functional Performance among Children with Erb's Palsy

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ABSTRACT

Background: Children with Erb's palsy may experience persistent shoulder dysfunction, while the comparative benefits of rehabilitation approaches remain uncertain. Objective: To compare conventional physical therapy and proprioceptive neuromuscular facilitation (PNF) for shoulder range of motion, arm circumference, and functional performance. Methods: This quasi-experimental study used convenience sampling at Children Hospital, Faisalabad, Pakistan. Analyses included 41 children receiving conventional physical therapy (n = 20) or PNF (n = 21). Assessments occurred at baseline and six weeks using goniometry, circumference measurement, modified Mallet categories, and the Pediatric Arm Function Test. Exploratory comparisons used Welch's t-tests for baseline continuous measures and Fisher's exact tests with confidence intervals for categorical outcomes. Results: For each of three functional tasks, the most favorable observed category was attained by 50.0% of the conventional-therapy group and 66.7% of the PNF group, a difference of 16.7 percentage points (95% CI −12.6 to 42.4; p = 0.350). Category increases occurred in 80.0% and 95.2%, respectively (difference 15.2 percentage points; 95% CI −6.3 to 37.2; p = 0.184). Conflicting continuous-outcome summaries prevented reliable comparative interpretation. Conclusion: Favorable categorical functional changes occurred in both groups, but PNF superiority was not established. Keywords: Erb's palsy; brachial plexus birth injury; physiotherapy; proprioceptive neuromuscular facilitation; shoulder function.

INTRODUCTION

Erb's palsy is an upper brachial plexus injury involving the C5–C6 nerve roots that can compromise shoulder movement and upper-limb function from early life. In children with obstetric Erb's palsy, weakness and muscle imbalance may interfere with the development of coordinated movement and functional use of the affected arm (1). Persistent impairments can include restricted shoulder mobility, contractures, joint deformity, and differences in

limb growth, with consequences for everyday activities (2). Rehabilitation therefore needs to address both physical impairments and the child's ability to use the affected upper limb during developmentally appropriate tasks.

Conventional physical therapy is an important component of conservative rehabilitation for children with brachial plexus birth injuries. Treatment may incorporate therapeutic exercise, positioning, tactile stimulation, soft-tissue techniques, and caregiver education, with the aim of maintaining mobility and encouraging active movement and functional participation (3). Afzal and Afzal reported improvements in movement and functional performance following a combination of conventional physical therapy approaches, although recovery of shoulder external rotation remained a particular challenge (4). Similarly, Anees et al. reported improvements in upper-limb strength, range of motion, and functional abilities following a physiotherapy program in children with Erb's palsy (5). These findings support continued investigation of rehabilitation strategies, while differences in treatment content, participant characteristics, and assessment methods limit direct comparison across studies.

Several approaches have been investigated to supplement or provide alternatives to conventional rehabilitation. Okafor et al. compared electrical stimulation with conventional physiotherapy and assessed changes in movement and arm circumference over a six-week intervention period (6). However, a subsequent review of neuromuscular electrical stimulation identified variation in treatment protocols and inconsistent evidence concerning muscle-strength recovery, highlighting the need for more clearly defined comparative investigations (7). Reviews of physical rehabilitation in children with Erb's palsy and brachial plexus birth injury have likewise described potentially beneficial interventions but emphasized limitations arising from heterogeneous samples, varied outcome measures, and the quality of the available evidence (8,9). Consequently, improvement following a rehabilitation program does not, by itself, establish that the program offers greater benefit than another active treatment.

Proprioceptive neuromuscular facilitation (PNF) provides a potential approach to addressing movement limitations through coordinated movement patterns and facilitation techniques. Its clinical application extends beyond stretching to the integration of sensory input and movement practice intended to support neuromuscular control and functional performance. Nevertheless, a review of PNF in physiotherapy practice found that methodological variation and limited comparable evidence restricted firm conclusions about its effectiveness across clinical populations (10). A pilot study involving patients with subacromial impingement reported improvements in shoulder range of motion after PNF treatment, providing indirect support for investigating its application to shoulder movement limitations (11). These findings cannot be assumed to apply directly to young children with obstetric plexus injury, whose developmental abilities and underlying impairments differ from those of adult musculoskeletal populations.

PNF has also been incorporated into a rehabilitation protocol for adults undergoing surgical treatment for traumatic upper brachial plexus injury. Chagas et al. described the development of this protocol and proposed a randomized comparison with conventional physiotherapy; their publication did not establish comparative clinical effectiveness (12). Although this work provides a rationale for examining PNF in plexus rehabilitation, the differences between adult traumatic injury and pediatric obstetric injury require population-specific investigation. The literature reviewed therefore leaves uncertainty about the relative outcomes of PNF and conventional physical therapy in young children with Erb's palsy, particularly when shoulder mobility, arm circumference, and functional performance are considered together (8–10,12).

Assessment across these domains is relevant because changes in joint movement do not necessarily correspond to equivalent changes in functional use. Shoulder abduction and external rotation describe important movement limitations, arm circumference provides an additional anthropometric measure, and functional assessment addresses performance of upper-limb tasks. Previous pediatric rehabilitation studies have used movement, circumference, and functional measures to characterize treatment-associated changes, supporting a multidimensional evaluation rather than reliance on a single impairment measure (4–6). A direct comparison of the two rehabilitation approaches may therefore help clarify their relative short-term outcomes while recognizing the limitations of nonrandomized treatment allocation.

Accordingly, this quasi-experimental study aimed to compare changes in shoulder range of motion, arm circumference, and functional performance between children with Erb's palsy receiving conventional physical therapy and those receiving proprioceptive neuromuscular facilitation at Children Hospital, Faisalabad.

MATERIAL AND METHODS

A quasi-experimental study with two parallel treatment groups and preintervention and postintervention assessments was conducted at Children Hospital, Faisalabad, Pakistan. The study compared conventional physical therapy with proprioceptive neuromuscular facilitation (PNF) in children with obstetric Erb's palsy. The overall study duration was three months, and outcomes were assessed before treatment and after six successive weeks of intervention. The comparison focused on shoulder range of motion, arm circumference, and functional performance.

Children aged one month to three years of either sex, were eligible if they had a diagnosis of obstetric Erb's palsy involving the C5–C6 nerve roots and grade II or III performance on the Mallet classification at initial assessment. Children were excluded if they had upper-limb contractures or fixed deformities, a history of upper-limb fracture or surgical intervention, psychosocial problems, or inflammatory joint disease. Participants were recruited using convenience sampling and assessed against the eligibility criteria before inclusion. The study purpose and procedures were explained to their guardians, and informed consent was obtained before participation.

The sample size was set at 46 children with reference to a previous study of physiotherapy in children with Erb's palsy (5). The reported outcome analyses included 41 children: 20 in Group A and 21 in Group B. Group A received conventional physical therapy, comprising therapeutic exercise, tactile stimulation, and soft-tissue manipulation techniques. Group B received PNF using upper-limb D1 and D2 flexion and extension patterns with the basic principles of facilitation. Both groups underwent baseline assessment and reassessment following the six-week treatment period.

Data collection incorporated a universal goniometer, the modified Mallet classification, an upper-arm circumference measuring tape, and the Pediatric Arm Function Test (PAFT). Shoulder abduction and external rotation were recorded as angular measurements in degrees. Functional shoulder movements were assessed through hand-to-neck, medial rotation, and hand-to-mouth tasks. The modified Mallet classification has also been used in previous physiotherapy research involving children with Erb's palsy (4,5). The classification illustrated in the study materials distinguished hand-to-neck performance as not possible, difficult, or easy; medial rotation according to inability to perform the task or the ability to reach the S1 or T12 vertebral level; and hand-to-mouth performance according to a marked trumpet sign, partial trumpet sign, or completion with less than 40° of shoulder abduction. These categories represented progressively better task performance.

Arm circumference was measured on the affected side at a point 6 cm distal to the acromion process and recorded in inches. This anatomical measurement site has previously been used in a comparative rehabilitation study involving children with Erb's palsy (6). Circumference was evaluated separately from shoulder movement and functional performance.

The PAFT assessment form comprised unilateral and bilateral upper-limb tasks and recorded the use and functional ability of the affected arm. Functional ability was graded from 0 to 5, with 0 indicating no attempt with the tested upper limb and 5 indicating movement that appeared normal. Intermediate grades reflected differing levels of assistance, compensatory movement, coordination, and task completion. The scoring instructions distinguished spontaneous use of the affected arm from the quality of its use. For functional ability, unilateral and bilateral section scores were calculated from the relevant task ratings, and the total functional ability score was obtained by averaging the two section scores. The assessment form specified that parental presence should remain consistent between baseline and postintervention testing when a parent attended the initial assessment.

Statistical analysis was performed using SPSS version 16. Categorical variables were summarized as frequencies and percentages, while numerical variables were described using means and standard deviations. Cross-tabulations described transitions between baseline and postintervention categories for hand-to-neck, medial rotation, and hand-to-mouth performance within each group. Paired-samples t-tests were used to assess preintervention and postintervention differences within groups, and independent-samples t-tests were used for between-group comparisons. The reported analyses included shoulder abduction, external rotation, numerically coded functional movement categories, arm circumference, and the functional performance score. Within-group paired comparisons were presented with mean differences and 95% confidence intervals. Tests were two-sided, and a p-value below 0.05 was considered statistically significant.

Permission to conduct the study was obtained from the head of the department. Participation was voluntary, and the consent form stated that participation could be discontinued without providing a reason. Guardians received an explanation of the study's purpose and procedures before consenting to their child's participation. Participants' personal information was kept confidential.

RESULTS

The analyses included 41 children, comprising 20 in the conventional physical therapy group and 21 in the PNF group. The largest age category in both groups was 1.5–2.0 years, accounting for 11 children in each group (55.0% and 52.4%, respectively; Table 1). Mean age was 2.17 ± 0.52 years in the conventional physical therapy group and 2.25 ± 0.52 years in the PNF group. Baseline between-group differences were 0.08 years for age (95% CI −0.24 to 0.41; p = 0.607), −0.08° for shoulder abduction (95% CI −13.68 to 13.51; p = 0.990), and 0.06 inches for arm circumference (95% CI −0.27 to 0.39; p = 0.716; Table 2).

At baseline, no child in either group demonstrated easy hand-to-neck performance, medial rotation reaching T12, or hand-to-mouth performance with less than 40° of abduction. At six weeks, each of these categories was attained by 10 children receiving conventional physical therapy (50.0%) and 14 receiving PNF (66.7%; Table 3). For each endpoint, the between-group difference was 16.7 percentage points (95% CI −12.6 to 42.4; p = 0.350; Table 4).

Table 1. Age distribution by treatment group

Age, years	Conventional physical therapy, n (%)	PNF, n (%)
1.5–2.0	11 (55.0)	11 (52.4)
2.1–2.5	6 (30.0)	3 (14.3)
2.6–3.0	3 (15.0)	7 (33.3)
Total	20 (100.0)	21 (100.0)

PNF, proprioceptive neuromuscular facilitation. Percentage denominators: conventional physical therapy, 20; PNF, 21.

Table 2. Baseline age, shoulder abduction, and arm circumference

Variable	Conventional physical therapy, mean ± SD (n = 20)	PNF, mean ± SD (n = 21)	Mean difference	95% CI	p-value
Age, years	2.17 ± 0.52	2.25 ± 0.52	0.08	−0.24 to 0.41	0.607
Shoulder abduction, °	49.70 ± 23.11	49.62 ± 19.63	−0.08	−13.68 to 13.51	0.990
Arm circumference, inches	4.77 ± 0.55	4.83 ± 0.50	0.06	−0.27 to 0.39	0.716

SD, standard deviation; CI, confidence interval; PNF, proprioceptive neuromuscular facilitation. Mean differences represent PNF minus conventional physical therapy. Confidence intervals and two-sided p-values were calculated using Welch's independent-samples t-test.

Table 3. Functional shoulder categories at baseline and six weeks

Outcome	Category	Conventional physical therapy: baseline, n (%)	Conventional physical therapy: six weeks, n (%)	PNF: baseline, n (%)	PNF: six weeks, n (%)
Hand-to-neck	Not possible	6 (30.0)	0 (0.0)	6 (28.6)	0 (0.0)
Hand-to-neck	Difficult	14 (70.0)	10 (50.0)	15 (71.4)	7 (33.3)
Hand-to-neck	Easy	0 (0.0)	10 (50.0)	0 (0.0)	14 (66.7)
Medial rotation	Not possible	6 (30.0)	0 (0.0)	6 (28.6)	0 (0.0)
Medial rotation	S1	14 (70.0)	10 (50.0)	15 (71.4)	7 (33.3)
Medial rotation	T12	0 (0.0)	10 (50.0)	0 (0.0)	14 (66.7)
Hand-to-mouth	Marked trumpet sign	6 (30.0)	0 (0.0)	6 (28.6)	0 (0.0)
Hand-to-mouth	Partial trumpet sign	14 (70.0)	10 (50.0)	15 (71.4)	7 (33.3)
Hand-to-mouth	<40° abduction	0 (0.0)	10 (50.0)	0 (0.0)	14 (66.7)

PNF, proprioceptive neuromuscular facilitation. Percentage denominators at both assessments: conventional physical therapy, 20; PNF, 21. S1 and T12 denote the vertebral levels reached during medial rotation.

Table 4. Between-group comparisons of functional category attainment at six weeks

Outcome	Endpoint	Conventional physical therapy, n (%)	PNF, n (%)	Difference, percentage points	95% CI, percentage points	p-value
Hand-to-neck	Easy	10 (50.0)	14 (66.7)	16.7	−12.6 to 42.4	0.350
Medial rotation	T12	10 (50.0)	14 (66.7)	16.7	−12.6 to 42.4	0.350
Hand-to-mouth	<40° abduction	10 (50.0)	14 (66.7)	16.7	−12.6 to 42.4	0.350

CI, confidence interval; PNF, proprioceptive neuromuscular facilitation. Percentage denominators: conventional physical therapy, 20; PNF, 21. Differences represent PNF minus conventional physical therapy. Confidence intervals use the Newcombe method based on Wilson score intervals for independent proportions. Two-sided p-values use Fisher's exact test, comparing attainment versus nonattainment of each endpoint. P-values are unadjusted for multiple comparisons.

Table 5. Within-participant functional category transitions over six weeks

Outcome	Transition	Conventional physical therapy, n (%)	PNF, n (%)
Hand-to-neck	≥1-category increase	16 (80.0)	20 (95.2)
Hand-to-neck	No category change	4 (20.0)	1 (4.8)
Hand-to-neck	≥1-category decrease	0 (0.0)	0 (0.0)
Medial rotation	≥1-category increase	16 (80.0)	20 (95.2)
Medial rotation	No category change	4 (20.0)	1 (4.8)
Medial rotation	≥1-category decrease	0 (0.0)	0 (0.0)
Hand-to-mouth	≥1-category increase	16 (80.0)	20 (95.2)
Hand-to-mouth	No category change	4 (20.0)	1 (4.8)
Hand-to-mouth	≥1-category decrease	0 (0.0)	0 (0.0)

PNF, proprioceptive neuromuscular facilitation. Percentage denominators: conventional physical therapy, 20; PNF, 21. Category order follows Table 3, with increasing categories representing better task performance.

Table 6. Between-group comparisons of functional category increases

Outcome	Difference in ≥1-category increase, percentage points	95% CI, percentage points	p-value
Hand-to-neck	15.2	−6.3 to 37.2	0.184
Medial rotation	15.2	−6.3 to 37.2	0.184
Hand-to-mouth	15.2	−6.3 to 37.2	0.184

CI, confidence interval. Differences represent PNF minus conventional physical therapy. Confidence intervals use the Newcombe method based on Wilson score intervals for independent proportions. Two-sided p-values use Fisher's exact test, comparing a category increase versus no increase. P-values are unadjusted for multiple comparisons.

For each of the three functional tasks, an increase of at least one category occurred in 16 children in the conventional physical therapy group (80.0%) and 20 in the PNF group (95.2%). Four children receiving conventional physical therapy and one receiving PNF remained in the same category; no category decreases were recorded (Table 5). The between-group difference in the proportion showing a category increase was 15.2 percentage points for each task (95% CI −6.3 to 37.2; p = 0.184; Table 6). Although the proportions numerically favored PNF, the confidence intervals included differences in either direction.

DISCUSSION

Both conventional physical therapy and proprioceptive neuromuscular facilitation were associated with favorable shifts in categorical shoulder function over the six-week assessment period. Although a greater proportion of children receiving PNF attained the more favorable functional categories, the between-group comparisons did not establish a clear advantage for either intervention. These findings provide a cautious response to the study objective: functional changes were observed in both groups, but comparative superiority was not demonstrated. The conflicting continuous-outcome summaries also prevent a reliable interpretation of the full comparison involving shoulder range of motion, arm circumference, and overall functional performance.

The functional changes observed with conventional physical therapy are consistent with previous reports describing gains following rehabilitation in children with Erb's palsy. Afzal and Afzal reported improvements following a combination of conventional treatment approaches, while identifying external rotation as a persistent rehabilitation challenge (4). Anees et al. likewise described gains in upper-limb strength, movement, and functional

ability following physiotherapy (5). These reports support the possibility of functional progress during rehabilitation, but differences in participant age, intervention content, treatment duration, and assessment methods limit direct comparison with the present study. Improvement within either treatment group should therefore be distinguished from evidence that one approach provides greater benefit than another.

Comparative pediatric rehabilitation research has also examined interventions beyond the approaches evaluated here. Okafor et al. reported favorable outcomes with electrical stimulation relative to conventional physiotherapy, using movement and circumference assessments over six weeks (6). However, a review of neuromuscular electrical stimulation identified inconsistent findings for strength and substantial variation in treatment protocols and patient characteristics (7). Broader reviews of rehabilitation for children with Erb's palsy and brachial plexus birth injury similarly highlight heterogeneity and limitations in the available evidence (8,9). The present findings fit within this uncertain evidence base: numerical differences between rehabilitation approaches require consideration alongside their precision, the comparability of treatment groups, and the reliability of outcome measurement.

PNF offers a plausible framework for encouraging coordinated upper-limb movement through patterned activity and sensory facilitation. Repeated practice, therapist contact, and movement guidance could contribute to improved task execution, while conventional exercise and tactile stimulation may provide overlapping opportunities for motor practice (3,10). These shared components could partly explain why favorable categorical transitions occurred in both groups. Nevertheless, the study did not measure neural adaptation, muscle activation, or treatment-specific physiological mechanisms. Functional category changes cannot establish nerve regeneration or identify which intervention component contributed to the observed progress.

Evidence from other clinical populations provides indirect support for investigating PNF but does not resolve its comparative effectiveness in pediatric obstetric palsy. Olędzka and Jaczewska-Bogacka reported increased shoulder mobility following PNF in patients with subacromial impingement, a population differing substantially from young children with peripheral nerve injury (11). Chagas et al. developed a PNF protocol for adults undergoing treatment for traumatic upper brachial plexus injury, but their publication described protocol development rather than completed evidence of treatment superiority (12). Differences in developmental capacity, injury mechanism, surgical history, and treatment exposure restrict extrapolation from these studies. Accordingly, they support the rationale for investigation rather than confirmation of the present numerical pattern.

From a clinical perspective, the categorical findings suggest that changes in practical shoulder tasks can occur during either rehabilitation program. However, the confidence intervals around the comparative estimates included differences favoring either group. The absence of a statistically clear difference does not demonstrate equivalence, and the numerical advantage observed with PNF does not establish clinically important superiority. Reviews of pediatric plexus rehabilitation emphasize the need to consider multiple dimensions of recovery and the limitations of the underlying evidence (8,9). In this study, categorical task performance provides only part of that assessment, and the findings do not justify preferring PNF on the basis of demonstrated comparative effectiveness.

The study has several useful features, including an active treatment comparator, repeated assessment of the same children, and evaluation of functional tasks relevant to shoulder use. The transition tables permit examination of individual movement between ordered categories rather than reliance solely on group averages. Nevertheless, the quasi-experimental design and convenience sampling leave the comparison vulnerable to selection bias and confounding. Treatment allocation was insufficiently described, and information concerning previous therapy, baseline clinical severity, treatment adherence, and assessor blinding was limited. Similar baseline values for selected characteristics do not exclude imbalance in other prognostic factors.

The small analyzed sample further limits precision, while the discrepancy between the stated sample of 46 children and the 41 represented in the analyses leaves participant accounting unresolved. Developmental maturation and the natural course of recovery may contribute to within-group changes, particularly in a pediatric condition for which recovery varies across children (1,3). Without adequate control of these influences, the observed changes cannot be attributed exclusively to either intervention. The six-week assessment period also provides no evidence concerning persistence of functional gains.

Measurement and reporting limitations materially affect interpretation. The three categorical outcomes show identical transition patterns, and their correspondence with the conflicting numerical score summaries requires

verification. The exploratory analyses of category attainment and category increase were not identified as prespecified outcomes, and they do not provide independent replication across the three tasks. In addition, developmental differences may influence performance on functional tasks, and the manuscript does not adequately describe how these differences were handled. Most importantly, contradictory continuous measurements and statistical summaries prevent dependable conclusions about comparative changes in angular ROM, circumference, and the overall functional score. These limitations constrain the study to a cautious description of the recoverable functional findings rather than a definitive evaluation of relative treatment effectiveness.

CONCLUSION

Over six weeks, favorable changes in categorical shoulder function were observed among children with Erb's palsy receiving either conventional physical therapy or PNF. Although the observed proportions numerically favored PNF, the between-group estimates did not establish superiority. Inconsistencies in the continuous-outcome reporting prevented a reliable conclusion regarding comparative changes in shoulder range of motion, arm circumference, and overall functional performance; therefore, the available findings do not support a clinical preference for either intervention.

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