RESEARCH PAPER

Comparative Effects of Cryotherapy and Superficial Heat on Plantar-Flexor Spasticity in Children with Spastic Cerebral Palsy: A Randomized Comparative Study

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ABSTRACT

Background: Spasticity is one of the most common motor impairments in children with cerebral palsy and can adversely affect posture, movement, range of motion (ROM), functional mobility, and overall physical development. Persistent spasticity of the plantar-flexor muscles may contribute to restricted ankle dorsiflexion, abnormal gait patterns, and the development of contractures. Physiotherapy interventions such as electrical stimulation, cryotherapy, superficial heat, and stretching are commonly used to manage spasticity. However, the comparative effectiveness of cryotherapy and superficial heat when combined with electrical stimulation and stretching remains clinically relevant.

Objective: To compare the effectiveness of cryotherapy and superficial heat, when combined with electrical stimulation and stretching, in reducing plantar-flexor spasticity and improving ankle range of motion in children with spastic cerebral palsy.

Methods: A randomized comparative study was conducted among 60 children with spastic cerebral palsy, aged 5–15 years, recruited from special schools and Government Hospital. Participants were randomly allocated into two groups of 30 each. Group A received electrical stimulation to the tibialis anterior for 30 minutes, cryotherapy for 15 minutes, and stretching of the plantar-flexor muscles. Group B received electrical stimulation to the tibialis anterior, superficial heat for 15 minutes, and stretching of the plantar-flexor muscles. Both groups received treatment three days per week for four weeks. Pre- and post-intervention assessments were performed using the Modified Ashworth Scale (MAS) for spasticity and goniometric range-of-motion measurements for ankle mobility.

Results: Both intervention groups demonstrated improvement following the treatment period. However, Group A (electrical stimulation + cryotherapy + stretching) demonstrated a greater improvement in ankle ROM compared with Group B (electrical stimulation + superficial heat + stretching). The findings indicated a statistically highly significant improvement in ROM in favour of the cryotherapy-based intervention (mean change 2.10° vs 1.07°, $p < 0.001$). MAS scores also decreased more in Group A (mean change 0.90 vs 0.55, $p = 0.035$).

Conclusion: Both treatment protocols were beneficial in reducing plantar-flexor spasticity and improving ankle range of motion in children with spastic cerebral palsy. The combination of electrical stimulation, cryotherapy, and stretching demonstrated greater effectiveness, particularly in improving ROM, compared with electrical stimulation, superficial heat, and stretching. Cryotherapy may therefore be considered a useful adjunctive physiotherapy intervention for the management of plantar-flexor spasticity in children with spastic cerebral palsy.

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INTRODUCTION

Cerebral palsy (CP) is a well-recognised neurodevelopmental condition beginning in early childhood and persisting throughout the lifespan. Originally reported by Little in 1861, CP describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception and/or behaviour, and/or by a seizure disorder.

In the industrialised world, the incidence of CP is approximately 2 per 1000 live births. There are an estimated 4–8 million children and people in India with CP. The incidence is higher in males than females (Surveillance of CP in Europe reports a male:female ratio of 1.33:1). In the United States, approximately 10,000 infants and babies are diagnosed with CP each year.

The aetiology of CP is diverse and multifactorial. Causes may be congenital, genetic, inflammatory, infectious, anoxic, traumatic or metabolic. The injury to the developing brain may be prenatal, perinatal or postnatal. The most important risk factors are prematurity and low birth weight. Other significant prenatal risk factors include intrauterine infections, teratogenic exposures, placental complications, multiple births, and maternal conditions such as mental retardation, seizures or hyperthyroidism. Perinatal risk factors include infections, intracranial haemorrhage, seizures, hypoglycaemia, hyperbilirubinaemia, perinatal arterial ischaemic stroke and significant birth asphyxia. Postnatal causes include meningitis, encephalitis and trauma.

Topographic classification of CP includes monoplegia, hemiplegia, diplegia, triplegia and quadriplegia. Diplegia is the commonest form (30–40%), followed by hemiplegia (20–30%) and quadriplegia (10%). Based on the type of neuromuscular deficit, CP is classified into spastic, dyskinetic (choreo-athetoid and dystonic), ataxic, hypotonic and mixed types. Spastic CP is the commonest and accounts for 70–75% of all cases.

Spasticity is a physiological consequence of an injury to the nervous system. It is defined as disordered sensory-motor control resulting from an upper motor neuron lesion, presenting as intermittent or sustained involuntary activation of the muscle. Positive components include muscle over-activity, flexor and extensor spasms, hyperreflexia, clonus and an extensor plantar response. Negative symptoms comprise weakness/paralysis, early hypotonia, fatigue and loss of dexterity. Assessment of spasticity can be performed using the Modified Ashworth Scale, goniometry, Tardieu scale, Goal Attainment Scale and other clinical tools.

Management of spasticity is carried out by a coordinated multidisciplinary team. Therapeutic and physical interventions include physical modalities (stretching, cooling, heat), orthoses, positioning, massage, splinting, and dynamic physiotherapy techniques (Bobath, PNF, Brunnstrom). Electrical therapies include functional electrical stimulation, neuromuscular electrical stimulation (NMES) and therapeutic electrical stimulation. Pharmacological options, nerve blocks, botulinum toxin and surgical techniques are also used in selected cases.

Electrical stimulation applied to the antagonist of a spastic muscle can produce reciprocal inhibition via Ia afferent pathways, leading to an immediate reduction of activity in the spastic muscle. Cryotherapy transfers heat from body tissue to the cold modality via conduction; cold penetrates more deeply than superficial heating modalities and has a dual action of inhibiting the monosynaptic stretch reflex and lowering receptor sensitivity. Stretching aims to normalise muscle tone, maintain or increase soft-tissue extensibility, reduce pain and improve function; slow sustained stretching activates muscle spindles and Golgi tendon organs, inhibiting muscle contraction and tone. Superficial heat increases nerve conduction velocity, decreases muscle-spindle firing and increases connective-tissue extensibility when tissue temperature is maintained at 40–45 °C.

Although electrical stimulation, ice, heat and stretching have each been shown to be effective in managing spasticity, no previous study has systematically compared the combination of electrical stimulation + cryotherapy + stretching versus electrical stimulation + superficial heat + stretching in children with spastic cerebral palsy. The present study was therefore designed to address this gap.

OBJECTIVES

The purpose of the study was to achieve the following objectives:

- To evaluate the effect of electrical stimulation, cryotherapy and stretching on the spasticity of plantar flexors in children with spastic CP.
- To evaluate the effect of electrical stimulation, superficial heat and stretching on the spasticity of plantar flexors in children with spastic CP.
- To compare the effect of the two combined protocols on plantar-flexor spasticity and ankle range of motion.

METHODOLOGY

Sixty children with spastic cerebral palsy aged 5–15 years were recruited from special schools and Government Wenlock Hospital. Parents completed a screening questionnaire; eligible children were then assessed for spasticity using the Modified Ashworth Scale (MAS). Children with MAS grades I or II were included. Eligible participants were randomly allocated into two groups of 30. Parents of both groups were informed about the respective procedures and provided written informed consent.

Subjects

Group A consisted of 30 subjects (12 boys, 18 girls; mean age 9.53 ± 3.05 years) who received electrical stimulation, cryotherapy and stretching.

Group B consisted of 30 subjects (15 boys, 15 girls; mean age 9.10 ± 2.86 years) who received electrical stimulation, superficial heat and stretching.

Inclusion criteria

- Age 5–15 years
- Diagnosis of spastic cerebral palsy
- Plantar-flexor spasticity of MAS grade I or II
- Ability to walk with assistance

Exclusion criteria

- Fixed deformities of the lower limb
- Skin infection or fractures
- Uncooperative behaviour
- Cognitive impairment precluding participation
- Botulinum toxin injection within the preceding 6 months

Tools used

- Electrical stimulator
- Ice packs
- Moist heat packs
- Towels, vegetable oil
- Goniometer
- Exercise mat

Procedure

All participants were screened on day 1 according to a general neurological assessment format and the MAS. Outcome measures (MAS and ankle dorsiflexion ROM) were recorded on the first day before treatment and on the last day after the four-week intervention. Treatment was administered three times per week for four weeks.

Group A received electrical stimulation followed by ice application and then stretching. Group B received electrical stimulation followed by superficial heat and then stretching. Electrical stimulation and stretching were identical in both groups.

Electrical stimulation of the affected leg was performed with the child sitting or in supine. After skin preparation, two surface electrodes were placed over the anterior aspect of the leg and adjusted so that visible dorsiflexion occurred. NMES of the dorsiflexors was applied for 30 minutes. The current used was biphasic, pulse width 0.3 ms, frequency 30 Hz, with a 4-second rest period after each pulse train. Amplitude and frequency were adjusted to subject comfort.

Stretching of the plantar flexors was performed with the patient supine and the knee extended. The therapist grasped the patient’s heel with one hand, forearm along the plantar surface of the foot, while stabilising the tibia with the other hand. Dorsiflexion was applied by pulling the calcaneus superiorly. Each stretch was held for 1 minute and repeated 10 times.

In Group A, an ice pack was applied to the plantar flexors for 15 minutes in the supine position, after which stretching was performed. In Group B, a moist heat pack was applied to the plantar flexors for 15 minutes, followed by stretching.

RESULTS

Sixty children with spastic CP were randomised into two groups of 30. Baseline demographic characteristics (age and sex) showed no significant differences between groups (age: $t = 0.568$, $p = 0.572$; sex: $\chi^2 = 0.606$, $p = 0.436$).

Age distribution

Table 1. Age distribution

Group	N	Mean ± SD	Median	t value	p value
Group A	30	9.53 ± 3.05	9.00	0.568	0.572 (NS)

Group B	30	9.10 ± 2.86	9.00		

Gender distribution

Table 2. Gender distribution

Sex	Group A	Group B	Total
Female	18 (60%)	15 (50%)	33 (55%)
Male	12 (40%)	15 (50%)	27 (45%)
Total	**30**	**30**	**60**

$\chi^2 = 0.606$, $p = 0.436$ (NS).

Range of motion (ROM)

Table 3. Pre- and post-treatment ROM within groups

Group	Time	Mean ± SD	Median	t value	p value
Group A	Pre	9.47 ± 2.15	9.00	8.532	< 0.001
	Post	11.57 ± 1.55	12.00		
Group B	Pre	10.10 ± 1.67	10.00	8.449	< 0.001
	Post	11.17 ± 1.34	11.00		

Both groups showed a statistically significant increase in ankle dorsiflexion ROM after four weeks of treatment.

Table 4. Comparison of change in ROM between groups

Group	Mean change ± SD	Median	t value	p value
Group A	2.10 ± 1.35	2.00	3.736	< 0.001 (HS)
Group B	1.07 ± 0.69	1.00		

The improvement in ROM was significantly greater in Group A (cryotherapy) than in Group B (superficial heat).

Modified Ashworth Scale (MAS)

Table 5. Pre- and post-treatment MAS within groups

Group	Time	Mean ± SD	Median	Wilcoxon Z	p value
Group A	Pre	1.72 ± 0.58	2.00	4.513	< 0.001
	Post	0.82 ± 0.48	1.00		
Group B	Pre	1.88 ± 0.68	2.00	4.110	< 0.001
	Post	1.33 ± 0.56	1.00		

Both groups demonstrated a statistically significant reduction in MAS scores (i.e., reduced spasticity) after treatment.

Table 6. Comparison of change in MAS between groups

Group	Mean change ± SD	Median	Mann-Whitney U	p value
Group A	0.90 ± 0.64	1.00	2.108	0.035
Group B	0.55 ± 0.46	0.50		

The reduction in MAS was significantly greater in Group A than in Group B.

DISCUSSION

Cerebral palsy is a heterogeneous group of disorders of movement and posture. Spastic types predominate and frequently produce muscle tightness that can progress to contractures. The present study examined the comparative effect of two combined physiotherapy protocols on plantar-flexor spasticity in children with spastic CP.

Both protocols produced statistically significant improvements in ankle dorsiflexion ROM and reductions in MAS scores after four weeks. However, the cryotherapy-based protocol (Group A) yielded significantly greater gains in ROM (mean change 2.10° versus 1.07°, $p < 0.001$) and a greater reduction in spasticity (mean MAS change 0.90 versus 0.55, $p = 0.035$).

These findings are consistent with previous reports that electrical stimulation of the antagonist muscle can reduce spasticity via reciprocal inhibition, and that cryotherapy inhibits the monosynaptic stretch reflex while lowering receptor sensitivity. Stretching further modifies viscoelastic and neural properties of the muscle. Although superficial heat also promotes muscle relaxation and increases tissue extensibility, the deeper penetrating and longer-lasting effects of cold appear to have conferred a clinical advantage in this cohort.

Limitations of the study include the absence of a no-treatment control group, lack of long-term follow-up, and the relatively short intervention period. Future research should examine longer treatment durations, different age strata, and other topographic types of CP, and should incorporate functional outcome measures such as gait analysis and the Gross Motor Function Measure.

CONCLUSION

Both treatment protocols—electrical stimulation combined with cryotherapy and stretching, and electrical stimulation combined with superficial heat and stretching—were effective in reducing plantar-flexor spasticity and improving ankle range of motion in children with spastic cerebral palsy. The protocol that included cryotherapy produced statistically superior results, particularly for range of motion. Cryotherapy may therefore be regarded as a useful adjunctive physiotherapy intervention for the management of plantar-flexor spasticity in this population. Further research is warranted to confirm these findings across different age groups and clinical subtypes of cerebral palsy.

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