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Effect of Cryo-Airflow Therapy on Calf Muscle Spasticity in Children with Cerebral Palsy

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Abstract

Background: Cerebral palsy, a condition that occurs in two to three out of every 1,000 live births, encompasses a variety of difficulties associated with mobility, posture, atypical walking patterns, and problems with balance. Spastic diplegic cerebral palsy, which specifically refers to a condition where there is increased muscle tone in the legs, frequently leads to challenges in walking. One common symptom of this condition is walking on tiptoes, which is caused by tightness in the calf muscles.

Objective: This study aimed to investigate the effect of cryo-airflow therapy on calf muscle spasticity in children with spastic diplegic cerebral palsy (CP). **Methods:** This study involved the participation of 40 children, comprising both males and females, aged between 6 and 12, who had been diagnosed with spastic CP. Children were evaluated using the Modified Ashworth Scale as well as the H/M ratio. The participants who met the specified criteria for inclusion were categorized into two distinct groups: group A were given cryo-airflow therapy for 10 minutes and a physical therapy program consisting of 30 minutes of physical exercises once daily, five times each week, for a duration of eight weeks and Group B were given only a physical therapy program consists of a 30-minute session of physical exercises once day, five times per week, for a duration of eight weeks. **RESULTS:** The study group had a substantial decline in calf muscle spasticity, as evidenced by a decline in spasticity grade ($p = 0.001$) as well as a 23.11% reduction in the H/M ratio ($p = 0.001$). The control group demonstrated a substantial reduction in calf muscle spasticity, as evidenced by a decline in spasticity grade ($p = 0.001$) as well as a decrease in the H/M ratio by 10.08% ($p = 0.001$). The study group experienced a substantial reduction in both spasticity grade as well as H/M ratio after treatment, in comparison to the control group ($p = 0.02$ and $p = 0.001$). **Conclusion:** The combined effect of cryotherapy and physical exercises is more effective in controlling the spasticity of calf muscles in spastic diplegic cerebral palsy children.

Keywords: Spastic Diplegia, Cerebral Palsy, Cryotherapy, physical exercises.

1. Introduction

Cerebral palsy has a prevalence of two to three cases per 1,000 live births and encompasses a variety of difficulties associated with movement, posture, atypical walking patterns, and problems with balance. [1].

CP can be classified into two physiological types: spastic, which affects the corticospinal pathways, and extrapyramidal, which impacts other areas of the developing brain. The extrapyramidal forms of CP encompass athetoid, choreiform, ataxic, rigid as well as hypotonic[2].

CP often involves motor abnormalities that are commonly accompanied by disturbances in sensation, cognition, communication, perception, behavior, in addition the occurrence of seizures[3].

Spastic diplegic CP, which has an incidence rate of 80%, is specifically characterized by leg spasticity. This condition commonly leads to difficulty in walking, with tiptoeing being a common symptom caused by tightness in the calf muscles[4]. CP is the predominant cause of physical impairment in children, leading to restricted mobility and consequently affecting their social interactions. Therefore, a main challenge in the therapy of these children is reducing the degree of spasticity.

Prior research has documented diverse therapeutic methods and techniques for the management of spasticity among children having spastic CP and other conditions involving damage to the UPPER motor neurons. These options encompass the utilization of oral neuropharmacological drugs, injectable substances like botulinum toxin, or surgical intervention. The treatment options include contracture reduction, orthosis, topical anesthetic application via diverse massage techniques, strengthening the antagonist musculature using electrical stimulation, as well as the administration of cryotherapy or ice therapy[5].

Cryotherapy can enhance muscle contraction, hence promoting improved joint mobility following an injury. Another outcome of being exposed to cold is a decrease in spasticity, which occurs over time following prolonged exposure to the cold. There are three methods to apply cold to the body: immersion in cold water, applying icy cubes or ice packs, or using evaporative sprays such as ethyl chloride[6].

Extended exposure to cold air flow therapy at -32°C can effectively lower both skin as well as joint temperature, resulting in an analgesic effect. This therapy also reduces inflammation as well as muscular spasm, leading to improved physical function as well as decreased disease activity[7].

The primary clinical measure of muscular spasticity among individuals with neurological

diseases is the Modified Ashworth Scale (MAS). Both the upper and lower body muscles can be evaluated using the MAS. Contradictory findings regarding reliability and validity are indicated by the MAS[8].

2. Material and Methods

A randomized controlled study was conducted from December 2023 to June 2024, A total of 40 children, ranging in age from 6 to 12 years old, both male and female, with a MAS score of 3 or less, will be enrolled in the study. Participants will be allocated to one of two groups, group A (study group) were given cryotherapy airflow for 10 minutes, and physical therapy program 30-minute session of physical exercises once daily, 5 times a week for a duration of eight weeks. Group B (control group) were given only a Physical therapy program 30-minute session of physical exercises once daily, 5 times a week, for a duration of eight weeks. All participants were evaluated prior to and following the study with MAS as well as the H/M ratio. The study's participants were recruited from the Deraya University outpatient clinic. The Ethical Committee of the Faculty of Physical Therapy at Deraya University in Egypt approved the study, and it was given the reference number [PT/REC/230005].

A total of fifty patients were initially recruited, however, only 40 patients were ultimately selected at random for the study. This sample size was chosen in order to conduct a power analysis with a desired power of 80% as well as an alpha level of 0.05.

The participants were assigned randomly to two groups, A as well as B, utilizing a blind process to ensure equitable distribution of participants in each group. A computer-generated randomization card was contained in sealed envelopes that were opened by an independent research assistant. The study group (A) comprised 11 males & 9 females, with an average age of 9.61± 2.39 years. The control group (B) comprised 7 males & 13 females, with an average age of 9.45 ±2.55 years.

3. Instrumentation & Procedures

3. 1- For evaluation:

(a)- Modified Ashworth's Scale:

Pretest measurements the assessment of spasticity via the MAS[9]. It entails the manual movement of the ankle joint through the entire ROM to passively stretch the calf muscle during dorsiflexion[10].

(b)- Electrophysiological Testing:

An electromyographic device, specifically the computerized Section 8 Ronald S. Bienstock EMG, Inc. Serial Number 77736183 from Great Britain, was utilized to measure the H/M ratio. Subjects were positioned in a prone posture, then the emg signals from the soleus muscle on the side affected by hemiplegia were recorded via 2 silver surface electrodes. This was achieved by stimulating the tibial nerve at the popliteal fossa.

The active electrode was positioned on the distal one-third of the soleus muscle, right below the point where the gastrocnemius muscle attaches to the Achilles tendon. The placement of the reference electrode was positioned directly above the calcaneus, approximately 6 cm along the Achilles tendon. A ground electrode was positioned on top of the fibular head as a point of reference[11]. The excitability of the motor neuron pool, which indicates the extent of spasticity as well as CNS excitability, can be measured by calculating the ratio among the maximum Hoffman reflex as well as maximum Myogenic responses via an EMG machine[12].

3. 2- For Treatment:

(a)- Cryotherapy:

The Cryo-flow 700/1000 machine, manufactured by Gymna Uniphy NV in Belgium, is a portable therapeutic device that produces precise amounts of cold air by taking air from the surrounding environment then cooling it. The patient was placed in a prone posture while a steady stream of cold air was slowly pushed over the majority of the spastic calf muscle for a duration of 10 minutes, maintaining a temperature that may reach approximately 30°C intramuscularly[13]. (figure 1)

In group (A), a 10-minute session of cryotherapy was administered, followed by a 30-minute session of targeted physical rehabilitative exercises aimed at enhancing active ankle dorsiflexion.

Fig. 1. Cryotherapy Airflow Device.

(a)- Therapeutic Exercise:

Group (B) received therapeutic exercise in the following manner: a bridging exercise was performed in a supine lying position, gliding the sole on the wall in an upward and downward motion while lying on the non-involved side, gliding the foot on the floor in a forward and backward motion while sitting on a chair with back support, stepping up and down on a block heel while standing with a straight back, then participating in homolateral limb synkinesis exercise by resisting hip flexion[14]. The exercise duration consisted of 30 minutes per session, occurring once daily, Five times weekly, throughout a duration of eight weeks.

Statistical analysis

The unpaired sample t-test was used for comparing the subject characteristics between various groups. The chi-squared test evaluated the difference in gender distribution among different groups. The Wilcoxon signed ranks test was utilized to analyze the levels of spasticity, whereas the paired sample t-test was performed to assess the H/M ratio prior to and following treatment. The Mann—Whitney U test was used to analyze the levels of spasticity, while the unpaired sample t-test was used to evaluate the H/M ratio between the groups. All statistical tests were regarded statistically substantial if the p-value was below 0.05. The Windows-based version of the Statistical Program for Social Studies (SPSS), version 25, was employed to perform all statistical analyses.

4. Results

4.1.Distribution of gender: (Table 1)

Table 1: Distribution of gender:

	Study group Group (A)	Control group Group (B)
Male	11	7
Female	9	13
Total	20	20

4.2.Age Distribution: (Table 2)

Table 2: Age Distribution:

	Study group Group (A)	Control group Group (B)
6-9 years	12	9
10- 12 years	8	11
Total	20	20

4.3.Effect of treatment on spasticity and the H/M ratio

- **Within-group comparison** Spasticity grades as well as the H/M ratio both decreased significantly between the pre- and post-therapy comparisons of the study group as well as control groups (p = 0.001). The study group experienced a 23.11% change in the H/M ratio, while the control group had a 10.08% change (p = 0.001). (Tables 3 and 4).
- **Comparison between study and control groups:** The study group exhibited a substantial reduction in spasticity grade following therapy, in comparison to the control group (p = 0.02). Following therapy, the study group had a significantly reduced H/M ratio contrasted to the control group. (p = 0.001) (Tables 3 and 4).

Table 3: Mean values of spasticity grades:

	Study group Median (IQR)	Control group Median (IQR)	*U*-value	*p*-value
Spasticity grades Pre-treatment	2 (1, 8)	2 (1.,8)	13.5	0.69
Post-treatment Z-value	1 (1, 1) –2.42 *p* = 0.001	2 (1, 5) –1.32 *p* = 0.001	63	0.02

IQR, interquartile range; *U* value, Mann—Whitney test; *Z* value, Wilcoxon signed rank test; *p*-value, level of significance.

Table 4: The mean H/M ratios

H/m ratio	Study group	Control group	MD	t-value	p-value

	mean ± SD	**mean ± SD**			
Pre-treatment	90.65±7.45	91.34±8.06	-0.69	1.36	0.31
Post-treatment	73.75±6.75	82 ± 4.01	-8.25	-4.13	0.001
MD	16.9	9.34			
% of change	23.11	10.08			
t-value	14.82	5.78			
p-value	0.001	0.001			

SD, standard deviation, MD, mean difference; *p*-value, level of significance

5. Discussion

The objective of this study was to assess the impact of Cryo-airflow therapy on the calf muscles of children having spastic diplegic CP.

The study group had a substantial reduction in calf muscle spasticity, evidenced by a decrease in the severity of spasticity grades ($p = 0.001$) as well as a reduction in H/M ratio by 23.11% ($p = 0.001$). Furthermore, the control group had a substantial decline in calf muscle spasticity, evidenced by a decline in spasticity grades.

($p = 0.001$) as well as a decline in H/M ratio by 10.08% ($p = 0.001$). The study group experienced a substantial reduction in spasticity grade as well as H/M ratio following therapy contrasted to the control group.

($p = 0.02$ and $p = 0.001$), showing that children with diplegic CP can effectively manage their spasticity with cold air therapy.

Numerous studies have been conducted to assess the impact of physiotherapy on children diagnosed with spastic CP. Research has demonstrated that engaging in physical exercise helps to restore muscle tone to a normal level[15,16].

Our results agree with (**Priya J and Ashish W. 2021)**[17] their findings indicates that the combination of cryotherapy as well as myofascial release technique, or either of these approaches individually, may lead to a substantial decrease in calf muscle spasticity among children having spastic diplegic CP.

Also, (Draper and Knight, 2012)[18] their work aligns with our findings, since they observed that when the body cools down, pain receptors in the skin decrease their signaling to the CNS, resulting in a reduction in pain.

The objective of all therapeutic techniques is to reduce the occurrence of extension reflexes. Cryotherapy diminishes the monosynaptic extension reflexes as well as decreases the sensitivity of receptors. It modifies the impact of mediators on the synapses of the reflex arc as well as blocks the neuromuscular junction or motor nerve that forms the reflex arc. This impact persists beyond the cryotherapy process.

Another study corroborates our findings, which indicated that cold application can suppress the activity of gamma motoneurons in the muscles while enhancing the activity of alpha motoneurons. Muscle spasticity is reduced when the overall impact of gamma inhibition is greater than the excitement of alpha motoneurons[19].

Several studies have demonstrated that cryo-airflow therapy is highly beneficial in managing spasticity, as it provides a consistent, prolonged, and profound cooling impact[20]. The integration of cryotherapy as well as wrapping techniques is employed to diminish lower limb spasticity among children having hemiplegic CP[21]. For another study, a total of 30 individuals diagnosed with spastic diplegic CP were selected and divided into three categories, with each category consisting of 10 individuals. Group A got cryotherapy, Group B got MFR, as well as Group C got a combination of cryotherapy as well as MFR. Both pre- and post-therapy, muscle tone and joint ROM are evaluated using MAS as well as goniometry to determine calf muscle spasticity as well as ankle PROM. Intra-group comparison revealed a substantial decrease in spasticity as well as improvement in ROM ($p<0.05$). The findings of this study found that the

combined effect of cryotherapy as well as MFR is beneficial in reducing stiffness in the calf muscles among children suffering spastic diplegic CP[22].

The outcomes of this research are in line with those of a previous study (Mostafa MS, et al, 2021)[23] that examined the effects of long-term versus short-term ice application on reducing spasticity among children having spastic hemiplegic CP. The researchers employed the MAS to measure muscle tone prior to and following the treatment period.

Kinematic gait analysis (3D motion analysis) was carried out before and after the interventions to determine the kinematic gait parameters, they found that cadence, wrist flexors, and ankle plantar flexors spasticity decreased significantly after treatment compared with the pre-treatment condition with prolonged cold application group[23].

Our results contradict with (Ehsan Tasoujian, and Sayed)[24] Research has shown that including massage therapy as well as cryotherapy into the physiotherapy along with occupational therapy program enhances the ROM in the upper extremities of spastic children aged 7-12 years. However, it does not have a positive impact on reducing spasticity in these children.

Conclusion

The combined effect of cryotherapy along with physical exercises is more effective in controlling the spasticity of calf muscles in spastic diplegic cerebral palsy children**.**

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