PROLONGED VERSUS BRIEF ICE APPLICATION FOR SPASTICITY MODULATION IN CHILDREN WITH SPASTIC HEMIPLEGIC CEREBRAL PALSY (A RANDOMIZED CONTROLLED TRIAL)

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ABSTRACT

Ice application has thought to reduce spasticity presented in upper motor neuron lesions in children and adults. Objectives was investigate the effect of prolonged ice application on the spastic muscle versus brief ice application on the antagonist muscles on the degree of muscle spasticity and kinematic gait parameters in children with spastic hemiplegic cerebral palsy (CP). Thirty children with spastic hemiplegic CP participated in this study. They were randomly assigned into two equal groups. Group A involved 15 children who received cryotherapy (ice pack) to the spastic muscles (calf muscles and wrist flexors) for 20 successive minutes. Group B involved 15 children who received cryotherapy (ice pack) to the antagonist muscles for the antispastic muscles (dorsiflexors and wrist extensors) for 10 seconds/20 seconds for 10 minutes. The study continued for two successive months for each child. The Modified Ashworth Scale was used for assessing the muscle tone before and after the treatment period. Kinematic gait analysis (3D motion analysis) was carried out before and after the interventions to assess the kinematic gait parameters. Mixed design Multivariate Analysis of Variance (MANOVA) revealed that stride length, speed, and ankle joint angle at initial contact increased significantly (p<0.05) while the cadence, wrist flexors and ankle plantar flexors spasticity decreased significantly after treatment compared with the pre-treatment condition for patients within group A, while patients within group B showed non-significant improvements. By comparing the post-treatment values of all the measured variables between both groups, the tests revealed significant effects in all the measured variables for the favor of group A. In conclusion, Prolonged cryotherapy application to the spastic muscles is more effective than brief cryotherapy application to the antagonist muscles in reducing muscle spasticity and improving gait pattern in children with spastic hemiplegic cerebral palsy.

Keywords:Cerebral Palsy, Spasticity, Hemiplegia, Cryotherapy, 3D Motion Analysis.

I. INTRODUCTION

Cerebral palsy (CP), the most common reason of disability for children, is a group of motor and posture disturbances caused by non-progressive brain damage [1]. Cerebral paralysis has a constant movement and postural dysfunction because of brain damage that ranges from 1.7 to 3 births per 1000 births[2]. The hemiplegic CP influences motion and muscle tones on either side of the body, although the body's opposite side can also be slightly affected [3]. It is the commonest type of CP with an estimated 33-39% of all CP patients[4].

In children with hemiplegic CP, spasticity is the prevalent clinical disability symptom that is progressed with motor growth over time [5, 6]. This symptom affects the growth of motor skills and functional skills [7]. Spastic cerebral paralysis is characterized by tight, rigid, and weak muscles which make it more difficult to control
movement. It represented in about 70% of the affected children \[7\] and considered as the most common form of brain paralysis. \[8\]

The temperature affects both the biological and neurophysiological processes. Lower temperatures cause slow nerve conduction velocity (NCV), high muscle and nerve potential amplitudes, slow and weak musculoskeletal contraction in addition to the enhancement of the neuromuscular transmission \[9\].

Cryotherapy techniques are usually used to relieve spasticity and the muscle clone. Miglietta \[10\] proved that, after 30 minutes of cold application, the clonus was disappeared in 35 of 40 spastic patients. The researcher mentioned that the triceps surae muscles themselves were cooled \[10\]. He reported also that all clonus was re-appeared after 90 minutes. Ottoson \[11\] reported a reduced sensitivity of the muscle spindle when the muscle was cooled down from 32°C to 3°C \[11\].

Not only changes in the signals of the muscle spindles inside the specific muscle can affect the strength of a muscle contraction, but also changes in the feedback from the skin overlying the muscle and the joints around which the muscle operates. \[12\] Cooling for long time of skin area with ice has shown to modify the temperature of the underneath muscle \[13\]. Quick icing is however used in clinical settings often as a facilitative strategy, with two or three ice hits on the skin overlying the muscle belly. Physiotherapists verbal reports show that this technique is used as it is quick, safe and efficient to produce increased muscle contraction \[14\].

There were limited researches studying the effects of prolonged versus brief ice application techniques on spasticity and gait pattern in children with spastic hemiplegic CP. So, the current study was conducted to investigate the effect of prolonged ice application on the spastic wrist flexors and ankle planter flexors versus brief ice application on the antispastic muscles of the wrist and ankle joints (wrist extensors and ankle dorsiflexors) on the degree of muscle spasticity and kinematic gait parameters in children with spastic hemiplegic CP.

II. MATERIALS AND METHODS

An experimental study (pre-test post-test randomized controlled trial) was conducted to assess the effect of prolonged ice application on the spastic wrist flexors and ankle planter flexors versus brief ice application on the antispastic muscles of the wrist and ankle joints (wrist extensors and ankle dorsiflexors) on the degree of muscle spasticity and gait parameters in children with spastic hemiplegic CP. All patients participated in this study were randomly assigned into two groups (Group A and group B). The procedures followed agreed with the Institutional Ethical Committee Clearance. Written informed consents were taken from the legal guardians of the children according to the principals stated in the declaration of Helsinki. The Pan African Clinical Trial Registry number is (PACTR 202008516929306).

Participants

Thirty children with spastic hemiplegic CP participated in this study. They were referred from the Pediatric Outpatient Clinics, Faculty of Physical Therapy, Pharos University, Alexandria. Their chronological ages were ranged between 5 and 8 years. All patients had +1 to 3 degree of spasticity (according to The Modified Ashworth Scale). They were randomly assigned into two experimental groups, with equal number.

Patients were excluded if they had fixed deformity of the upper or lower limb joint, received anti-spastic drugs, or underwent any corrective surgery for upper or lower limb joints. They were excluded also if they had local insensitivity for hot or cold, cold adverse reactions, impairment of sensation (superficial, deep and cortical), any other diseases such as cardiac disease, severe mental retardation (IQ not less than 50), or any other neurological deficits such as convulsions, involuntary movements or receiving muscle relaxants.

The study was continued for two successive months for each child. All patients in both groups received the intervention program (prolonged ice application on the spastic muscle or brief ice application on the antispastic muscles), in addition to the ordinary physical therapy program that was designed for each specific case. The study was conducted from August to December 2020.

Randomization
A total of 46 patients were assessed for eligibility (fig. 1). Sixteen patients were excluded from the study, as shown in the flowchart. Thirty spastic CP children were randomized for allocation and subdivided into two groups; study group A (n=15), and Control group B (n=15). The children were allocated by creating random numbers from odd and even numbers by simple randomization. Every child was asked to blindly draw out a piece of paper containing a hidden number. The control group was assigned for the odd numbers and the study group was assigned for the even numbers.

![Fig. 1. Participants Flow Chart](image-url)

**Instruments**

The Modified Ashworth scale (MAS) was used to determine the grade of spasticity of the wrist flexors and ankle plantar flexors for each child. The Ashworth scale is the basic clinical classification to determine the grade of spasticity. It is a nominal 5-point scale, which uses contextual clinical tone tests from 0 'no tone increases' to 4 'limb rigid in bending or extension [abduction/adduction].' The Updated Ashworth Scale (MAS) has been added a further degree (1+) to improve sensitivity and accommodate patients who usually have scored at the lower end of the scale.

The Pro-Reflex motion analysis system was used to assess the kinematic gait parameters (ankle joint angle at initial contact, stride length, cadence and speed) before and after treatment for all children. This system includes three cameras, reflective markers, a Wand–Kit (for system calibration), an 8-meter long pass, and a personal computer with mounted Q-Trac software (Made in Sweden).

**Procedure**

**Initial Assessment**

Initially, each patient participated in the study underwent a full neurological examination. Each patient was placed in a supine position to assess the grade of spasticity for the wrist flexors and ankle plantar flexors (by Ashworth scale). The assessment of wrist flexors tone was started from full flexion of the wrist joint then the hand was moved passively into full extension of the wrist joint through 1 second. It was repeated for several repetitions to
achieve an accurate assessment of the muscle tone. The assessment of planter flexors tone was done by the same procedure applied for wrist flexors. It started with the ankle joint in full planter flexion then the joint was moved passively into full dorsiflexion. All the previous procedures were repeated again to assess the muscle tone after 2 months.

Patients were asked to remove their clothes to reveal the lower extremities up to the pelvis. The selected bony marks were marked by sticky material with seven reflective dots (at hip, supra patellar, knee, tibial tuberosity, ankle, heel and toes). 1) Hip: The greater trochanter. 2) Supra patellar: 1-cm near the top border of the patella when the knee was extended, along the central patella line of rectus femoris tendon. The patella's medial and lateral edges were palpated, the upper edge was then determined, and the marker was applied halfway between its edges and 1-cm higher than patella. 3) Knee joint line: The lateral joint line of the knee was formed via the tibia lateral tuber. The side of the knee was split into two equal sections when the patella was excluded, and the marker was positioned in the center of the knee joint. 4) Tibial tuberosity: the tuberosity marker was used for tibia. 5) Ankle: 30 millimeters near the lateral malleolus at the fibula at the lateral malleoli. This marker was used because the camera was not able to differentiate between the heel and ankle markers. 6) Heel: on the heel at posterior aspect of the calcaneus, on the same horizontal plane as the marker of the toe. 7) Toe: 10-15 mm proximal to the heads at foot between the second and third metatarsal. Each patient was asked to stand at the edge of the measuring field, in which the dots are visible to the cameras. The patient was then asked to walk around the chosen area in which he or she was captured.\[15\]

The three cameras, that was used to capture the movement of the patient, were arranged at a height of 1.5 to 2 meters on one side of the 8-meter-long path. The patient stood midway on the walkway to ensure that the patient was viewed by all cameras. It's around 3 meters, which allowed three full gait cycles, to be done on the route that the patient was going along. In the first position, there was a measuring area marked on the wooden passageway by putting four mirrored points in the four sides of the chosen distance to be seen in the cameras during installation.

The motion analysis process consisted of the following steps:

**Calibration**

The camera system was optimized to guarantee the accuracy of the value achieved before any three-dimensional (3-D) capture results. This calibration required the following instruments: AWand to provide the measuring points for calibration for the camera system. A reference framework for calibration coordinate process. In the area protected by the camera, the reference structure was mounted horizontally along the surface. Every camera saw the structure's four markers. When all the parameters have been properly set up, the calibration is carried out by pressing the capture button and by pushing the wand around during calibration data recovery. The wand was placed in the three dimensions during the calibration capture, beginning with Z, X and Y directions respectively.\[15\]

2) **Capture**

A new file with subject data was opened for each patient (name, age, weight and height). The patient was asked to walk from the previously determined point. The Q-Trac calculation was initiated when the patient passed the measurement starting place. During the Q-Trac assessment the patient was advised to proceed to the end of the walkway. The capture was started by choosing the capture from the toolbar and saving the measure.\[15\]

3) **Export**

For analysis, the selected gait cycles are transferred into the Tabulated Separated Values (TSV). Data processing involved two important steps (1) Monitoring the movement of the patient, defining the skin dots each by its location, (2) selecting and exporting the full gait cycles to the analytical file.\[15\]

4) **Analysis**

The dots were then been defined for the calculations. Finally, with the run button, calculations were launched. The results indicated the global gait parameters measured in tables and figures that were appeared when the calculations were finalized. The above assessment procedures were performed for each patient prior to and after 2 months of treatment.\[15\]

A. **Treatment**

Children in both groups received the physical therapy program in the form of facilitation for motor milestones (according to the level of motor development achieved by each child) that was preceded by ice application. The physical therapy program
was provided with a frequency of 3 sessions per week for successive two months, in addition to the application of ice packs in the following ways:

For patients within Group A: the ice pack was applied on the spastic muscles of the wrist and ankle joints (wrist flexors and ankle planter flexors) continuously for 20 minutes with a frequency of 3 sessions per week for successive 2 months.

For patients within Group B: the ice pack was applied on the skin of the antagonistic muscles for the spastic muscles of the wrist and ankle joints (wrist extensors and ankle dorsiflexors) for 10 minutes (time of application 10 seconds and a rest for 20 seconds) with a frequency of 3 sessions per week for successive 2 months.

The preference of cold modalities was determined by their high efficacy in reducing skin temperature and repeated use in the clinical setting. Gel packs of gelatinous material had been held frozen in a freezer until needed. A better example may include some anti-freeze forms that prevents the gel from freezing in a rigid position, so that, the pack can be fashioned to the form of the body part. They are ideal for a reusable use in a clinic and are not as chaotic as ice packs. To prevent frostbite, they were applied via a towel or tissue to the skin.

B. Re-assessment

The same whole procedure of initial assessment was repeated again after two successive months (after treatment) for all patients within both groups.

C. Statistical Analysis

All statistical analyses were performed through the Statistical Package for Social Science (SPSS) version 21 for windows. Initially, data were screened through conducting Kolmogorov-Smirnov and Shapiro-Wilk normality tests for normality assumption as a pre-requisite for parametric analysis. This was done also through assessing for the presence of significant skewness and kurtosis in addition to the presence of extreme scores. Once data were found not to violate the normality assumptions, parametric analysis was used.

Two-way mixed design Multivariate Analysis of Variance (MANOVA) was used to differentiate among the two tested groups for the degree of muscle spasticity, cadence, speed, stride length, and the ankle joint angle at initial contact before and after treatment. This study included two independent variables. The first independent variable was the tested group (between-subject factor) with two levels: group (A), and group (B). The second independent variable was the testing time (within-subject factor) with two levels: pre-training and post-training. There were many dependent variables; the degree of muscle spasticity, cadence, speed, stride length, and the joint angle of the ankle at initial contact. The level of significance was set at an alpha level of 0.05.

III. RESULTS

There was no significant difference between the tested groups regarding the age, weight and height (P > 0.05), as illustrated in table 1. There was no significant difference between both groups in the gender distribution, as the Chi-squared value was 0.53 (P > 0.05). The mean age ± SD was 6.86 ± 1.77 years for group A and 6.79 ± 1.91 years for group B. Group A included 10 males and 5 females, while group B had 8 males and 7 females.

Table 1. Demographic Characteristics of the Subjects at the Beginning of the Study

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control Group (X ± SD)</th>
<th>Study Group (X ± SD)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>6.86 ± 1.77</td>
<td>6.79 ± 1.91</td>
<td>0.36</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>119.6 ± 19</td>
<td>118.7 ± 17</td>
<td>0.62</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>35.7 ± 13</td>
<td>36.3 ± 14</td>
<td>0.73</td>
</tr>
</tbody>
</table>

X ¯: Mean, SD: Standard deviation, P-value: Level of significance

Data Analysis

Data were collected before and after treatment from patients within group (A) who received traditional exercise treatment program with ice pack application on the spastic muscles of the wrist and ankle joints (wrist flexors and ankle planter flexors) and group (B) who treated with ice pack application on the skin of the antagonistic muscles of the spastic muscles of the wrist and ankle joints (wrist extensors and ankle dorsiflexors) in addition to the traditional exercise treatment program. Mixed design MANOVA was conducted to compare between group (A) and group (B) for the degree of spasticity, stride length, cadence, speed, and ankle joint angle at initial contact before and after the treatment. The mixed design MANOVA revealed that there were statistically significant between and within-subject differences for all dependent variables (F = 14.652, p < 0.0001) and (F = 182.748, p
< 0.0001). The test revealed also significant interaction between the treatment and the time (F= 31.694, P < 0.0001).

Regarding the wrist flexors and ankle plantar flexors degree of spasticity, the subsequent multiple pairwise comparison tests showed that the wrist flexor and ankle PF muscle tone decreased significantly (p < 0.05) after treatment for patients in group A compared with the pre-training condition. While, the wrist flexor and ankle PF muscle tone revealed non-significant reduction after treatment for the patients within group B. Additionally, the mean values of wrist flexors and ankle plantar flexors muscle tone for patients within group A after treatment were significantly lower than those in the group B (P < 0.05). However, there was no significant difference (P > 0.05) in-between the two tested groups before treatment (Table 2).

Regarding the kinematic gait parameters, the subsequent multiple pairwise comparison tests showed that the speed, stride length and ankle joint angle mean values were significantly increased after treatment for all patients within both groups compared with the initial pre-training condition. On the other hand, the cadence mean value decreased significantly (p < 0.05) after treatment in both groups. Additionally, the post-treatment mean values of all gait parameters (speed, cadence, stride length and ankle angle) revealed significant difference between both groups for the favor of group A. However, there was no significant difference (P > 0.05) in-between the two tested groups for the pre-treatment values of all these parameters (Table 2).

The mixed design MANOVA revealed also significant interaction (F= 31.694, P < 0.0001) between the two independent variables (the group and the time). This interaction effect indicated that the difference between group (A) and group (B) on the linear combination of the dependent variables is different at pretest and posttest. Examination of the means suggested that this is because groups do not differ on either dependent variable at the time of the pretest, but they do differ at the time of the posttest. Group (A) showed superiority to group (B) after two months of intervention regarding all the dependent variables (P < 0.0001).

Table 2. Outcome Data for Speed, Cadence, Stride Length and Ankle Joint Angle Before and After Intervention for Both Groups

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>group A mean ± SD (n = 15)</th>
<th>Group B mean ± SD (n = 15)</th>
<th>Mean difference</th>
<th>P-value (Group A Vs B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed pre</td>
<td>0.4457±0.0933</td>
<td>0.4743±0.0769</td>
<td>0.027</td>
<td>0.405</td>
</tr>
<tr>
<td>Speed post</td>
<td>0.7206±0.1148</td>
<td>0.5877±0.0918</td>
<td>-0.137</td>
<td>0.001</td>
</tr>
<tr>
<td>P-value (pre Vs post)</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadence pre</td>
<td>131.53±5.567</td>
<td>130.09±3.944</td>
<td>-0.739</td>
<td>0.681</td>
</tr>
<tr>
<td>Cadence Post</td>
<td>119.95±5.103</td>
<td>125.08±4.229</td>
<td>5.068</td>
<td>0.006</td>
</tr>
<tr>
<td>P-value (pre Vs post)</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stride Pre</td>
<td>0.4007±0.0885</td>
<td>0.3809±0.0776</td>
<td>-0.022</td>
<td>0.507</td>
</tr>
<tr>
<td>Stride Post</td>
<td>0.7405±0.0996</td>
<td>0.5069±0.0705</td>
<td>-0.236</td>
<td>0.0001</td>
</tr>
<tr>
<td>P-value (pre Vs post)</td>
<td>0.0001*</td>
<td>0.0001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle angle pre</td>
<td>-2.7183±0.9074</td>
<td>-2.7277±1.089</td>
<td>-0.009</td>
<td>0.980</td>
</tr>
<tr>
<td>Ankle angle post</td>
<td>1.5568±2.295</td>
<td>-1.3607±0.6476</td>
<td>-2.918</td>
<td>0.0001*</td>
</tr>
<tr>
<td>P-value (pre Vs post)</td>
<td>0.0001*</td>
<td>0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist flexors tone pre</td>
<td>2.79 ± 0.46</td>
<td>2.47 ± 0.55</td>
<td>-1.98</td>
<td>0.08</td>
</tr>
<tr>
<td>Wrist flexors tone post</td>
<td>1.74 ± 1.07</td>
<td>2.23 ± 0.79</td>
<td>2.238</td>
<td>0.05</td>
</tr>
<tr>
<td>P-value (pre Vs post)</td>
<td>0.003</td>
<td>0.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle planter flexors tone pre</td>
<td>2.52 ± 0.71</td>
<td>2.71 ± 0.48</td>
<td>1.5</td>
<td>0.17</td>
</tr>
<tr>
<td>Ankle planter flexors tone post</td>
<td>1.83 ± 0.78</td>
<td>2.47 ± 0.84</td>
<td>3.67</td>
<td>0.005*</td>
</tr>
<tr>
<td>P-value (pre Vs post)</td>
<td>0.001*</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at alpha level < 0.05.
The results of this study showed significant improvement in both groups for all measured variables (degree of spasticity of wrist flexors and ankle planter flexors and the kinematics gait parameters) after two months of treatment. However, higher improvement was achieved in group A for all the measured parameters. The results of the current study agree with those of previous studies which indicated that cold therapy is an acceptable method for the temporary relief of spasticity. Additionally, the present study proved that cold therapy is effective when combined with physical and occupational therapy in reducing spasticity and improving gait pattern in children with spastic CP.

In this study, the cold therapy was applied for 20 min on the spastic muscles of the wrist and ankle joints, in patients within group A. This procedure was applied aiming to gain significant and long duration reduction in spasticity. As an adequate period of time was needed for subsequent ROM exercises and training of motor skills and gait without interference of spasticity. In most of the children (n = 13), the spasticity reduced for 60–90 minutes after cold application. This is supported by the findings reported by Miglietta. The researchers assessed the effect of cooling on clonus in 40 patients with spasticity. He found that the clonus stopped for 90 minutes after cold treatment and then re-appeared in 100% of patients.

Our results showed a substantial reduction in spasticity after treatment in both groups, which may be due to elbow and wrist flexor muscle stretching by manual passive stretching and hand weight bearing. All patients in both groups received continuous stretching of these muscles, which led to the fatigue of the stretch receptors and reduced its response to any stimulus. This also led to a breakdown of the contracture, which enabled further lengthening of muscle fibers to counteract the effect of spasticity. Additionally, the approximation of the upper limb by hand weight bearing reversed the proprioceptive reflex in the upper limb and introduced more suppression of the spasticity of the elbow and wrist flexors.

The post-treatment results of the degree of spasticity revealed a significant difference between the tested groups in favor of group A. This difference may be attributed to the effect of prolonged cold therapy on the spastic muscles rather than brief ice application in reducing spasticity. There are several potential causal mechanisms to understand how cold therapy decreases spasticity. The first step has been described by Eldred et al., Ottosn, Knutsson and Mattsson. Those researchers reported that the application of ice reduces the muscle tone by reducing the sensitivity of the spindle. They found that the rate of spontaneous spindle discharge decreased with low temperature. The discharge rate from the Golgi Tendon Organs was also found to be temperature dependent. The change in discharge of the muscle spindle may be resulted from the effect of cold on the extrafusal muscle, the intrafusal fibers or the sensory endings. Similarly, Michlovitz et al. claimed that the inhibition produced by the use of cryotherapy might be due to a local cooling effect on every element of the segmental sensorimotor complex, including large afferent muscle spindle fibers (alpha and gamma motoneurons), all skin receptors, extrafusal muscle fibers and myoneural junction.

The second possible mechanism was explained by Lippold et al. The researchers suggested that the impact of cold application might becaused by shifting in the membrane polarization. Hyperpolarization or low potassium concentrations have been found to minimize or remove spindle discharge. Also, their findings agree with those of Eldred et al. Those researchers concluded that the site of thermal effect is the sensory terminal itself and is likely to be the result of change in membrane stability similar to those included in axons by lowering the temperature. Finally, clonus and spasticity have not been documented to be eliminated unless the muscle temperature drops dramatically. Miglietta suggested the possibility that sympathetic fiber stimulation by cold application not only causes vasoconstriction but it also reduces the sensitivity of the spindle.

Additionally, Warren et al. reported that extreme sustained and penetrating colds could be used in therapy to promote relaxation. They related their findings to the lowering of the background level of the stretch afferent information. Extreme cold (penetration of muscle mass) has been documented to create cold blocks of receptors or afferent fibers themselves. The previous study conducted by Price et al. confirmed our findings. The researchers studied the effect of cryotherapy application on the spasticity of the ankle. They reported that cryotherapy reducing the length of the pathway, a parameter indicating the frequency-dependent viscoelastic response at the ankle. High path length values have been shown to be consistent with the existence of spasticity. They recommended the use of cryotherapy for 1 hour on the calf muscles. Moreover, Lehman and de Lateur reported that cold application has been found useful to be used to reduce spasticity in upper motor neuron lesion and in muscle re-educatin to facilitate muscle contraction.
In the current study, most of the children (n=13) treated with prolonged cold therapy on the spastic muscles had a significant reduction in spasticity, while the remaining two children’s spasticity scores remained constant. It can be claimed that these children had little spasticity to be treated with cold therapy, or that deep muscle cooling was not done and there was inadequate cooling. The results of the current study agree with those reported by Urbscheit et al. [14]. Those researchers investigated the changes in the H-response and Achilles tendon jerk in hemiplegic patients after cold administration. They found that hemiplegic patients reacted differently. The author proposed that local cooling could decrease, increase or have no impact on spasticity.

Regarding the kinematic gait analysis, there were significant improvements after treatmenmtin the mean values of all the measured variables in both groups. These might be due to the reduction of spasticity and strengthening of antagonistic muscles. Reduction of spasticity in wrist flexors and ankle planter flexors provided less resistance to lengthening those muscles during the movement in the opposite direction, thus allowing more ROM. The results agree with those reported by Elanchezhian and Swarnakumari [25]. The researchers compared between-diplegic CP children who allocated into a Traditional group (who underwent standard conventional training) and an Experimental group (who received cold therapy and passive stretching in both legs prior to training). All children were practiced for 45 minutes, 3 days a week for a total of 6 weeks. The researchers used The Modified Ashworth scale to measure spasticity before and after training. They also assessed the step length, stride length, and cadence during walking. They also used the Timed Up and Go test (TUG) to assess the functional movement. Their finding revealed decreased tone in the spastic muscles and improved gait parameters and functional capacity in the children with diplegic CP following cold therapy and passive stretching.

The results of this study agree with Knutsson [27] who found that passive resistance to stretching the cooled muscle had been decreased and the clone had been eliminated. He also found that the strength of the chilled muscles did not increase, but that the force of the antagonist was enhanced. The antagonist could act better because the spastic muscles did not resist it. Similarly, Lin [28] found that cold therapy can facilitate increasing the range of motion in a joint. Also, Lehmann et al. [29] stated that cold application (in the management of spasticity) may reduce tendon reflex excitability and clone, increase the ROM of the joints and improve the strength of the antagonistic muscle group.

Similarly, this study supports the work of Semenova et al. [30] who studied the EMG of the forearm muscles after local cryotherapy application onto hands. They found that the cryotherapy produced a reduction of spasticity and increased the functional possibilities of the hand, so that the writing became possible.

V. CONCLUSION

The findings of this study revealed that combination of cold therapy and traditional physical is effective for reducing spasticity and improving the gait patterns in children with spastic cerebral palsy. Cooling has been used to minimize spasticity, allowing physiotherapy training to be begun without interruption of spasticity for effective motor skills learning. Finally, cold therapy is important in the preparation of children with spastic CP for subsequent physical therapy, which should be provided immediately after the use of cold therapy.

RECOMMENDATION

Further studies are needed to evaluate the effects of cold therapy in combination with splints and neuromuscular electrical stimulation on ankle and foot complex in children with spastic cerebral palsy.

REFERENCES


www.turkjphysiotherrehabil.org