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Effects of cryotherapy associated with kinesiotherapy and electrical stimulation on spastic hemiparetic patients

Efeitos da crioterapia associada à cinesioterapia e da estimulação elétrica em pacientes hemiparéticos espásticos

Efectos de la crioterapia asociada a la cinesioterapia y de la estimulación eléctrica en pacientes hemiparéticos espásticos

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ABSTRACT | Spasticity caused by stroke is a cause of functional disability of the upper extremity. The aim of this study was to check the effect of cryotherapy associated with kinesiotherapy and electrical stimulation on the palmar grip strength of the spastic limb of stroke patients in the chronic phase. Forty patients whose mean age was 60.5 (±9.45) years old and who had spastic hemiparesis participated in the study, having been randomly sorted into group A (GA): submitted to cryotherapy on the wrist flexors and kinesiotherapy on the wrist flexors and wrist extensors, and Group B (GB): submitted to electrical stimulation on the wrist extensors. Palmar grip strength was evaluated by a bulb dynamometer before, after 16 sessions and one month after the end of treatment. The results showed that there was an increase in palmar grip strength in GA ($p=0.0244$) and GB ($p=0.0144$) after treatment, with maintenance one month after its completion ($p=0.6002$ and 0.3066, respectively), and no statistical difference was observed between them. The findings indicate that both therapeutic resources were effective in increasing the study participants' palmar grip strength.

Keywords | Stroke; Cryotherapy; Muscle Spasticity; Electrical Stimulation.

RESUMO | A espasticidade causada pelo acidente vascular encefálico (AVE) é uma das principais causas de incapacidade funcional no membro superior. O objetivo do estudo foi verificar o efeito da crioterapia associada à cinesioterapia e da estimulação elétrica na capacidade de preensão palmar do membro espástico de pacientes com AVE na fase crônica. Participaram do estudo 40 pacientes com idade média de 60,5 (±9,45) anos e hemiparesia espástica, divididos aleatoriamente em grupo A (GA): submetidos à crioterapia nos músculos flexores de punho e cinesioterapia nos músculos flexores e extensores de punho; e grupo B (GB): submetidos à estimulação elétrica nos músculos extensores de punho. A capacidade de preensão palmar foi avaliada por meio de um dinamômetro de bulbo antes, depois de 16 atendimentos e um mês após o término do tratamento. Os resultados demonstraram que houve aumento da capacidade de preensão palmar no GA (p=0,0244) e GB (p=0,0144) após o tratamento, com manutenção um mês após seu término (p=0,6002 e 0,3066 respectivamente), sem diferença estatística entre estes. Os achados apontam que ambos os recursos terapêuticos foram eficazes para o aumento da capacidade de preensão palmar dos participantes do estudo.

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Descritores | Acidente Vascular Encefálico; Crioterapia; Espasticidade Muscular; Estimulação Elétrica.

RESUMEN | La espasticidad causada por el accidente cerebrovascular (ACV) es una de las principales causas de incapacidad funcional en el miembro superior. El objetivo del estudio fue verificar el efecto de la crioterapia asociada a la cinesioterapia y de la estimulación eléctrica en la capacidad de prensión palmar del miembro espástico de pacientes con ACV en fase crónica. Participaron del estudio 40 pacientes con edad media de 60,5 (±9,45) años y hemiparesia espástica, divididos aleatoriamente en grupo A (GA) —sometidos a la crioterapia en los músculos flexores del puño y cinesioterapia en los músculos flexores y extensores del puño — y grupo B (GB) —sometidos a la estimulación eléctrica en los músculos extensores del puño. Se evaluó la capacidad de prensión palmar por medio de un dinamómetro neumático antes del tratamiento, después de 16 atendimientos y un mes después del término del tratamiento. Los resultados demostraron un aumento de la capacidad de prensión palmar en el GA (p=0,0244) y en el GB (p=0,0144) después del tratamiento, con mantenimiento un mes después de su término (p=0,6002 y 0,3066 respectivamente), sin diferencia estadística entre éstos. Los hallazgos apuntan que ambos recursos terapéuticos fueron eficaces para aumentar la capacidad de prensión palmar de los participantes del estudio.
Palabras clave | Accidente Cerebrovascular; Crioterapia; Espasticidad Muscular; Estimulación Eléctrica.

INTRODUCTION

Stroke (CVA) is the second cause of death in the world and the first cause of disability[1,2], and among the survivors, 44% have some type of functional dependence[3].

Symptoms usually includes hemiplegia, sensory dysfunction, aphasia, deficits in the visual field, mental and intellectual impairment[4], decrease in muscle strength[5] and functional limitations[6].

Approximately half of stroke survivors show sensorimotor dysfunctions of the affected upper limb[7]. From three to six months after the stroke, the functions of grasping, holding and manipulating objects remain impaired in 55% to 75% of patients[8].

The total restoration of the upper limb is a difficult task, but even a small improvement can help promote the patient's independence when performing activities of daily living. The increase in the muscle tone of finger flexors makes it difficult to extend the fingers, which can lead to flexion contractures[9-11].

Surgical procedures, drug use, type A botulinum toxin and physical therapy are used to treat spasticity[12], although there is no treatment that will cure it definitively[13]. Therapeutic resources such as hydrotherapy, movement restriction and induction therapy, proprioceptive neuromuscular facilitation, cryotherapy, kinesiotherapy and neuromuscular electrical stimulation can be used to treat spasticity[2].

Cryotherapy contributes to the control of spasticity[14] and kinesiotherapy helps prevent secondary incapacities and promotes neuromotor reeducation[13]. Neuromuscular electrical stimulation (NMES) can produce contractions in groups deprived of voluntary control, with the aim of improving function, increasing muscle strength and range of motion, reducing spasticity, and restoring proprioceptive joint sensation[15].

In view of the studies and methods applied, it is important to base this research on the need to seek physiotherapeutic techniques that are easy to apply and inexpensive, to improve the palmar grip strength of the paretic upper limb of stroke patients in the chronic phase, who often are not in treatment, allowing their early return to the activities of daily living. Researchers have stated that the patients' return to their usual environment with the most functional autonomy possible is a fundamental objective in the treatment of stroke patients[3]. In addition, treatment protocols need to be established for the development of future studies and guidance programs. Therefore, the objective of this study was to verify the effect of cryotherapy associated with kinesiotherapy and neuromuscular electrical stimulation on the palmar grip strength of the spastic limb of stroke patients in the chronic phase.

METHODOLOGY

The study began after its approval by the Research Ethics Committee of Centro Universitário de Barra Mansa, under opinion No. 2,766,663, in addition to the signing of an informed consent form by the participants, who met the following inclusion criteria: in the chronic CVA phase, at least seven months after the injury, 3 being the maximum and 1 the minimum spasticity score according to the modified Ashworth scale[16,17], with medical indication for physical therapy, as well as adequate understanding and communication skills. The exclusion criteria were: patients with Raynaud's disease, thromboangiitis obliterans, cryoglobulinemia, cold urticaria, uncontrolled hypertension, sensory deficiency, aversion to cold, trophic abnormalities at the site of the NMES's application, 0 or 4 spasticity score according to the modified Ashworth scale, Wernicke's aphasia or dysphasia.

All patients underwent an initial assessment using the modified Ashworth scale for the exclusion criteria only, and a Sammons Preston bulb dynamometer to determine their palmar grip strength. The patients were instructed to perform three gripping attempts, considering the mean of the movements. The dynamometer was applied after the 16 sessions and one month after the end of treatment.

The patients were randomly sorted into Group A (GA): submitted to cryotherapy on the spastic wrist flexors and kinesiotherapy on the spastic wrist flexors and extensors' agonists and antagonists; and Group B (GB): submitted to NMES on the spastic muscle's antagonist. The two groups underwent 16 sessions, twice a week, for two months.

During treatment, the patients remained seated with their forearm resting on a table and their elbow flexed to 90 degrees. Cryotherapy was performed for 25 minutes on the venter of the spastic upper limb's wrist flexors using a plastic bag containing ice, with an elastic band and a wet towel wrapped around it. After the application, the patients underwent two 30-second sets of passive stretching of their wrist flexors and extensors. Subsequently, they were asked to perform three sets of 15 wrist flexion and extension repetitions.

In GB, NMES was applied on the patients' wrist extensors using an Ibramed Neurodyn Compact device. For this procedure, a symmetrical two-phase rectangular pulse current was used, with the following parameters: 50Hz frequency, 300μs pulse duration, 5 seconds on and 15 seconds off, for 15 minutes. Two carbon-impregnated silicone rubber electrodes measuring 5x3cm were attached to the skin using a conductive gel, and then fixed with adhesive tape, one on the forearm's proximal region, adjacent to the lateral epicondyle, and the other at a 1.5cm distance from the first.

After collection, the data were exported to a database system and analyzed by the BioEstat Software version 5.0. D'Agostino's normality test was applied to verify if the data followed a normal distribution. Then, the Wilcoxon Signed-Rank Test was applied to the paired data and the Wilcoxon Rank-Sum Test was applied to the unpaired data, with significance level of $p \leq 0.05$.

RESULTS

Forty patients of a physical therapy clinic located in the state of Rio de Janeiro – Brazil, where the study was conducted, were randomly chosen to participate in this research. The study group's initial characteristics are listed in Table 1.

Table 1. Initial characteristics of the study groups

Characteristics	GA (n=20)	GB (n=20)
Mean (SD) Age	61 (±8.55)	59.7 (±9.89)
Gender – Male: Female (% – n)	75%:25% (15:5)	30%:70% (14:6)
Mean (SD) Post-CVA months	87.3 (±75.79)	73.8 (±67.42)

SD: standard deviation; n: sample; CVA: cerebrovascular accident.

In Table 2, it is possible to see that there was an increase in palmar grip strength in GA and GB when comparing the moments before and after treatment. In both groups, it was possible to observe that the palmar grip strength was maintained one month after the end of treatment; however, there was no statistical difference between them.

Table 2. Values of p, mean, and standard deviation for the analysis of palmar grip strength

Outcome		A	B	Comparison between groups
Palmar grip	Before x After	p=0.0244*	p=0.0144*	p=0.8817
Mean (SD)	After x 1 month After 1 month	p=0.6002 2.11 (±1.45)	p=0.3066 3.32 (±1.78)	p=0.4171

*statistically significant value; SD: standard deviation.

DISCUSSION

There are studies in the literature highlighting the treatment of stroke patients in the acute phase[18,19]. However, the continuity of the physiotherapeutic treatment in the chronic phase, and not only the provision of guidelines regarding the performance of functional activities at home after discharge from the rehabilitation services, is of fundamental importance.

The evolution of stroke patients in the chronic phase during the physical therapy treatment can be good in functional terms[20] when the improvement in muscular strength is associated with the improvement in functional capacity[21]. In this study, it was verified that there was a significant increase in grip strength after the two treatments performed. This increase might be due to the muscle neuroplasticity mechanism, which could lead to the improvement in motor control and synergism, as the central nervous system may find different ways to reorganize itself, depending on the lesion and on the therapeutic resources used[22]. One of the limitations of this study was lacking an instrument to evaluate functionality, making it difficult to prove that the increase in muscle strength contributed to the improvement in the study participants' functional capacity.

Cryotherapy associated with kinesiotherapy promoted an increase in palmar grip strength (p=0.0244), which was maintained one month after the end of treatment. This increase could have been be due to fact cooling may improve muscle strength[23]. The mechanisms responsible for muscle strength changes after cryotherapy are still unclear, but may be related to changes in the impulse's propagation along nerve fibers modifying the motor unit's activation, and to the influence of temperature on the muscle spindle afferent[24,25].

Nerve conduction velocity in afferent and efferent fibers decreases with the reduction in the nervous tissue's temperature. The perception of the stimulus may change when afferent pathways are decelerated. It is possible that the reduction in the transmission of the action potential resulting from the decrease in nerve conduction velocity leads to an increase in the number of receptors, stimulating the pressure necessary to promote a response after the application of ice[26]. The proposed mechanisms to promote the increase in muscle strength caused by cooling include the facilitation of motor nerve excitability and greater psychological motivation to perform the activity[27].

Harlaar et al.[26] noted an increase in the range of motion of spastic patients after cryotherapy, and stated that this effect is only temporary. As cooling does not lead directly to the function's improvement, it is necessary to perform exercises after cryotherapy. In view of this, this study proposes the execution of stretches and active assisted exercises.

The reduction of resistance to motion caused by kinesiotherapy is reported by Nuyens et al.[28], who observed a decrease in the spastic hypertonia of stroke patients after performing passive movements. According to the authors, kinesiotherapy would not only affect reflex responses, but also viscoelastic characteristics, and the muscle's mechanical factors would also be involved. Fowler et al.[29] and Lima et al.[30] observed that kinesiotherapy increased muscle strength without increasing the resistance to motion of spastic patients. In this study, it was not possible to state that resistance to motion changed after treatment, since the modified Ashworth scale was only used before treatment, to select the patients that fit the exclusion criteria.

NMES, in this study, increased the paretic limb's hand grip strength (p=0.0144), which was maintained one month after the end of treatment. This improvement in motor function can be attributed to a possible improvement in the blood flow of the muscle groups submitted to NMES. The NMES's application on the antagonist muscles probably released the spastic agonist muscles, increasing blood flow in this region. A study conducted by Wang et al.[31] showed an increase in the arterial response and vascular endothelial dilatation of the paretic upper extremity after applying NMES on the wrist flexors and extensors of patients with acute stroke. Studies have shown the improvement in functional tasks and increase in muscle strength after treatment with NMES or NMES associated with exercises[8,32,33].

When comparing the groups' results, no statistical difference was observed between them. It may be concluded that the proposed physiotherapeutic resources were effective in the rehabilitation of the spastic hemiparetic patients participating in the research, and that even chronic patients can benefit from treatment.

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