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ARTICLE

# Comparison of functional electrical stimulation associated with kinesiotherapy and kinesiotherapy alone in patients with hemiparesis during the subacute phase of ischemic cerebrovascular accident

## Comparação da estimulação elétrica funcional associada à cinesioterapia com a cinesioterapia isolada em pacientes com hemiparesia na fase subaguda por acidente vascular cerebral isquêmico

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**ABSTRACT**

**Objective:** To compare the functional electrical stimulation associated with functional kinesiotherapy alone in patients after ischemic cerebrovascular accident. **Methods:** The study included 20 patients who were divided into two groups: Group I (GI): functional electrical stimulation plus functional kinesiotherapy and Group II (GII): functional kinesiotherapy. We evaluated active and passive range of motion, in knee flexion and extension muscle strength, activities of daily living and quality of life. The evaluations were conducted in the pretreatment period, after 10 sessions and after 20 physical therapy sessions. **Results:** There was a significant improvement in all variables studied for both groups. However, significant improvements for the sub-items functional capacity and social aspects were seen only in the patients treated with associated functional electrical stimulation and kinesiotherapy. **Conclusion:** Although both groups of patients improved with the treatment, the association of functional electrical stimulation and kinesiotherapy showed superiority in two quality of life items, in the sub-items functional capacity and social aspects.

**Key words:** electric stimulation, stroke, paresis, physiotherapy.

**RESUMO**

**Objetivo:** Comparar a estimulação elétrica funcional associada à cinesioterapia com a cinesioterapia funcional isolada no membro inferior de pacientes em fase subaguda após acidente vascular cerebral isquêmico. **Método:** Participaram do estudo 20 pacientes divididos em 2 grupos: Grupo I (GI): eletroestimulação funcional mais cinesioterapia funcional e Grupo II (GII): cinesioterapia funcional. Foram avaliadas as amplitudes de movimento ativo e de movimento passivo em flexão e extensão do joelho, a força muscular, as atividades da vida diária e a qualidade de vida. As avaliações foram realizadas nos períodos pré-tratamento, após 10 e após 20 sessões de fisioterapia. **Resultados:** Houve melhora significativa em todas as variáveis estudadas para ambos os grupos. Contudo, melhorias significativas para os subitens capacidade funcional e aspectos sociais foram vistos apenas nos pacientes tratados com a estimulação elétrica funcional associada à cinesioterapia. **Conclusão:** Os dois grupos de pacientes melhoraram com o tratamento, mas a associação da estimulação elétrica funcional à cinesioterapia mostrou superioridade nos subitens capacidade funcional e aspectos sociais da qualidade de vida.

**Palavras-Chave:** estimulação elétrica, acidente vascular cerebral, paresia, fisioterapia.

The cerebral vascular accidents (CVA) are divided, according to their anatomical and pathological features, into subarachnoid and intraparenchymatous hemorrhages; and as ischemic (ICVA), caused by primary vascular disease, thrombosis or embolism and hemorrhagic (HCVA); divided, respectively[1,2]. Approximately 75% of CVA are ischemic and 25% are hemorrhagic[2].

The acute stage of the disease is characterized by a state of flaccidity, areflexia, hemiplegia, hemi-anesthesia and

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cognitive alterations, which are the result of cerebral hypoxia and in accordance with the location of the lesion. The duration of this stage is usually brief and may finish in approximately 15 to 30 days, when the clinical course is modified and the individual then goes to a subacute stage, which last 1–3 months and can reach up to 6 months[3-6]. In most cases, the return of function occurs spontaneously in one to three months after the CVA, reaching a plateau from six months to one year after the injury, although some patients exhibit substantial recovery at the later stages[7-9].

Functional electrical stimulation (FES) is a resource used by physical therapy that enables the transmission of electrical signals to the muscles, facilitating movement[10,11]. It consists of functional electrical stimulation of a muscle deprived of normal control to produce a functionally useful contraction. This stimulation depolarizes the motor nerve, producing a synchronous response in all motor units of the stimulated muscle, improving throphism[11]. Its mechanism of action is closely linked to the facilitation of physiological mechanisms of striated muscle (muscle contraction), allowing selective and repetitive afferent input to the CNS, activating not only the local muscles, but also reflex mechanisms that are necessary for reorganization of the motor activity[10,11].

The present study aimed to compare the FES associated with functional kinesiotherapy (FK) and functional kinesiotherapy alone in patients with sequelae of ICVA with hemiparesis in the subacute phase.

## METHODS

The study included 20 patients of both genders with hemiparesis in the subacute phase after an ICVA. The sample consisted of 11 female and 9 male patients, with a mean age in Group I (GI) of 66.70 and 66.90 years in Group II (GII). The project was approved by the Committee of Ethics in Research of the *Hospital do Servidor Público Estadual,* São Paulo SP, Brazil, and the free and informed consent form was signed by all patients.

### Inclusion criteria

Adult literate patients of both genders, aged 18 years and older, who were treated between July 2011 and January 2012 with ischemic CVA in the middle cerebral artery territory, with clinical and imaging diagnosis and within 90 days since the onset of the condition, with no structural deformities were included in the study.

### Exclusion criteria

Patients with pacemakers, vascular alterations and sensitivity impairment in hemiparetic lower limb were excluded.

### Matching

Study patients, whose score was lower than 85 in the initial Barthel Index (pretreatment assessment) were selected for the comparative analysis between the groups (study and control) to allow comparison of health-related quality of life (QOL) results from the patient's perspective and the performance of activities of daily life assessed by physical therapists in patients treated with FES+FK (GI) and patients treated with FK alone (GII).

### Evaluations

#### *Muscle strength (MS) assessed by Daniels numerical grading system[12].*

Barthel index (BI) is a scale that assesses functional capacity in activities of daily living and the degree of dependence from the perspective of the examiner.

#### *Quality of Life Questionnaire-SF-36.*

Joint range of motion (ROM): joint range of motion (ROM) assessment was performed using a goniometer for the assessment of posterior and anterior ROM of the hemiparetic lower limb in knee extension and flexion. The patient remained supine and the lower limp (LL) was unclothed.

### Intervention

The physical therapy intervention program for the groups (GI and GII) consisted of 20 physical therapy sessions twice a week in consecutive weeks, with 60-minute sessions for groups GI and GII, administered by the first author only.

#### *First phase*

Use of FES current; the electrodes were fixed on the thigh of the hemiparetic leg in the quadriceps muscle group (consisting of the rectus femoris, vastus lateralis/vastus medialis/vastus intermedius, knee joint), which promotes contractions in muscles deprived of nervous control.

We used the following stimulation parameters: frequency (F) of 30 to 100 Hz[13,14]; pulse width (T)=250 microseconds[13-15], cycle ON/OFF=1/2 (7 seconds of contraction/14 seconds of relaxation); the intensity was the minimum possible to produce an effective and uniform muscle contraction, respecting the voluntary thresholds[16-19], as high intensities cause muscle fatigue[18]. Each FES session lasted 30 minutes.

#### *Second phase*

FK (therapeutic exercises directed at activities of daily living – ADLs), therapeutic exercises with entertaining features that encourage interpersonal relationship.

The FK that was administered is based on the guidelines of the American Physical Therapy Association. The summary of the exercises and their therapeutic goals are showed in Table 1[20].

### Statistical analysis

To compare the variables by group and assessment, we used two-way analysis of variance (ANOVA), with significance level set at 5%. If a difference was detected, Tukey's multiple comparisons test was used. The variables were

displayed as figures. These were distributed in order to demonstrate the evolution of patients from GI and GII, in the pretreatment period, after 10 sessions and at the end of 20 physical therapy sessions, verifying whether there was a difference between the evaluation periods, between the groups and for the interaction.

## RESULTS

General distribution of patients in Groups I and II according to age and time since injury, are shown in Table 2.

There were no significant differences between groups regarding age and time since injury.

Table 3 shows gender, affected hemisphere and comorbidities. There were no significant differences between the groups regarding the parameters of the table.

### Quality of life: SF-36

The SF-36 scale is subdivided into eight domains, namely: functional capacity, physical aspect limitation, pain, general health status, vitality, social aspects, emotional aspect limitation, and mental health.

### Functional capacity

The mean score in the study group ranged from 62.80 (pre) to 69.03 (10 sessions) and 76.02 points (20 sessions) and in the control group, it ranged from 61.85 (pre) to 64.63 points (10 sessions) and 67.42 (20 sessions). The GI group showed significant improvement after the sessions, compared to GII (p=0.004) and at the time effect (p<0.001) (Fig 1). We have the following hierarchy as a result: (Pre)<(10 sessions)=(20 sessions) for both groups.

Table 4 shows the means and standard deviations of functional capacity.

Fig 1 shows the confidence intervals for each combination of group and time of assessment of the functional capacity sub-item for both groups.

### Social aspects

The mean in the study group ranged from 66.20 to 66.30 (10 sessions) and remained at 66.30 (20 sessions), and in the control group, it ranged from 63.90 points (pre) to 64.60 (10 sessions) and remained at 64.60 (20 sessions). We observed a significant difference for both groups (p=0.034) and at the time

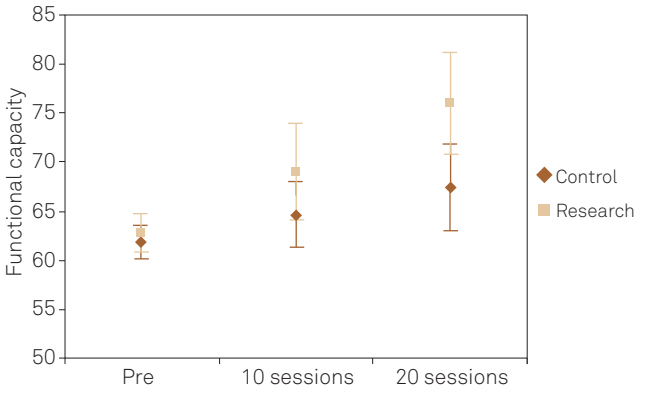


Fig 1. Confidence intervals for each combination of group and moment of assessment of the functional capacity sub-item for both groups.

Table 2. Age and time of lesion. General distribution of patients in Groups I and II, according to age and time of lesion.

| | Study group G1 Mean (SD) | Control group G2 Mean (SD) | *t*-test (p-value) |
|---|---|---|---|
| Age (years) | 66.70 (8.54) | 66.90 (12.32) | 0.967 |
| Time of lesion (days) | 32.70 (15.69) | 38.80 (13.69) | 0.367 |

SD: standard deviation.

Table 3. Gender, affected hemisphere and comorbidities. General distribution of patients in Groups I and II according to gender, affected hemisphere, hypertensives, diabetics, smokers and alcohol consumers demonstrated in %.

| | Study group G1 | Control group G2 | Fisher's test (p-value) |
|---|---|---|---|
| Female | (5) 50% | (6) 60% | 1.000 |
| Male | (5) 50% | (4) 40% | |
| Right hemiparesis | (0) 0% | (4) 40% | 0.087 |
| Left hemiparesis | (10) 100% | (6) 60% | |
| Systemic arterial hypertension–Systemic Arterial Hypertension | (5) 50% | (8) 80% | 0.350 |
| Diabetes mellitus | (1) 10% | (5) 50% | 0.070 |
| Smoking | (4) 40% | (3) 30% | 1.000 |
| Alcohol consumption | (3) 30% | (2) 20% | 1.000 |

Table 1. Functional kinesiotherapy. Physical exercises for lower limbs with therapeutic objective for orthostatic position.

| Physical exercises | Therapeutic objectives |
|---|---|
| Passive mobilization, active assisted or active free exercises, of small and large joints of the axial and appendicular skeleton | Maintain or restore normal joint flexibility and prevent clinical complications arising from motor skill reduction |
| Passive, active assisted, free, and resisted exercises of excursion, stretching and muscle relaxation | Maintain or restore the viscoelastic properties of muscle fibers, preventing muscle shortening, as well as stimulating ideal tissue conditions for best neuromotor performance |
| Exercises that stimulate postural control, balance reactions and reactions of protection on stable and unstable surfaces in different postures (lying, sitting, on all fours, kneeling, half-kneeling, standing, one-leg support) | Stimulate the development of strategies to maintain balance and body protection, adjusting the posture |
| Exercises for aerobic capacity conditioning using functional activities (rolling, sitting, standing and walking), monitor blood pressure and heart rate | Improve cardiorespiratory fitness, preventing cardiovascular diseases and collaborating in the treatment of hypertension |

effect (p=0.019) (Fig 2). We have the following hierarchy as result: (Pre) <(10 sessions)=(20 sessions) for both groups, but the study group had higher responses at the three moments.

Table 5 shows the means and standard deviations of social aspects.

Fig 2 shows the confidence intervals for each combination of group and time of assessment of the sub-item social aspects for both groups.

Regarding other domains of the SF-36, and other items assessed, there was no significant difference from a statistical viewpoint.

## DISCUSSION

The functional electrical stimulation was well tolerated by all study patients, respecting their tolerance threshold.

Although some hemiparetic patients with ischemic CVA may show spontaneous improvement, best results occur when patients are treated with physical therapy[21,22].

Table 4. Means and standard deviations: functional capacity.

| Group | | Pre | 10 sessions | 20 sessions |
|---|---|---|---|---|
| | Mean | 61.85 | 64.63 | 67.42 |
| Control | SD | 2.61 | 5.04 | 6.81 |
| | n | 10 | 10 | 10 |
| | Mean | 62.80 | 69.03 | 76.02 |
| Study | SD | 3.01 | 7.59 | 7.98 |
| | n | 10 | 10 | 10 |
| ANOVA Table | | | | |
| Effect | | | | p-value |
| Group (Control x Study) | | | | 0.004* |
| Moment (pre, 10 sessions, 20 sessions) | | | | <0.001* |
| Group x Moment (interaction) | | | | 0.132 |
| Tukey's multiple comparisons for Moment effect | | | | |
| | | Pre | 10 sessions | 20 sessions |
| Pre | | | 0.050* | <0.001* |
| 10 sessions | | 0.050* | | 0.132 |
| 20 sessions | | <0.001* | 0.132 | |

SD: standard deviation; *statistically significant.

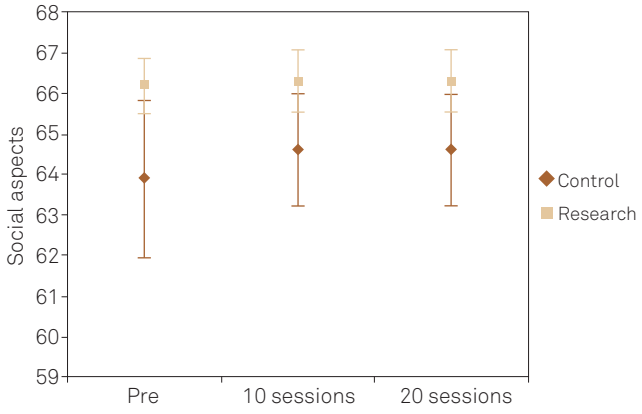


Fig 2. Confidence intervals for each combination of group and moment of assessment of the social aspects sub-item for both groups.

The element that made up the study intervention and promoted satisfactory results was the fact that the beginning of the program did not exceed 40 days since the CVA onset. It has been suggested that treatment started as soon as possible is a factor to achieve more satisfactory results[22]. Some authors have inferred that the early start of therapy seems to be more important for patient evolution than the duration of the program[23].

Regarding muscle strength, the study showed a significant increase in strength after the treatment period, in flexion and knee extension for both groups, with no difference between them. The improved strength in GI (FES+FK) is consistent with the studies of Kesar et al.[24], which determined that the FES facilitates recovery of muscle strength, increasing isometric strength of knee extensors and flexors in individuals with hemiparesis due to CVA.

Traditionally, epidemiological studies with a population of CVA patients are focused on mortality and its occurrence, but not on quality of life of these patients[25], considering that the dysfunctions and disadvantages in this regard are significant for CVA patients[26].

Although the quality of life for CVA patients is clearly influenced by multiple factors, functional independence is one of the most important factors[27].

In this study, regarding quality of life, the results demonstrated significant improvement in the group that underwent treatment with FES+kinesiotherapy, in the functional capacity and social aspects domains, demonstrating that the combination of the two techniques was more beneficial than kinesiotherapy alone. For the pain, vitality and mental health domains, there was significant improvement for both groups at the moment effect (pre, 10 and 20 sessions) (p<0.001) and in the mental health item, there was also a significant difference in the interaction effect (p=0.012).

Several studies differ regarding the training protocol with FES associated with several techniques according to the aforementioned studies. With these differences, it becomes difficult to evaluate which protocol would be recommended for lower-limb improvement in the hemiparetic patient.

Table 5. Means and standard deviations: social aspects.

| Group | | Pre | 10 sessions | 20 sessions |
|---|---|---|---|---|
| | Mean | 63.90 | 64.60 | 64.60 |
| Control | SD | 2.96 | 2.12 | 2.12 |
| | n | 10 | 10 | 10 |
| | Mean | 66.20 | 66.30 | 66.30 |
| Study | SD | 1.03 | 1.16 | 1.16 |
| | n | 10 | 10 | 10 |
| ANOVA Table | | | | |
| Effect | | | | p-value |
| Group (Control x Study) | | | | 0.034* |
| Moment (pre. 10 sessions. 20 sessions) | | | | 0.019* |
| Group x Moment (interaction) | | | | 0.097 |

SD: standard deviation; *statistically significant.

This study was important, as in addition to showing the effects of FES, functional kinesiotherapy and associated treatment, it also evaluated the quality of life and activities of daily living of the patient. These variables are significantly impaired in many aspects, especially when the patient is affected by an ischemic CVA in the acute and subacute phases.

In conclusion, functional electrical stimulation associated with functional kinesiotherapy was more effective than functional kinesiotherapy alone, regarding quality of life in the domains (functional capacity and social aspects). Both muscle strength and passive and active range of motion as well as activities of daily living showed no difference between the groups.

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