ORIGINAL ARTICLE

Electromyography of the upper limb muscles of patients with hemiparesis using Mirror Therapy

Avaliação eletromiográfica dos músculos do membro superior de indivíduos hemiparéticos com uso da Terapia do Espelho

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http://dx.doi.org/10.11606/issn.2238-6149.v27i3p278-288

Rodrigues ACT, Faganello-Navega FR. Electromyography of the upper limb muscles of patients with hemiparesis using Mirror Therapy. Rev Ter Ocup Univ São Paulo. 2016 Sept.-Dec.;27(3):278-88.

ABSTRACT: The aim of this study was to analyze muscle electrical activity during the performance of the Mirror Therapy with the upper limb of paretic subjects with stroke. This is a quantitative character study. Participated in this survey ten users of SORRI - BAURU Rehabilitation Center with stroke history for at least six months with hemiparesis sequel. Data collection was formed by the application of the Modified Ashworth Scale and electromyographic evaluation of the affected upper limb in the following muscles: abductor pollicis brevis, flexor carpi radialis, extensor carpi ulnaris, biceps and triceps. The analysis of the EMG signal was performed in specific routines developed in Matlab (Mathworks®) and statistical analysis was applied using ANOVA for repeated measures, adopting the significance level of $p<0.05$. Significant differences were found on the data for abductor pollicis brevis ($p = 0.005$); flexor carpi radialis ($p = 0.032$); biceps ($p = 0.002$) and triceps ($p = 0.024$), probably due to an adjustment of tone during the course of mirror therapy, however, it is still necessary to carry out studies comparing these data before and after the intervention using the technique in search of a more effective motor recovery member affected.

KEYWORDS: Stroke; electromyography; Occupational therapy.

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RESUMO: O objetivo deste estudo foi analisar a atividade elétrica muscular durante a realização da Terapia do Espelho no membro superior parético de indivíduos com sequela de AVE. Trata-se de um estudo de caráter quantitativo. Participaram desta pesquisa dez usuários do Centro de Reabilitação SORRI-BAURU, com histórico de AVE há pelo menos seis meses, com sequela de hemiparesia. A coleta de dados foi constituída pela aplicação da Escala Modificada de Ashworth e avaliação eletromiográfica dos seguintes músculos do membro superior acometido: abdutor curto do polegar, flexor radial do carpo, extensor ulnar do carpo, bíceps e tríceps. A análise do sinal EMG foi realizada em rotinas específicas desenvolvidas em ambiente Matlab (Mathworks®) e a análise estatística feita através do teste ANOVA para medidas repetidas, sendo adotado o nível de significância de $p<0,05$. Foram encontradas diferenças significativas nos dados referentes aos músculos abdutor curto do polegar ($p=0,005$); flexor radial do carpo ($p=0,032$); bíceps ($p=0,002$) e tríceps braquial ($p=0,024$), provavelmente, devido a uma adequação do tônus durante a realização da Terapia do Espelho, porém, ainda é necessária a realização de estudos que comparem estes dados pré e pós-intervenção com o uso da técnica, em busca de uma recuperação motora mais efetiva do membro acometido.

DESCRITORES: Acidente vascular Encefálico; eletromiografia; Terapia ocupacional.

Article based on the Master's dissertation presented at the Biosciences Institute (Rio Claro Campus) of Universidade Estadual Paulista (UNESP), as part of the requirements for the master's degree in the Human Development and Technologies Graduate Program.

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INTRODUCTION

Over the years, we can observe a significant increase in the incidence of cerebrovascular accident (CVA) in the world, with growth in the number of individuals with neurological disorders and sequelae[1].

Among the compromises caused by CVA, hemiparesis on the contralateral side of the lesion is one of the most frequent and refers to muscle weakness or partial motor paralysis in a hemibody[2]. Hemiparesis may cause losses in upper limb fine and global motor coordination, with deficits in motion range, reach, hold and, function[3], causing great deleterious effects to independence during the performance of everyday activities. In addition, there may occur spasticity, defined as "the increase, speed dependent, of muscle tonus, with exacerbation of deep reflexes, resulting from hyperexcitability of the stretch reflex[4]".

One of the ways to evaluate the deficits caused by hemiparesis and by spasticity in the upper limb is through Surface Electromyography (EMG), which is an important surface quantitative method for evaluating muscle electrical activity[5].

Studies of Pereira and Araújo[6], Campos et al.[7], and Song and Tong[8] showed that detailed observation of the behavior of the paretic upper limb is enabled through surface EMG[6-8] and demonstrated that the hypertonic muscle's electromyographic signal is significantly different in relation to the noncompromised side, and EMG activity in the spastic side is higher than in the noncompromised side at rest and in reflex and lower in maximum voluntary contraction[6]. In addition, there is greater involvement of distal flexor muscles in relation to proximal ones[7] and excessive co-contraction between agonists and antagonists that result in decreased general motor performance in the upper limb affected by CVA[8].

In an attempt to minimize sensorimotor deficits and accelerate the process of functional recovery, occupational therapists have used a technique on upper-limb rehabilitation in hemiparetic patients: Mirror Therapy[9]. Introduced by Ramachandran and Rogers in 1992 in the treatment of patients with phantom pain, this technique is based on neuroplasticity and activation of mirror neurons[5] and consists in re-educating the brain through a series of movements with the unaffected limb, which is seen in the mirror as if it were the paretic limb. With that, it is intended that the brain simulate the movements performed with the affected limb due to the functional limb's reflection on the mirror, with the aim of improving motor response[9].

Several studies sought to demonstrate the effects of Mirror Therapy on the recovery of hemiparetic patients, observing improved movement and function in the affected upper limb in all studies[10-12]; however, the authors found no studies that measure muscle electrical activity in paretic upper limb through EMG using Mirror Therapy.

Thus, our study is justified, since many post-CVA individuals maintain no functional use of the paretic limb and EMG is an instrument for quantitative analysis, which minimizes the occurrence of possible errors made by subjective evaluations such as questionnaires and scales.

Therefore, this study aimed to analyze muscle electrical activity during Mirror Therapy on paretic upper limb of individuals with CVA sequelae. The hypothesis is that Mirror Therapy can cause a change to the paretic upper limb's muscle electrical activity pattern compared with the execution of the proposed exercises with no use of mirror.

MATERIAL AND METHODS

This is a study of quantitative character. The bibliographic survey to support the theoretical framework was performed in the databases Pubmed, Lilacs, and Bireme. The project was submitted and approved by the Committee of Ethics in Research involving humans of the UNESP – Faculdade de Filosofia e Ciências (FFC) – campus Marília through the protocol number 1111/2014 and by the Brazil Platform through the CAAE number 52659216.1.0000.5406.

This work was conducted from March 2014 to March 2016, during the period proposed for preparation of Master's thesis by the Human Development and Technologies Program of the Institute of Bioscience of the Universidade Estadual Paulista (UNESP), campus Rio Claro. Data collection was conducted in the first half of 2015.

Participants

Participated in this research ten users of the Rehabilitation Center SORRI-BAURU, of both sexes, aged above 30 years, with a history of Cerebrovascular Accident (CVA), with sequela of hemiparesis, and that presented no cognitive compromises.

The volunteers were selected according to the following criteria: history of up to two episodes of CVA, resulting in sequela of hemiparesis in only one upper limb; having a minimum of six months of injury; having performed no application of botulinum toxin type A (BTA) in the muscles of the affected upper limb; compromised upper limb having active range of motion of at least 45 degrees of shoulder flexion and abduction, 20 degrees of elbow extension, 10 degrees of wrist extension, 10 degrees of thumb extension/abduction, and 10 degrees of extension in metacarpophalangeal and interphalangeal joints in at least two fingers in addition to the thumb[13], measured by goniometry of the limb; presenting, in the application of the Mini Mental State Examination (Mini Mental), higher score than the cutoff point according to the individual's education level (above 23 points for highly educated individuals, above 17 for individuals with high school education, and above 13 for illiterate individuals[14]).

Procedures

Participants were selected through the electronic health record of the SORRI-BAURU. Participants who agreed to participate in the research signed the informed consent, received the necessary guidelines about the research and how it would be performed and, then, initiated the practical procedures.

Data collection was performed individually in only one day per participant and comprised, primarily, application of Mini Mental State Examination and goniometry test of paretic upper limb, instruments used as eligibility criteria. Goniometry test was performed with two goniometers: one large goniometer (universal) of 20 cm to measure active range of motion of shoulder, elbow, and wrist and one goniometer for fingers and small joints to measure active range of motion of fingers. For better standardization, participants were seated and we evaluated the arch of joint motion on the proximal to distal order. All volunteers evaluated were eligible to complete data collection.

Then, anamnesis was performed, the Modified Ashworth Scale applied, and electromyographic assessment of the affected upper limb conducted.

Modified Ashworth Scale

The Ashworth Scale is a tool developed by Ashworth in 1964 to measure the degree of spasticity of a limb. Aiming to improve the evaluation instrument, Bohannon and Smith[15] modified the scale, adding the 1+ degree, naming it the Modified Ashworth Scale. In the application, the examiner should move along its joint range, passively, the patient's segment corresponding to the muscle or group of muscles to be evaluated and grade the resistance found[15].

Currently, this scale is the most widely used for this purpose, although the literature presents limitations, among them, its subjectivity[16]. Concerning the scale's positive points, we can mention the fact that it requires no equipment for evaluation, no material expenditure, being easy to implement and fast[15,16].

Research participants were submitted to application of Modified Ashworth Scale to the hemiparetic upper limb, wrist and elbow flexor muscle groups, seeking a relation between the increase of tonus and the results to be found in EMG with Mirror Therapy. The muscle groups were assessed with the patient in a sitting posture.

Surface Electromyography

For evaluation of muscle electrical activity through surface EMG, participant remained seated in front of a table with upper limbs supported.

Data for electromyographic activity is obtained through an analog signal that must be converted to digital signal to be viewed through a specific software on the computer, such data is obtained by Lynx equipment®, brand Lynx Tecnologia Eletrônica Ltda., of 6 channels with sampling frequency selected to 2000Hz. We used disposable passive electrodes Solidor, manufactured by Medico Electrodes International®, model MSGST-06, of Ag/AgCl, with solid gel and foam. An electrode coupled to the lateral malleolus of the lower limb contralateral to hemiparesis was used as reference to reduce the noise during the acquisition of the signals.

We also used a laptop model HP mini 110-3100, manufactured by Hewlett-Packard, Intel® Atom™ processor with specific software for registration and analysis of electromyographic activity data.

We evaluated the following muscles of the upper limb affected by hemiparesis: short abductor of thumb, radial flexor of carpus, ulnar extensor of carpus, brachial triceps and biceps. To decrease the impedance, we performed shaving with a disposable razor and asepsis of the skin with cotton soaked with 1.5 mL of 70% ethyl alcohol in regions where, later, the electrodes would be positioned. The placement and positioning of electrodes followed the determinations of the Surface Electromyography Protocol for the Non-Invasive Assessment of Muscles (Seniam) protocol for short abductor muscle of thumb, biceps, and triceps, of Mogk and Keir[17] for radial flexor of carpus, and of the Electronic Myoanatomical Atlas for Clinical

Electromyography of CASA Engineering for the ulnar extensor muscle of carpus.

First, we evaluated the electromyographic activation of the hemiparetic side at rest, in one minute. Then, five types of exercises were performed, with a series of 10 repetitions each, with 30 seconds intervals each, as follows:

- Active exercise of thumb abduction and adduction, starting from adducted position with forearm in neutral position;
- Active exercise of thumb flexion and extension, starting from a point drawn in the participant's index finger, corresponding to the extension, with forearm supine;
- Active exercise of flexion and extension of the wrist with tenodesis, initiating the sequence with flexed wrist and fingers in extension, with forearm in neutral position;
- Active exercise of elbow flexion and extension, starting with extended elbow and forearm supine.
- Active exercise of pronation/supination, with elbow flexed to 90 degrees, starting with forearm pronated.
- The exercises described above were carried out in four random situations, selected by drawing lots prior to data collection with the participants: performing the proposed movements only with the preserved side; performing the movements with both limbs at the same time; using the mirror supported sagittally, performing the movements only with the unaffected side; and using the mirror, performing the exercises with both upper limbs. At each stage, the participant was instructed about the activity that should be performed.

Mirror therapy

For electromyography in conjunction with the mirror technique, we coupled an ordinary mirror of 38 cm x 48 cm to a base, for better positioning and safety, supported sagittally in relation to the participant and provided the necessary guidelines for them to understand that they should perform the movements with the preserved limb, but always looking at the limb's reflection on the mirror. A familiarization session of 10 minutes was held with standardization of verbal commands and the same sequence of exercises for all participants, minimizing errors in data collection.

The results expected in the sequence of exercises performed with the mirror – asking the participant to use only the unaffected limb – followed the same assumptions pointed in the literature about Mirror Therapy, which state that the reflection of the mirror gives the patient the vision of the unaffected hand and of the reflected hand, as if it were the affected limb, leading the participant's brain to understand that the movements performed by the noncompromised limb are also being performed by the affected side, improving motor response.

DATA ANALYSIS

The visualization and digital processing of the electromyographic signal were performed by the AqDados 7.02 and AqAnalysis programs, and the signals were evaluated through the values of the linear envelopment integral, using as reference the data of each muscle at rest.

The EMG signal analysis was performed in specific routines developed in Matlab environment (Mathworks®). Data processing was performed using a bandpass filter of 20–500Hz. Then, the signal was rectified using the full-wave rectification method. To create the linear envelopment we used a low-pass filter of fourth order with cutoff frequency of 6Hz for signal smoothing. All electromyographic signal registration and analysis procedures followed the Standards for Reporting EMG Data.

Subsequently, the data were grouped in Excel worksheets for presentation in mean and standard deviation. After that, we applied statistical analysis using SPSS® software and ANOVA test for repeated measures, adopting the significance level of $p<0.05$.

RESULTS

Study participants were 10 volunteers with mean age of 53.4 (±13.71) years; of these, 60% were male and 40% were female. Table 1 shows the data of the volunteers.

In order to compare the participants' percentage of muscle electric activation during specific exercises in relation to rest, electromyographic collection was conducted at rest. The results in mean and standard deviation for the muscles evaluated – namely, short thumb abductor, radial carpal flexor, ulnar carpal extensor, brachial biceps, and brachial triceps of the volunteers' hemiparetic upper limb – are described in Figure 1.

To observe the patients' electromyographic activation, the routine in Matlab environment – in addition to showing the absolute values – was created in order to compare the percentage of activation of each muscle in each exercise over the absolute value at rest of each muscle. Thus, Table 2 presents the values of means and standard deviation for each muscle evaluated in each exercise and during the four conditions employed. On average, when greater than zero, the percentage of muscle activation during the exercise described was higher than the percentage at rest. When less than zero, the percentage of activation of the muscle described was higher during the rest period than during the proposed exercise.

Table 1 – Characterization of sample M: male; F: female; m: months; y: years; I: ischemic; H: hemorrhagic; SD: standard deviation

VOLUNTEER	AGE	SEX	CVA TIME	I OR H	PARETIC LIMB	ASHWORTH BICEPS	ASHWORTH FL. Fist	MINI MENTAL
1	51	M	6 m	H	RIGHT	1	1	17
2	71	M	6 m	I	LEFT	0	0	24
3	67	F	6 m	I	LEFT	1+	1+	26
4	62	M	7 m	I	RIGHT	0	0	29
5	35	F	1y 7m and 1y 6m	I and H	RIGHT	0	1	28
6	41	M	9 m	I	RIGHT	0	0	25
7	33	F	9 m	I	RIGHT	0	0	17
8	67	M	12 m	I	RIGHT	0	0	30
9	50	M	1y 1m	I	LEFT	1	0	28
10	57	F	1y 2m	H	RIGHT	1+	0	30
MEAN	**53.4**							**25.4**
SD	**±13.71**							**±4.85**

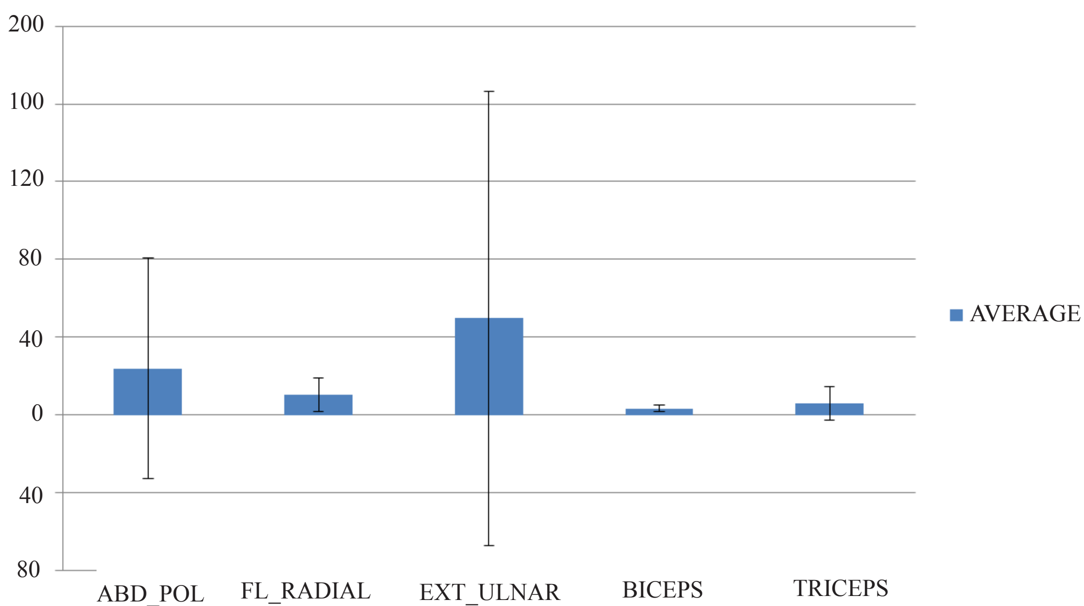

Figure 1 – Mean and standard deviation of the electromyographic activity of the five muscles collected during the volunteers' rest period. Abd_thumb: short thumb abductor muscle; fl_radial: radial carpal flexor muscle; ext_ulnar: ulnar carpal extensor muscle

Table 2 – Values of mean and standard deviation of the percentage of electromyographic activation during exercise in relation to rest of all muscles analyzed, in all situations. Values that showed significant difference ($p<0.05$) are bold in the table. Abd_thumb: short abductor muscle of thumb; fl_radial: radial flexor muscle of carpus; ext_ulnar: ulnar extensor muscle of carpus.

	EXERCISE OF ABDUCTION/ADDUCTION OF THUMB									
	LIMB NOT AFFECTED - NO MIRROR					LIMB NOT AFFECTED - WITH MIRROR				
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	**-122,05**	-141,04	-248,75	-37,86	-23,73	**-150,73**	-179,33	-427,84	-27,03	-32,02
SD	**±154,17**	±274,78	±549,8	±104,77	±58,1	**±247,26**	±279,84	±738,8	±76,26	±69,09
	TWO HANDS - NO MIRROR					TWO HANDS - WITH MIRROR				
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	48,87	-47,6	-2,99	0,45	-20,51	34,82	0,19	31,48	-3,81	-13,81
SD	±36,99	±109,31	±121,81	±73,23	±84,2	±101,83	±61,92	±68,72	±76,38	±88,9
	EXERCISE OF FLEXION/EXTENSION OF THUMB									
	LIMB NOT AFFECTED - NO MIRROR					LIMB NOT AFFECTED - WITH MIRROR				
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	-150,7	-279,31	-308,5	-45,72	-59,22	-92,42	-215,93	-478	-11,91	-17,46
SD	±203,48	±441,66	±810,77	±121,27	±91,08	±182,39	±291,69	±804,02	±54,85	±46,04
	TWO HANDS - NO MIRROR				TWO HANDS - WITH MIRROR					
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	41,26	-60,22	22,99	45,07	-30,7	35,36	-109,59	-21,74	26,66	-29,85
SD	±57,39	±104,23	±63,83	±39,66	±80,52	±59,91	±192,49	±134,58	±59,52	±127,26
	EXERCISE OF FLEXION/EXTENSION OF WRIST									
	LIMB NOT AFFECTED - NO MIRROR					LIMB NOT AFFECTED - WITH MIRROR				
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	-79,07	**-135,92**	-328,35	-45,83	-65,65	-85,54	**-209,61**	-497,94	-22,24	-21,03
SD	±93,22	**±250,45**	±799,01	±108,3	±80,89	±182,99	**±250,72**	±851,98	±73,56	±51,6
	TWO HANDS - NO MIRROR					TWO HANDS - WITH MIRROR				
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	1,04	1,8	20,96	31,79	-38,27	-85,58	-38,35	-12,71	54,9	-31,39
SD	±96,81	±99,15	±68,8	±51,43	±80,42	±246,19	±189,5	±125,82	±41,52	±67,93
	EXERCISE OF FLEXION/EXTENSION OF ELBOW									
	UNAFFECTED LIMB - NO MIRROR					UNAFFECTED LIMB - WITH MIRROR				
	abd_thumb	fl_radial	ext_ulnar	biceps	triceps	abd_thumb	fl_radial	ext_ulnar	biceps	triceps
MEAN	-89,81	-133,71	-226,16	**-20,83**	**-35,58**	-13,69	-167,05	-183,89	**-23,09**	**-22,89**
SD	±118,56	±281,57	±551,89	**±96,05**	**±86,16**	±48,99	±218,89	±309,22	**±75,66**	**±68,93**

Continues...

Table 2 – Values of mean and standard deviation of the percentage of electromyographic activation during exercise in relation to rest of all muscles analyzed, in all situations. Values that showed significant difference (p<0.05) are bold in the table. Abd_thumb: short abductor muscle of thumb; fl_radial: radial flexor muscle of carpus; ext_ulnar: ulnar extensor muscle of carpus.

	TWO HANDS - NO MIRROR					**TWO HANDS - WITH MIRROR**				
	abd_thumb	**fl_radial**	**ext_ulnar**	**biceps**	**triceps**	**abd_thumb**	**fl_radial**	**ext_ulnar**	**biceps**	**triceps**
MEAN	-62,99	-68,2	-77,74	75,8	8,27	-20,26	-61,2	-373,87	63,89	13,68
SD	±160,01	±192,69	±292,66	±28,41	±78,5	±97,58	±192,58	±1000,4	±49,89	±52,52
	EXERCISE OF PRONATION/SUPINATION OF FOREARM									
	UNAFFECTED LIMB - NO MIRROR					**UNAFFECTED LIMB - WITH MIRROR**				
	abd_thumb	**fl_radial**	**ext_ulnar**	**biceps**	**triceps**	**abd_thumb**	**fl_radial**	**ext_ulnar**	**biceps**	**triceps**
MEAN	-207,37	-87,56	-299,81	**-42,84**	-27,53	-108,3	-227,43	-455,29	**-46,15**	-45,77
SD	±276,87	±208,71	±774,69	±**118,48**	±80,22	±191,51	±263,36	±916,95	±**103,31**	±46,69
	TWO HANDS - NO MIRROR					**TWO HANDS - WITH MIRROR**				
	abd_thumb	**fl_radial**	**ext_ulnar**	**biceps**	**triceps**	**abd_thumb**	**fl_radial**	**ext_ulnar**	**biceps**	**triceps**
MEAN	7,41	-77,79	29,2	43,82	-1,35	40,41	-14,62	14,03	13,86	-11,51
SD	±63,53	±244,55	±72,7	±48,3	±74,5	±24,69	±131,4	±78,47	±84,9	±76,19

ANOVA test for repeated measures showed significant difference in the following situations: Thumb abductor muscle during thumb adduction/abduction exercise (p=0.005); radial carpal flexor muscle during wrist flexion/extension (p=0.032); brachial biceps muscle during elbow flexion/extension (p=0.002) and forearm pronation/supination (p=0.025); and brachial triceps muscle during elbow flexion/extension (p=0.024); all with exercises performed only with the limb unaffected by hemiparesis, with mirror and without mirror, and this is the percentage of electric activation during exercise in relation to rest. No significant difference was found related to the extensor Carpi ulnaris muscle. Figure 2 illustrates these data.

Finally, in the agonist/antagonist relation, statistically significant difference was found between the brachial triceps and biceps muscles during elbow flexion and extension, and the data are presented in Figure 3. No significant differences were found between the wrist flexor and extensor muscles evaluated.

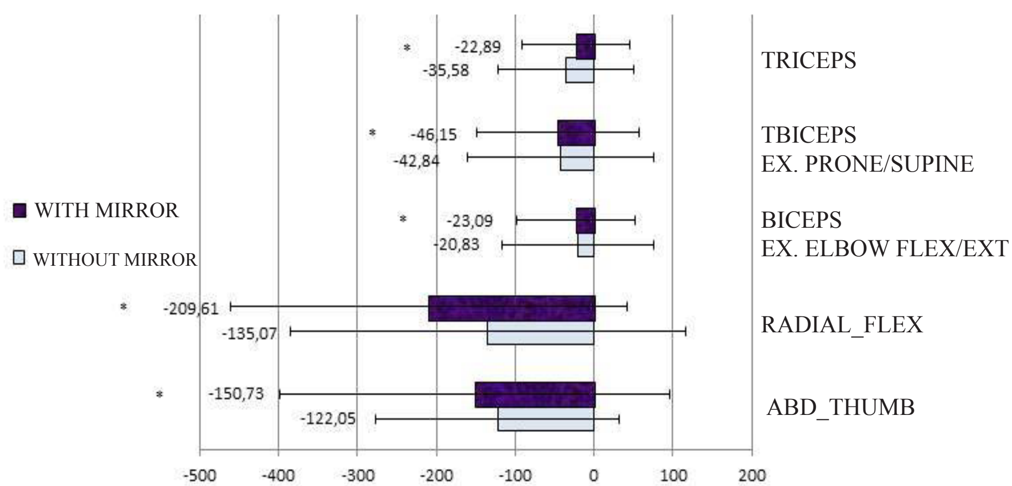

Figure 2 – Electromyographic data that presented statistically significant difference, comparing the electrical activation with mirror and with no mirror, performing the exercises only with the noncompromised limb. Percentage of activation during exercise in relation to rest. Abd_thumb: abductor muscle of thumb; Fl_radial: radial flexor muscle of carpus; Ex. fl/ext elbow: exercise of flexion/extension of elbow; Ex. prone/supine: exercise of pronation/supination of forearm. *: p<0.05.

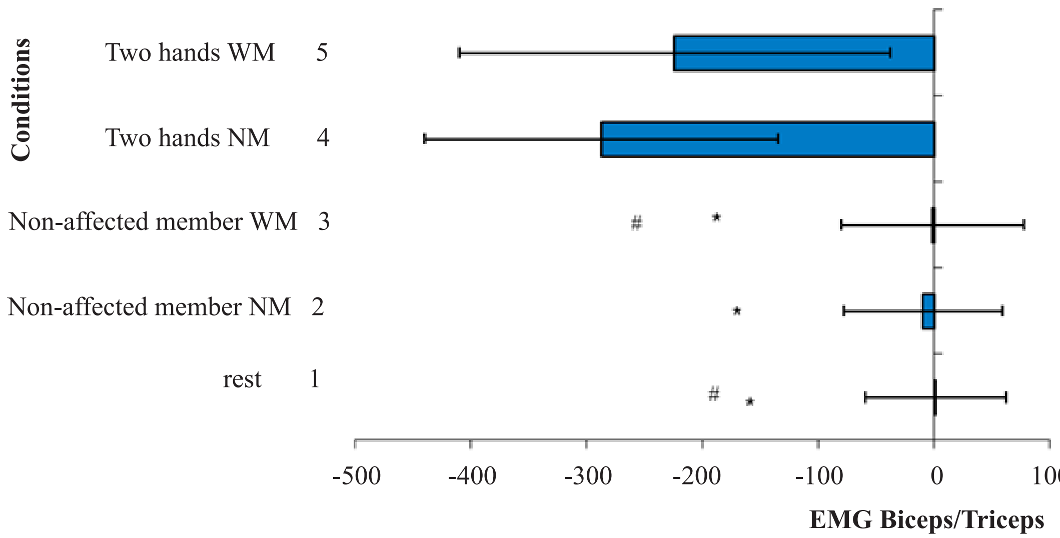

Figure 3 – Agonist/antagonist relation between biceps and triceps during all conditions tested. When greater than zero, higher activation of biceps in relation to triceps. When less than zero, higher activation of triceps in relation to biceps. *: Conditions 1, 2, and 3 different from condition 4; #: conditions 1 and 3 different from condition 5. $p<0.05$. WM: with mirror; NM: no mirror.

DISCUSSION

The study aimed to analyze the muscle electrical activity during Mirror therapy on paretic upper limb of individuals with CVA sequela.

According to the results found at rest, we could observe greater involvement of distal flexor muscles in relation to proximal flexor muscles, since distal activity was greater than proximal activity, corroborating the findings of Campos et al.[7], indicating the predominance of spasticity in the distal joint motion of the affected upper limb. This result justifies the fact that the major challenge in the rehabilitation of post-CVA patients is improving the upper-limb distal mobility, particularly in the improvement of wrist extension. Thus, the data presented enable relating the upper limb distal muscle hyperactivity observed at rest and the higher compromise of these muscles in hemiparesis[7], having a lower percentage of activation in relation to proximal muscles during active exercises.

No results found showing higher increase in tonus for distal flexor muscles in relation to distal extensor muscles at rest, i.e., higher electromyographical activation of the radial flexor muscle in relation to the ulnar carpal extensor. As in the study of Campos et al.[7], it was expected that, due to the presence of flexor muscle activity because of some volunteers' spasticity, the antagonist would be inhibited reflexively, hence being relaxed; however, this fact was not observed in the results.

Musampa et al.[18] demonstrated – in a study with 10 healthy individuals and 11 post-CVA individuals , through surface EMG – alteration in the regulation of stretch reflex between agonists/antagonists of the elbow flexor and extensor muscle groups, due to hypertonicity of the flexor of patients with spasticity and, since regulation of the stretch reflex has been described as the main mechanism of control of posture and of movement in healthy subjects, they suggested the evaluation of both upper limbs of post-CVA individuals, and not only of the hemibody affected by hemiparesis. The results found in our study corroborate the findings of Musampa et al.[18] and of Gerachshenko et al.[19], in which they observed antagonist muscle activity (extension) at rest in the upper limb of hemiparetic individuals.

It is important to note that, differently from the research of Pereira and Araújo[6], which showed – in a study with 25 healthy individuals and 25 post-CVA individuals, at rest – that the more severe the spasticity, the higher the EMG signal for the brachial biceps muscle; another hypothesis for the nonoccurrence of higher flexor muscle activity in relation to the proximal extensor at the volunteers' rest is due to the low score in the Modified Ashworth Scale of the patients, as, if volunteers with high degree of spasticity were selected for the study, they could not carry out the proposed exercises, as shown by other authors, who observed that the spasticity influences towards a poor performance in tests of manual dexterity of the upper limb, besides being related with muscle weakness, and patients with higher spasticity have higher deficit for strength and dexterity[20,2].

The muscles short thumb abductor, radial carpal flexor, and brachial biceps showed decreased electrical activity during exercises in which the muscles are responsible, respectively, for thumb abduction/adduction, wrist flexion/extension, and elbow flexion/extension when using the mirror technique compared with nonuse of the mirror, probably due to a higher adaptation of muscle tonus, agreeing with the study's hypothesis that there would be alteration in muscle electrical activity with Mirror Therapy. We believe that this decrease in electrical activity concerns the interhemispheric inhibition, studied by Ward and Cohen[21] and by Guimarães et al.[22], a concept that shows that, when performing motion with the unaffected upper limb, motor activity is reduced in the hemiparetic side. In the case of our research, electrical activity was reduced because the patients showed some activation at rest due to spasticity presented, although at lower levels. Probably, with prolonged intervention, it would be possible to observe motor recovery in these patients, since, in our study, it has been possible to observe, through the evaluation and familiarization, a change in the electromyographic pattern of the muscles under study, a result of the probable adaptation of tonus, a necessary requirement for motor recovery itself, as stated by Luvizutto and Gameiro[23].

This change in electrical activity was also observed in the brachial biceps muscle during pronation/supination exercise, since the biceps, in addition to being responsible for elbow flexion, also assists the supinator muscle in forearm supination exercise.

On the other hand, the muscles analyzed showed lower percentage of activation during exercises with the contralateral limb without using mirror, compared with rest, enabling observe that there was adaptation of tonus through interhemispheric inhibition; however, this fact also occurred during Mirror Therapy, in which only the evaluation and familiarity were not sufficient for patients to perform effectively the movement with the hemiparetic limb. Therefore, we believe to be necessary the intervention with use of Mirror Therapy, as conducted by researchers such as Altschuler et al.[10] who performed the therapy for 4 weeks; Stevens and Stoykov[11], 3 weeks; and Yavuzer et al.[12] for 4 weeks.

We could observe in the agonist/antagonist relation of the brachial biceps and triceps that there was a higher electromyographical activation of biceps compared with triceps at rest, which was expected due to the presence of flexor spasticity in the patients. During exercises with the contralateral limb, the biceps tonus underwent adaptation, decreasing its activity and, consequently, increasing the activity of the triceps, its antagonist. During exercises with both upper limbs, triceps activation was considerably higher compared with biceps activation in elbow flexion and extension exercise, agreeing with the assumptions that spasticity collaborates to inadequate motor unit recruitment and, consequently, to poor general motor performance of the limb[24,25].

A limitation of the study is the fact that no comparison was performed between the upper limb affected by hemiparesis and the contralateral side of the volunteers, dominance was not determined, and no assessment of the volunteers' sensitivity was carried out .

It is necessary to conduct future studies that compare the upper limb muscle electrical activity of post-CVA individuals before and after intervention with Mirror Therapy, in addition to the use of another functional evaluation instrument combined with surface electromyography.

CONCLUSION

Considering the results, we could observe changes in the electromyographic activity of muscles of the hemiparetic upper limb of post-CVA individuals using Mirror Therapy; however, it is still necessary to conduct studies that compare these data pre- and post-intervention with the technique, seeking a more effective motor recovery of of the affected limb.

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Received: 04.24.16
Accepted: 09.12.16