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ORIGINAL RESEARCH

Effects of mirror therapy through functional activites and motor standards in motor function of the upper limb after stroke

Efeito da terapia de espelho por meio de atividades funcionais e padrões motores na função do membro superior pós-acidente vascular encefálico

Efecto de la terapia del espejo por mediante actividades funcionales y patrones motores em la función del miembro superior después de um accidente cerebrovascular

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ABSTRACT | The study aimed to evaluate the effects of mirror therapy through functional activities and motor standards in upper limb function of chronic stroke subjects. Six patients with paresis of the arm within at least six months after stroke were randomly to a group of functional activities (GAF – n=3) and group of motor standards (GPM – n=3). Both groups performed 15 sessions of mirror therapy for 30 minutes, but the first one (GAF) were instructed to do the bilateral and symmetrical movements based on functional activities (i.e. games fitting) and the second one (GAP) made movements based on normal motor patterns (i.e. wrist flexion-extension). There was no statistical significance between pre- and post-treatment for both groups independently. However, analyzing the groups together (n=6), it was observed significance values in the cognitive and total MIF (p=0.002) pre- and post-mirror therapy. This study showed improvement in the functional impairment whatever the type of movement made during the mirror therapy.

Keywords | Stroke; Upper Extremity; Mirror Neurons.

RESUMO | O objetivo do estudo foi avaliar os efeitos da aplicação da terapia de espelho por meio de atividades funcionais e padrões motores do movimento na função motora do membro superior de hemiparéticos crônicos pós-Acidente Vascular Encefálico (AVE). Seis pacientes com hemiparesia do braço com pelo menos seis meses pós-AVE foram randomizados para um grupo de atividades funcionais (GAF – n=3) e um grupo de padrões motores (GPM – n=3). Ambos os grupos realizaram 15 sessões de terapia de espelho por 30 minutos, mas o primeiro (GAF) foi instruído a fazer movimentos bilaterais e simétricos baseados em atividades funcionais (isto é, jogos de encaixe) e o segundo (GPM), a fazer movimentos baseados em padrões motores normais (isto é, flexão-extensão de punho). Não houve significância estatística entre o pré e o pós-tratamento para ambos os grupos de modo independente. No entanto, analisando os grupos em conjunto (n=6), foram observados valores significativos na medida de independência funcional (MIF) cognitiva e total (p=0,002) pré e pós-terapia de espelho. Este estudo mostrou melhora no comprometimento funcional seja qual for o tipo de movimento feito durante a terapia de espelho.

Descritores | Acidente Vascular Cerebral; Extremidade Superior; Neurônios-Espelho.

RESUMEN | El objetivo del estudio fue evaluar los efectos de la aplicación de la terapia de espejo por medio de

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actividades funcionales y patrones motores del movimiento en la función motora del miembro superior de hemiparéticos crónicos pos-Accidente Vascular Encefálico (AVE). Seis pacientes con hemiparesía del brazo con al menos seis meses pos-AVE fueron asignados de modo aleatorio a un grupo de actividades funcionales (GAF – n=3) y un grupo de patrones motores (GPM – n=3). Ambos grupos realizaron 15 sesiones de terapia del espejo durante 30 minutos, pero el primero (GAF) fue orientado a hacer movimientos bilaterales y simétricos en base a las actividades funcionales (es decir, juegos de encaje) y el segundo (GPM), a hacer movimientos basados en patrones motores normales (es decir, flexión-extensión de la muñeca). No hubo diferencias estadísticamente significativas entre pre y post-tratamiento para ambos grupos de forma independiente. Sin embargo, el análisis de los grupos en conjunto (n=6) demostró valores post-terapia significativos en la Medida de Independencia Funcional (MIF) cognitiva y total (p=0,002) pre y post-terapia de espejo. Este estudio mostró una mejoría en el deterioro funcional en cualquier tipo de movimiento realizado durante la terapia del espejo.

Palabras clave | Accidente Cerebrovascular; Extremidad Superior; Neuronas Espejo.

INTRODUCTION

Cerebral vascular accident (CVA), or stroke, is a vascular acute neurological dysfunction caused by the interruption of blood flow to focal areas of the brain[1,2]. Sequelae are often disabilities, and global involvement interferes significantly with Activities of Daily Living (ADLs)[2].

The upper limbs (UL) are very important to motor functionality and the effective handling, gripping and reaching capability required in most ADLs. Arm functions are impaired in 73-88% of CVA survivors, and 55-75% of them present hemiplegia, resulting in disabilities and restrictions to function[3-5].

Some studies point that sensorial-motor skill training and motor learning training with repetitive movements by the patient, with introduction of new movements in oriented environments are essential to reduce motor impaiment[6]. Among therapies available for the upper limbs, electrical stimulation therapy, electromyographic (EMG) biofeedback, mirror therapy, constraint-induced movement therapy (CIMT), Sensory-Motor Imagery Training, and robotic-assisted rehabilitation take pride of place in the recovery of these subjects[3-5,7-9]. Apart from the improvements in arm functions, studies do not bring data related to ADLs and quality of life[8]. These therapies often require expensive machinery that is also difficult to handle, which limits their large-scale use in clinical practice[3,5].

Mirror therapy (MT) is a low-cost and easy intervention developed to treat phantom limb pain that is currently used in post-stroke rehabilitation[5,10-12]. MT is applied with a mirror positioned in the sagittal plane between the upper limbs. In order to trick the brain, by promoting a visual and kinesthetic illusion, the subject performs movements with the normal limb that are reflected to the mirror and interpreted by the brain as performed by the affected limb[11,12]. By activating the mirror-neuron system (MNS) and the corticospinal tract, MT accelerates recovery of hemiparesis and promotes cortical reorganization, resulting in functional and motor improvements[3,12-13].

Thus, MT is a strategy proven feasible and effective for motor recovery[3,4,8,14-16]. The effects of this therapy are beneficial for movement execution and control, but do not reflect in CVA patients' daily activities[5].

The literature still lacks studies about mirror therapy approaches, aimed at movements related to functional activities or to the motor patterns of hemiplegic arm. Therefore, this paper aimed to assess the effects of mirror therapy using functional activities and motor patterns of chronic hemiplegic upper limbs resulting from VCA.

METHODOLOGY

This is a quasi-experimental, randomized, blinded trial conducted with patients who had a stroke, living in Santa Cruz (RN), recruited by means of a study on the prevalence and risk factors of Cerebral Vascular Accident in Santa Cruz, approved by the Research Ethics Committee of *Faculdade de Ciências da Saúde do Trairi* (FACISA/UFRN). All subjects were enrolled in the study by random draw.

Individuals aging more than 18 years, diagnosed with only, unilateral VCA in chronic phase (over six months after ictus) with hemiparesis of the upper limb as sequelae, scoring more than 20 on Fugl-Meyer Assessment of Motor Recovery (FM), absence of cognitive disorders scoring ≥24 (educated subjects) and >14 (illiterate subjects) on

Mini-Mental State Examination (MMSE), walking with good stability upon seating, scoring more than 40 on Berg Balance Scale (BBS). Patients presenting other neurological disorders with associated physical or mental disabilities, traumatic VCA, joint pain and straining in upper limbs that could prevent the performance of movements were excluded[20-22].

Patients were assessed before and after treatment by one examiner. Pre-treatment assessment was composed of sociodemographic analysis and application of MMSE, BBS, FM, Modified Ashworth Scale (MAS) and Functional Independence Measure (FIM). Post-treatment assessment was made by FM, FIM and MAS.

Sociodemographic evaluation form was pre-structures and addressed personal data (name, gender, age, marital status), clinical data (diagnosis, type and time of damage, hemiplegic side), and table for monitoring initial and final blood pressures during appointments.

We used: the dimension of the upper limb of FM Assessment of Motor Recovery, which assesses sensory-motor impairment of the hemiplegic arm[17]; MAS, by application of muscle resistance to passive strain of the upper limb[23]; FIM, to assess subjects' performance in 18 tasks, comprehending motor (mFIM), cognitive (cFIM), and total (tFIM) domains[21].

Each patient was assessed and treated individually in their home environment with 15 mirror therapy sessions of 50 minutes, 3 times a week. Patients were divided into two groups by random draw: functional activities group (FAG) and motor pattern group (MPG).

Before mirror therapy, Kinesiotherapy was applied in the first 10 minutes of the session, with passive muscle stretching and joint mobilizations in upper limbs. Upon mirror therapy, a rectangular platform measuring 40x70 cm was used, where a mirror was put in the sagittal plane and could be removed according to the side of hemiparesis of each patient (Figure 1). The platform extension and sides were closed to avoid patients to be drawn attention by the environment. The platform with the mirror was secured on a table where the patient would be sitting by, on a comfortable chair with backrest, with legs leaned on the ground. Patients were oriented to watch the reflection of their normal hand on the mirror as it was the affected one, and to perform activities bilaterally. The sessions lasted 30 minutes and the focus of intervention was task repetition. To avoid muscle fatigue, patients could rest in an interval of 1-2 minutes between tasks.

FAG subjects performed activities in the mirror with recreational objects (cups, cubes, balls, toys, bottles) in varied colors, sizes and shapes. Activities were related to functional range, fitting, transferring and stacking objects. MPG subjects performed movements of finger flexion and extension, finger adduction/abduction, forearm pronation and supination, elbow extension, without relating them to functional activities (Figure 2). During therapy, subjects were verbally commanded by examiners so they were motivated and corrected whenever the activities were performed incorrectly.

The study was approved by the Ethics committee of UFRN (CAAE: 11732712.8.0000.5537), and subjects who agreed to participate signed the informed consent form.

Data were descriptively analyzed using the software SPSS 20.0®. Absolute frequency (n) and percentage (%) of categorical variables were calculated, as well as mean and standard deviation of continuous variables. Mann-Whitney, Fisher's Exact test, chi-square tests were used, and also generalized estimating equation (GEE). Significance level was set at 5% in order to minimize type error.

RESULTS

Initially, 20 patients with VCA sequelae were assessed, among which only 6 met all inclusion criteria. These six patients were randomly and equally divided into two groups: functional activities (FAG) and motor pattern

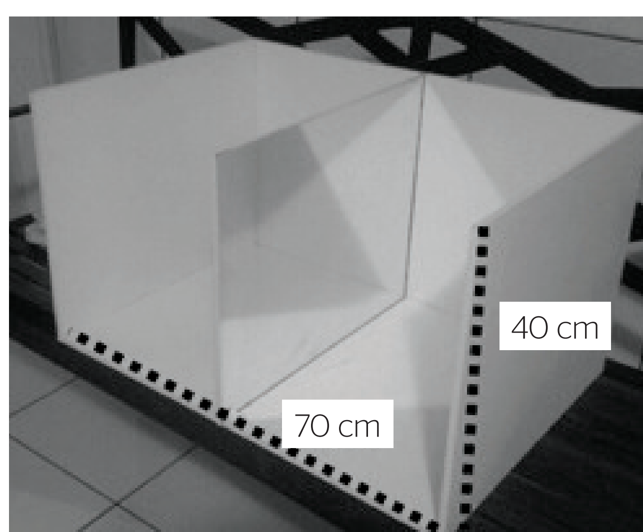

Figure 1. Dimensions of the mirror used in mirror therapy

(MPG). Table 1 shows demographic data of subjects and the characteristics of their lesions in each group.

There was a homogeneous relation between the variables gender, age, side and time of lesion, which means no significant differences between groups.

Results before and after intervention related to the variables of Fugl-Meyer and FIM scales for FAG and MPG, compared to groups of treatment (analysis between groups) and to the junction of both groups are described in Table 2. No significant differences were found before and after MT when GAF and MPG were compared or assessed on a stand-alone basis. However, when the groups of treatment were joined, a significance was found in FIM, FIMc (p=0.002) and FIMt (p=0.002), respectively.

Resistance to passive movements of the upper limbs through MAS did not vary significantly between groups throughout treatment, as shown in Table 3.

DISCUSSION

MT is beneficial for patients who had stroke, as reported in many studies[3,5,22]. The illusion induced by the mirror improves the training environment, increases somatosensory information, induces task repetition and boosts cortical function[3]. However, the approach of therapy does not influence functional and motor gains of the patients in this study.

Therapies involving the performance of tasks on the mirror, aimed at functional activities, are more effective when it comes to motor improvements, for they apply and reinforce the concepts of motor learning[23,24]. Functional activities are associated with better motor learning, once the tasks are usually more dynamic, with variations and training aimed at specific activities, making assimilation easier. When subjects are trained with simple motor patterns, they can have a good performance, but also more difficulty to associate them to ADLs[25]. Although studies point it out, no differences were found between the therapy groups.

There were no significant variations between therapy groups in pre and post-treatment assessments by FIM and FM. However, when groups were put together, there was an improvement in cFIM (p=0.002) and tFIM (p=0.002). Performing recreational tasks aimed at functional activities is believed to require more of the cognitive function along with sensory-motor areas for task execution compared to tasks of

Functional activities group

Motor patterns group

Figure 2. Mirror therapy with functional activities and motor patterns

Table 1. Sample characteristics

Variables	FAG (n=3) Mean	MPG (n=3) Mean	p-value
Gender (n)			
Male	0	1	
Female	3	2	0.500[a]
Age (years)	63±9.53	66.66±14.22	0.386[b]
Marital status (n)			
Married	1	2	
Widow/er	1	1	-
Single	1	0	
Type of lesion (n)			
Ischemic	100	100	-
Hemorrhagic	0	0	
Side affected (n)			
Left	2	2	0.800[a]
Right	1	1	
Time of lesion (years)	4.66±1.52	5.33±1.52	0.386[b]

FAG: functional activities group; MPG: motor patterns group; a: Fisher's exact test; b: Mann-Whitney test

Table 2. Statistical description of clinical and functional measures in chronic hemiparesis patients

Variables			mFIM	cFIM	tFIM	tFM
FAG (n=3)	Mean±SD	Pre	86.33±3.21	33.33±1.52	119.66±2.51	49.66±19.73
		Post	86.33±1.52	34±1	120.33±1.52	51±19.05
	χ^2		0.66	3.87	3.66	0.001
	p-value		0.72[a]	0.14[a]	0.99[a]	0.99[a]
MPG (n=3)	Mean±SD	Pre	84±37	29.33±6.35	113.33±11.01	53.33±1.54
		Post	84±6.08	30.33±6.35	114.33±11.01	54±3
	χ^2		0.57	2.58	3.66	0.001
	p-value		0.44[a]	0.74[a]	0.99[a]	0.99[a]
Analysis between groups	χ^2		0.001	1.58	1.36	0.13
	p-value		0.99[a]	0.20[a]	0.24[a]	0.13[a]
Both groups (n=6)	χ^2		0.001	9.37	9.37	2.07
	p-value		0.99[a]	0.002[a]	0.002[a]	0.15[a]

FAG: functional activities group; MPG: motor patterns group; mFIM: motor Functional Independence Measure; cFIM: cognitive Functional Independence Measure; tFIM: total Functional Independence Measure; tFM: total Fugl-Meyer scale; a: generalized estimating equation (GEE)

Table 3. Comparison of Modified Ashworth Scale between Functional Activities Group and Motor Patterns Group

MAS variables	FAG (n=3)		MPG (n=3)		p-value
	Pre	Post	Pre	Post	
Shoulder flexors	1±1	0.50±0.86	0.66±0.57	1±0.86	0.066[a]
Shoulder extensors	0.66±1.15	0.50±0.86	0.33±0.57	0±0	0.375[a]
Shoulder Abductors	0.33±0.57	0.33±0.57	0.66±0.57	0.33±0.57	0.558[a]
Shoulder Adductors	0.33±0.57	0.33±0.57	0.33±0.57	0.33±0.57	1.000[a]
Shoulder internal rotators	0.66±1.15	0.50±0.86	0.33±0.57	0±0	0.375[a]
Shoulder external rotators	0.66±1.15	0.50±0.86	0.33±0.57	0±0	0.375[a]
Elbow flexion	1±1	0.50±0.86	0.33±0.57	0.33±0.57	0.480[a]
Elbow extension	0.33±0.57	0.50±0.86	0.33±0.57	0±0	0.211[a]
Forearm supination	0.66±1.15	0.33±0.57	0.50±0.86	0±0	0.375[a]
Forearm pronation	0±0	0.33±0.57	0.50±0.86	0±0	0.368[a]
Finger flexion	0.66±0.15	0.66±1.15	0.33±0.57	0±0	0.574[a]
Finger extension	0±0	0.66±1.15	0.66±0.57	0±0	0.211[a]
Wrist flexion	1±1.73	0.66±1.15	0.66±0.57	0±0	0.212[a]
Wrist extension	1±1.73	1±1.73	0.03±0.57	0±0	0.574[a]

FAG: functional activities group; MPG: motor patterns group; MAS: Modified Ashworth Scale; Pre: pre-treatment assessment; Post: post-treatment assessment

motor patterns, which do not require attention, cognition, and activation of brain areas involved. Some studies reported a better response by the mirror-neuron system when the movements performed on the mirror are related to specific tasks in comparison to tasks without definite aims[13,23,24].

The most complex movement sequences require more attention and cognition in order to be performed. Therefore, our findings do not support data reported in literature. In a systematic review, the authors reported that MT is beneficial for ADLs and their effects on motor function are associated with the MT approach[10].

Responses of mirror visualization and task performances aimed at a certain purpose were compared, which promoted a significant activation of the bilateral sensorial-motor cortex, including the primary motor, pre-motor, and primary sensorial-motor cortex areas, compared to the group performing tasks without established aims[24]. MT and conventional treatment are more beneficial to the upper limbs motor function when associate with specific tasks after VCA[23].

Many activation ADN adaptation mechanisms take place after VCA, including increased use of the healthy side of the brain, boosted by the corticospinal tract activation and the mirror-neuron system after MT tasks[26]. The cortical reorganization was assessed by magnetic resonance imaging after MT in subjects who had had stroke, and some changes in pattern of primary motor cortex activation were found on the side affected, but without correlation to functional improvements and balance of activation between brain hemispheres[3]. The corticospinal tract is activated by the visualization of movements performed with the normal limb on the mirror[16] and boosted when the mirror is associated with the virtual environment[27].

Motor function of the upper limbs is an important prognostic factor for functional recovery after VCA. However, we found no significant variations in the muscle groups assessed in MAS or in FM values. After six weeks of MT, we did not observed any effects on sensory-motor function assessed by FM in ADLs, but there was a significant change in resistance to passive movements in finger flexor muscles[4]. Other studies have reported improvement in motor function after MT using FM and have associated this outcome to the appropriate visual input replacing the reduced proprioceptive input on the affected limb[3,5].

The literature is not consensual as to the minimum time of therapy session and the durations of MT effects. Some authors have applied MT for 30 minutes in lower limbs after VCA, and showed this time is insufficient[28]. Other authors also used 30-minute sessions for 4 weeks and reported motor improvement of wrist and hand, with tasks related to specific activities with objects[23]. The small size of our sample, as well as the short period of therapy, may have influenced our findings. These results can only be applied to subjects classified as mild to moderate phase of chronic VCA. Assessment scales were used in our study, but more accurate analyses of the movements performed by patients through kinematics were not made.

CONCLUSION

In general terms, functional improvement is achieved by mirror therapy, regardless of the use of functional activities or movement patterns. The literature addressing mirror therapy modes of execution is very scarce, so there is a need to perform further studies with larger samples in order to truly assess the efficacy of this therapy.

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