Journal of Bodywork & Movement Therapies 21 (2017) 1024–1027

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

PREVENTION & REHABILITATION: ORIGINAL RESEARCH

Immediate effect of mental practice with and without mirror therapy on muscle activation in hemiparetic stroke patients☆

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A R T I C L E I N F O

Article history:
Received 25 August 2016
Received in revised form
10 December 2016
Accepted 20 December 2016

Keywords:
Stroke
Electromyography
Mental practice
Mirror therapy

A B S T R A C T

Mental practice (MP) consists of the repeated mental rehearsal of a physical skill without movement, called motor imagery (MI). Studies show that MP and MI associated mirror therapy (MPMT) may improve muscle control of the upper limbs in hemiparesis. This study aimed to evaluate muscle activation during active flexion of the wrist (MA), MP, and MPMT in patients with history of stroke and hemiparesis. Individuals diagnosed with stroke showing sequelae of upper limb hemiparesis were enrolled. The flexor carpi ulnaris was analyzed using electromyography during tasks (MA, MP, MPMT) involving wrist flexion. Greater electromyographic activity was detected during MP and MPMT techniques compared to active movement ($p = 0.02$). There was no significant difference between MP and MPMT ($p = 0.56$). These results were found in both the affected limb and unaffected limb. Immediate effects on muscle activation are experienced during MP and MPMT, and muscle activity was similar with both therapies.

1. Introduction

Mental practice (MP) and mirror therapy are complementary forms of treatment for some stroke sequelae. "During mental practice an internal representation of the movement is activated and the execution of the movement repeatedly mentally simulated within a chosen context. This mental simulation takes place in absence of bodily activity. It is used for the goal-oriented improvement or stabilization of a given movement" (Braun et al., 2006). MP consists of the repeated mental rehearsal of a physical skill without movement through the mental simulation, called motor imagery. So, motor imagery is "imagining oneself undertaking the skilled movement without actually doing the movement" (Jackson et al., 2001). Motor imagery, is a dynamic representation of the imagined motion, promoting its internal reactivation within the memory. In this way, the individual revives the sensation of a specific action, which promotes greater learning capacity and motor improvement (Pacheco et al., 2007; Gaspar et al., 2011).

Mental practice associated mirror therapy (MPMT) may be able to create an illusion within the brain of motor activation of the affected limb. During MPMT, the patient moves the unaffected limb in front of a mirror, where the reflection appears to the be that of the affected limb moving correctly; this occurs because of the activation of mirror neurons and consequently, increased proprioceptive input (Lamont et al., 2011; Rezende, 2014; Altschuler et al., 1999).

Investigating the literature related to MP, mainly systematic reviews, we found many articles using functional outcomes and Activities of Daily Life measures. The majority of them did not find significant improvement after MP treatment although the use of MP combined with other physical practices has shown functional gains in upper limbs after stroke. The methodological limitations of the studies are the main problem to ensure evidence (Braun et al., 2013; Carrasco and Cantalapiedra, 2013; Barclay-Goddard et al., 2011). In contrast, Mirror Therapy as a complement to conventional rehabilitation may promote improvement in motor function in patients with stroke (Hatem et al., 2016; Thieme et al., 2013; Castelli

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http://dx.doi.org/10.1016/j.jbmt.2016.12.010
1360-8592/

and Corbetta, 2011).

A measure little used to investigate MP and also mirror therapy is electromyography, and we believe in muscle activation during both. The study by Oliveira et al. (2014) used electromyography, and showed that MPMT may be capable of promoting improvement in muscle control of the hemiparetic upper limb. Other studies reporting electromyographic effects of MP are found in the literature (Guillot et al., 2007; Lebon et al., 2008; Sivadasan et al., 2013). Guilliot et al. (2007) and Lebon et al. (2008) used EMG to measure muscle responses during MI in healthy subjects; their results show increased muscle activation when comparing rest to imagined movement. Sivadasan et al. (2013) reported similar findings, but their study was conducted in individuals diagnosed with focal dystonia of the upper limb. Based on this little review the hypothesis of the present study are: (1) MP could promote greater muscle activation when compared to active movement, and (2) MPMT may produce greater muscle activation than that obtained by active movement and MP.

Therefore, this study aimed to determine if there are differences in muscle activation during active movement (AM) of flexion of the wrist, MP, and MPMT in patients who have suffered stroke and subsequent hemiparesis.

2. Methodology

This study was approved and follows all recommendations of the Ethics Committee of the UFTM Protocol (1647). It is characterized as experimental, transversal, and quantitative research, with intra- and interpersonal analysis.

We enrolled individuals diagnosed with stroke (ischemic or hemorrhagic, acute or subacute [up to 1 year post stroke]), with sequelae of upper limb hemiparesis and without disabling cognitive deficits. Individuals were excluded if they were diagnosed with other diseases and were required to have preserved imaginative capacity (as determined by Kinesthetic and Visual Imagery Questionnaire (Gregg et al., 2010) translated and validated for native language (Mendes et al., 2016), reaching a minimum score of 55 points). No patient had cognitive impairment as determined by the Mini Mental State Examination (Folstein et al., 1975), in which, Lourenço and Veras (2006), verify the validity of the criterion of the Portuguese version and participants were required to have a minimum score of 30 points on the Fugl-Meyer scale, with reliability and validity tested in the native language (Maki et al., 2006), only items matching the upper limbs (Scalha et al., 2011). In total, 8 subjects were included irrespective of age, ethnicity, or sex. Table 1 summarizes participants' characteristics.

We used the imagination questionnaire visual and kinesthetic, which evaluates the imaginative capacity of individuals in the visual and kinesthetic areas. Scores range from 1 to 7, considering the most difficult and most easily, respectively. The execution of mental task is determined by specific movements or actions (Gregg et al., 2010).

Table 1
Study participant characteristics.

Characteristic	n or mean (±standard deviation)
Sex, F/M	4/4
Age (years)	60.75 ± 10.26
Affected side, Right/Left	4/4
Stroke type, Ischemic/Hemorrhagic	5/3
Time since stroke (months)	7.29 ± 4.50
MMSE results	23.25 ± 2.69
Fugl Meyer results	110.375 ± 11.63
KVIQ results	68.87 ± 17.68

Label: F, female; M, male; MMSE, Mini Mental State Examination; KVIQ, Kinesthetic and Visual Imagery Questionnaire.

Physical performance was evaluated using the Fugl-Meyer assessment, which is used to measure sensorimotor recovery of post-stroke patients based on assessment of 5 areas: motor function, sensory function, balance, mobility, and pain. Scores range from 0 to 2, corresponding to complete disability and full capacity to complete the task, respectively (Scalha et al., 2011). For this study, we considered only items related to the upper limb. Total possible score was 128 points, as reported by Scalha et al. (2011).

Electromyographic analysis was performed using EMG System do Brasil®, band pass 20–500 Hz, with common mode rejection >120 dB, input impedance >10 MOhms, gain 100× signal conditioner, and 20× liabilities bipolar electrode, totalizing 2000×. The signal was collected at 1000 Hz, filtered and rectified. Electrodes were attached to the flexor carpi ulnaris, three to four finger widths distal to the midpoint of the medial epicondyle of the connecting line and biceps tendon, following the protocol of Perotto (2011) and later confirmed by palpation and proof of specific muscle function proposed by Mccreary et al. (2007).

EMG data were collected during tasks involving wrist flexion during AM, MP, and MPMT. During the task the individual sat comfortably in a chair facing a table, which allowed the full support of the forearm, keeping the shoulder joint at 0°, elbow at 90° and wrist at the neutral position. During the AM the individual performs the active flexion of the wrist, to perform the MP the subject was instructed to imagine the flexion of the wrist as performed in the previous task and during the MPMT the subject was oriented to position the affected member inside the mirror box, while the healthy one was positioned in front of the mirror, the subject was instructed to perform active flexion of the healthy wrist and to imagine that the reflex of the movement as being his affected member. Five recordings were made with an interval of one minute between each recording.

Data were digitized by conversion board A/D 16 bits resolution and sampling frequency 1 kHz in each channel. WinDaq (DataqInstruments®) software was used. Calculations were based on the EMG activity area, considering the whole area under the curve obtained during the time of flexor carpi ulnaris muscle activation.

Study participant data were analyzed using descriptive statistics (mean and standard deviation) and also the values on the Fugl-Meyer and Kinesthetic and Visual Imagery Questionnaire scales. EMG data were previously tested for normality by the Shapiro-Wilk test. As the data conforms to normality, we used the Student *t*-test with a significance level set at 5%.

3. Results

In the affected upper limb, there were significant differences in the area obtained by EMG between AM and MP ($t = -4.75$, $p = 0.00$) and between AM and MPMT ($t = -4.39$, $p = 0.00$). There was no significant difference between the values recorded for MP and MPMT ($t = -0.33$, $p = 0.75$) (Fig. 1).

Similar results were found for the unaffected upper limb, with significant differences between AM and MP ($t = -4.25$, $p = 0.02$) and between AM and MPMT ($t = -3.05$, $p = 0.03$). There was no significant difference between MP and MPMT ($t = 1.25$, $p = 0.72$) (Fig. 2).

4. Discussion

The aim of this study was to evaluate whether there are differences in muscle activation during AM, MP, and MPMT in post-stroke patients with hemiparesis. The first hypothesis was accepted, because the EMG values were significantly different between MP/MPMT and AM. The second hypothesis was partially