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Full Length Article

Effects of motor imagery and action observation on hand grip strength, electromyographic activity and intramuscular oxygenation in the hand gripping gesture: A randomized controlled trial

Alejandro Losana-Ferrer[a], Sergio Manzanas-López[a], Ferran Cuenca-Martínez[a,b], Alba Paris-Alemany[a,b,c,d], Roy La Touche[a,b,c,d,*]

[a] Departamento de Fisioterapia, Centro Superior de Estudios Universitarios La Salle, Universidad Autónoma de Madrid, Spain
[b] Motion in Brains Research Group, Institute of Neuroscience and Sciences of the Movement (INCIMOV), Centro Superior de Estudios Universitarios La Salle, Universidad Autónoma de Madrid, Spain
[c] Instituto de Neurociencia y Dolor Craneofacial (INDCRAN), Madrid, Spain
[d] Instituto de Investigación Sanitaria del Hospital Universitario La Paz (IdiPAZ), Madrid, Spain

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ABSTRACT

The aim of this study was to evaluate the effects of motor imagery and action observation combined with a hand grip strength program on the forearm muscles. Sixty subjects were selected and randomized into three groups: motor imagery (n = 20), action observation (n = 20), or a control group (n = 20). Outcome measures included hand grip strength, electromyographical activity and intramuscular oxygenation. The hand grip strength significantly increased in the motor imagery ($p < .001$) and action observation ($p < .001$) groups compared with the control group, although there were no differences between the both groups ($p = .30$). In the electromyographical activity, intra-group significant differences were found in motor imagery ($p = .002$) and action observation ($p = .003$) groups, although there were no differences between the both groups ($p = 1.00$) Intramuscular oxygenation results did not show any statistically significant differences between any of the study groups ($p > .05$). Our results suggest that both motor imagery and action observation training, combined with a hand grip strength program, present a significant strength gain and significant change in the strength and electromyographical activity of the forearm muscles, however no change was found in intramuscular oxygenation.

1. Introduction

Motor imagery (MI) is defined as a dynamic mental process of an action, without its real motor execution (Decety, 1996). Action observation (AO) training consists of watching an action performed by someone else (Rizzolatti & Sinigaglia, 2010). Both MI and AO have been shown to produce a neurophysiological activation of the brain areas related to the planning and execution of voluntary movement in a manner that resembles how the action is performed in reality (Frenkel et al., 2014; Taube et al., 2015; Wright, Williams, & Holmes, 2014).

Several studies have shown that patients can report a significant improvement in strength with MI training (Arya, Pandian,

* Corresponding author. at: Facultad de Ciencias de la Salud, Centro Superior de Estudios Universitarios La Salle, Calle la Salle, no 10, 28023 Madrid, Spain.
E-mail address: roylatouche@lasallecampus.es (R. La Touche).

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Kumar, & Puri, 2015; Clark, Mahato, Nakazawa, Law, & Thomas, 2014; Fontani et al., 2007; Kumar, Chakrapani, & Kedambadi, 2016; Oostra, Oomen, Vanderstraeten, & Vingerhoets, 2015). There is also evidence regarding the improvements in motor skills in participants who perform MI training combined with mirror therapy (Battaglia et al., 2014; Sarafrazi, Abdulah, & Amiri-Khorasani, 2012). MI is recognized as one of the most popular and effective forms of training to improve learning strategies and to increase the capacity to perfect sports movements, as has been observed in rhythmic gymnastics athletes (Battaglia et al., 2014; Sarafrazi et al., 2012).

In addition to the previously mentioned adaptations, Collet, Di Rienzo, El Hoyek, and Guillot (2013) proved that MI and AO provoke an activation of the sympathetic-excitatory nervous system. Changes in respiration, heart rate and skin temperature are produced, as well as an increase in electrodermal activity (Bolliet, Collet, & Dittmar, 2005; Brown, James, Henderson, & Macefield, 2012; Collet et al., 2013; Paccalin & Jeannerod, 2000).

Both MI and AO are interventions that can generate adaptive neuroplastic changes on a cortical level, leading to a decrease in chronic pain (Coslett, Medina, Kliot, & Burkey, 2010). These rehabilitation techniques are used in pain treatment and impaired movement injuries that could be due to a nervous system alteration (Lagueux et al., 2012; Moseley, Butler, David, Beames, & Giles, 2012).

AO effectively facilitates motor learning, and is a tool for rehabilitation in neurological and musculoskeletal diseases (Agosta et al., 2017; Bek et al., 2016; Lee, Kim, & Lee, 2017; Park et al., 2016; Scott, Taylor, Chesterton, Vogt, & Eaves, 2017). AO training leads to significant improvements in static balance and helps improve gait in patients with hemiparesis after an ictus (Lee et al., 2017; Park et al., 2016).

Frenkel et al. (2014) showed that the patient's functionality loss is lessened if MI and AO are applied after an immobilization process, reducing the loss of wrist mobility, strength and muscle mass. Grabherr, Jola, Berra, Theiler, and Mast (2015) studied the precision of an upper limb movement in patients with hemiparesis. They found that both, motor imagery and action execution group, improved performance over six training sessions but the improvement was significantly larger in the motor imagery group.

However, the effectiveness of MI is controversial; several studies have presented unfavorable outcomes from this technique (Demougeot, Normand, Denise, & Papaxanthis, 2009; Kingsley, Zakrajsek, Nesser, & Gage, 2013). Some variables, such as the duration of the sessions, the time employed, the type of motor task or the number of sessions, can influence the outcomes of these studies. Thus, it is necessary to clarify the controversial aspects of MI, which lead us to perform this study.

Several studies have shown that therapeutic exercise improves hand grip strength (Garcia-Hernandez, Garza-Martinez, & Parra-Vega, 2017; Orizio, Baruzzi, Gaffurini, Diemont, & Gobbo, 2010), however, there is still a lack of evidence with motor imagery and action observation.

This study evaluates variables that have not yet shown conclusive results: intramuscular oxygenation (IO) and electromyography (EMG). Focusing principally on the effectiveness of the treatment and the adaptations that are generated on an intramuscular level leads to a better understanding of what occurs as a result of training with MI and AO, and also whether these variables influence the effectiveness of the treatment.

Therefore, the primary objective of this study was to evaluate the effects of MI and AO combined with a hand grip strength program on strength gains in asymptomatic participants. The secondary objective was to assess the influence of MI and AO training combined with a hand grip strength program on EMG activity and IO of the forearm muscles.

2. Methods

2.1. Study design

This study was a single-blind, randomized controlled trial: the researcher responsible for the study outcomes was blinded to the intervention group. This study was planned and conducted in accordance with Consolidated Standards of Reporting Trials (CONSORT) requirements (Schulz, Altman, Moher, & CONSORT Group, 2010). The study was approved by the ethical committee of the La Salle University Center for Advanced Studies and was registered with the United States Clinical Trials Registry (registration number NCT03324217).

2.2. Recruitment of participants

A sample of 60 asymptomatic volunteers was recruited from the local community through social media and email. Participants were recruited between January and May 2017. The inclusion criteria were as follows: (a) asymptomatic participants; and (b) men and women aged 18–65 years. The exclusion criteria included the following: (a) participants who had any knowledge of physical therapy; (b) underage participants; (c) participants with pain at the time of the study; and (d) participants with any type of neurological disease. All data were collected at the La Salle University Center for Advanced Studies.

Informed written consent was obtained from all the participants prior to inclusion. All the participants were given an explanation of the study procedures, which were planned under the ethical standards of the Helsinki Declaration.

2.3. Randomization

Randomization was performed using a computer-generated random sequence table with a balanced three-block design (GraphPad Software, Inc., CA, USA). Independent research generated the randomization list, and a member of the research team who was not involved in the assessment or treatment of the participants was in charge of the randomization and maintained the list. Those