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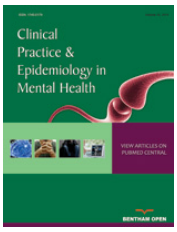

Mental Practice Combined with Motor Rehabilitation to Treat Upper Limb Hemiparesis of Post-Stroke Patients: Clinical and Experimental Evidence

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Abstract: Stroke is one of the major causes of disability in the world. Due to the extended lifetime of the world's population, the number of people affected by stroke has increased substantially over the last years. Stroke may lead to sensorimotor deficits, usually causing hemiplegia or hemiparesia. In order to reduce motor deficits and accelerate functional recovery, MP combined with motor rehabilitation was introduced to the rehabilitation process of post-stroke patients. Evidence has shown that MP combining with motor rehabilitation based on activities of daily living was more effective than conventional motor rehabilitation used per se. This combination proved very useful and effective, with significant results in improvement of motor deficits in post-stroke patients. However, further studies must be conducted to determine specific parameters, such as type of imagery, frequency or duration.

Keywords: Hemiparesis, kinesthetic imagery, mental practice, stroke, visual imagery.

Stroke is one of the major causes of disability in the world [1]. Due to the extended lifetime of the world's population, the number of people affected by stroke has increased substantially over the last years [2]. Stroke may lead to sensorimotor deficits, usually causing hemiplegia or hemiparesia [2]. Various forms of treatment have been proven by the literature as promising alternatives to improve motor function and quality of life in these patients [3 - 5]. Thus, in order to reduce motor deficits and accelerate functional recovery, some researchers began to investigate the effects of (MP) combined with motor rehabilitation for motor recovery of upper limbs in post-stroke patients [6 - 10].

MP consists of a training method, whereby the internal reproduction of a given motor act (mental simulation) is repeated extensively with the intention of promoting learning or improvement of motor skills [11]. This mental simulation (motor imagery) corresponds to a dynamic state during the performance of a specific action, internally reactivated by working memory in the absence of any movement [12]. MP results of a conscious access to motor intention, which is usually performed unconsciously during motor preparation [11, 12], establishing a relationship between motor events and cognitive perceptions [7].

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Studies have shown that there are similarities in psychophysical and physiological functions between executed and imagined movements, suggesting that they are based on the same processes [13, 14]. Experiments using functional magnetic resonance imaging (fMRI) showed that not only the supplementary and premotor motor areas and cerebellum were activated during imagined movements of the hand and fingers, but also the contralateral primary motor cortex (cM1) [8, 15, 16]. fMRI and transcranial magnetic stimulation (TMS) studies indicated that the contralateral side of the primary motor area is activated during the imagination of complex movements, confirming previous findings that showed a more prominent involvement of the primary motor area in the performance of complex motor sequences [17, 18].

Regarding the similarity of cortical areas activated and engaged in the execution and imagination of a movement, it was found that such resemblances in brain activity occurred during finger movements [19]. Within this context, several investigations attempt to apply these findings in the motor rehabilitation process, especially in cases that concern the recovery of areas involved in motor function, after lesion in the central nervous system [6, 9]. MP applied alone achieves less interesting results than motor rehabilitation alone in patients with neurological disorders. Nevertheless, the combination of both techniques (MP and motor rehabilitation) proved to be more effective than the two techniques applied alone [20 - 23].

Since its first applications in the context of neurological recovery, only eleven experiments were conducted combining these techniques in order to investigate whether this combination is really effective [24 - 34] or not. Thus, it was not possible to standardize the use of MP as a rehabilitation practice in neurological recovery in post-stroke patients. In this sense, there is no consensus on the frequency (how many days per week and how many weeks), duration (minutes per session), type (visual or kinesthetic) and the appropriate time of application of MP (recovery phase of the pathology). However, such investigations have shown evidence that combining MP with motor rehabilitation based on activities of daily living was more effective than conventional motor rehabilitation used per se [24 - 34].

MP demands a conscious engagement of certain brain regions often activated unconsciously during motor preparation. However, movement imagination is not reliant on motor execution skills, but it is quite dependent on central mechanisms processing [12, 14]. With this in mind, it may be possible that the frequent use of MP facilitates the organization of central motor commands. Based on the "neural networks" theory, which underlines that they are previously established for certain motor acts, studies have reported that those neural networks involved in motor gesture execution are rehearsed during MP [9]. Thus, the improved performance on the executed motor gesture occurs by the coordination of motor patterns responsible for that specific movement. It is based on the theory that "neural networks" remain intact despite the physical damages, which suggests that post stroke patients could benefit of MP to activate the partially damaged "neural networks". Those findings are in accordance with previous studies of MP despite the lack of neuroimaging data to reinforce this idea [24 - 29]. Moreover, those findings are also in accordance with studies that relate changes in motor functions to cortical functions after several specific motor training protocols were used [35], including MP [30]. Such theory is attributed to the mechanism of cerebral reorganization, where new areas are recruited to assist the movements of the affected arm [35]. Another theory currently emerging on the improvement in motor act is based on self-consciousness of movements (reflective and pre-reflective), where skilled atheletes seem to be able to increase its motor proficiency, although they are already experts [36]. There is an increased attentional focus on the "proprioceptive sense" of their movement while performing the skill. This suggests a greater capacity to switch attention between different modes of body perception during the performance [36]. Perhaps this greater cognitive effort required by the MP technique can contribute to the motor rehabilitation process.

Jeannerod [12] pointed out the importance of MP prior to motor execution. It would represent an additional or complementary technique to motor execution, but does not replace it [14]. Since the patients' ability to perform MP is evaluated, the focus can then be directed on the severity of the injury and the moment when MP should be introduced to the treatment. When the neurological condition does not allow patients to perform movements, MP is needed in order to keep the neural networks active [24 - 29] and also to promote cortical reorganization [30], so that the motor preparation can facilitate future executions of specific movements during the rehabilitation program.

MP represents an intriguing "backdoor" approach to access motor rehabilitation at all stages of stroke recovery. Unlike active and passive motor therapies, MP, in principle, does not rely on residual function but still incorporates voluntary drive. In stroke patients, MP may then provide a substitute for executed movement as a way to activate the motor network. Thus, MP is most effective when the skills being mentally rehearsed are also physically practiced. This is due to motor rehabilitation component, which is believed to create a motor program or "motor schema" that MP

reinforces.

When combined with motor rehabilitation, MP has proven to be useful with significant results in improvement of motor deficits in post-stroke patients. However, a recent published meta-analysis demonstrated that the use of mental practice had no significant results in motor rehabilitation of upper limbs [37]. Thus, further studies should be conducted to determine specific parameters such as number and weekly frequency, duration (minutes per session), type (visual or kinesthetic) and the appropriate moment to apply mental practice (recovery phases of pathology), in order to create specific protocols for each treatment phase. In addition, further studies are also needed using neuroimaging techniques in order to obtain more information about the patterns of brain activation and reorganization.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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