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The Use of Motor Imagery in Modulating Cardiopulmonary Activity: Future Perspectives

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Editorial

Motor Imagery (MI) describes the ability to simulate a given movement/motion consciously, without the need to stimulate physical peripheral muscles. The process of imagining and sensing external environmental cues utilize both cognitive and sensory-motor skills, which represents voluntary control. Several studies have observed situations of temporal and biomechanical similarities between the execution and imagination of the same task. The proximal time difference between the time it takes an individual to imagine and execute mentally the process of walking a fixed distance, is described as temporal similarity. Conversely, biomechanical similarity is perceived by the number of repetitions of a certain executed and imagined task is achieved over a fixed period of time. With the progression of neuroimaging techniques, it was possible to observe these similarities through the overlap of the neural circuits accessed during the execution and imagination of the same task.

MI can be understood as containing two main strategies: (1) visual, in which the individual "visualizes" the movement being executed by him or by another person (third person perspective) and (2) kinesthetic, in which the individual feels performing the first-person perspective movement. Although the two strategies have a common neural substrate, each of them access different neural circuits when imagining the same task. In the first strategy, the mental simulation occurs from the visual perception of the imagined movement (an external imagination strategy). In the second strategy, there is a subconscious activity of the muscles involved in the mental representation of the action, specifically activating somatomotor sensory regions of the brain, related to the individual's proprioception.

The conscious modulations using kinesthetic MI are also able to exert unconscious changes at the level of the autonomic nervous system (ANS) that regulates different visceral functions such as blood pressure, vascular resistance frequency and cardiac output. This is because activation of the central command from the somatomotor cortex (during execution or imagination) promotes an increase of sympathetic anterograde flow and reciprocal inhibition of parasympathetic activity, characterizing the cardiopulmonary response (cholinergic fibers). This anticipatory response promotes acceleration of heart rate (chronotropic effect), increased myocardial contractility (inotropic effect), increased respiratory rate, skeletal and cardiac vasodilation, as well as elevated blood pressure (BP) (baroreflex modulation). These changes occur because there are similarities in the brain areas responsible for the preparation and scheduling of the same task, which control cardiopulmonary feedforward responses during the execution and imagination of an activity.

These modulations most likely occur due to the changes in neuronal activity in the reticular formation and in the ventrolateral medullary, located in the brainstem (which receives projections

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of the limbic system and the hypothalamus), responsible for modulating the cardiopulmonary and musculoskeletal rhythm through following routes: (1) preganglionic fibers of the sympathetic system, releasing catecholamines (adrenaline and norepinephrine), which act directly on the sinoatrial, atrioventricular and ventricular muscles; (2) baroreflex system, mediated by aortic and carotid receptors, which exert negative feedback to inhibit the anticipatory sympathetic flow responsible for controlling BP elevation; (3) alpha motoneuron of the phrenic nerve, located in the anterior horn of the spinal cord (C3 to C5 levels) and intercostal nerves, which go to the diaphragm and intercostal muscles, respectively, modulating the respiratory rate and (4) through cortico-reticulo-spinal, responsible for anticipatory postural control (deep trunk muscles contract in anticipation of upper and / or lower limb agonists) during motor tasks.

Usually when an individual plan to initiate a physical activity (a race, for example) the areas of preparation and programming of movement are assessed (sensory [S1] and motor cortex [M1], cerebellum, basal nuclei, reticular formation, motor and supplementary motor areas). At that time, increased sympathetic influx (cholinergic fibers) generates an anticipatory cardiopulmonary response, which promotes the effects of increased heart rate and respiratory rate. Similarly, when an individual imagines this same physical activity (kinesthetic MI), the same areas related to the preparation and scheduling of the movement are also accessed, leading to cardiopulmonary anticipatory mechanisms (feedforward) that promote modulations of cardiopulmonary activity. To date, these autonomic effects are known only in healthy individuals and/or athletes and there are yet no studies in patients with cardiac or pulmonary diseases.

Although there are no studies comparing MI strategies (visual and kinesthetic), it is possible that the kinesthetic MI strategy is more relevant to access cardiopulmonary anticipatory responses, since it is related to specific motor and autonomic control mechanisms. In the future, it may be possible that cardiopathy and/or pneumopathy patients may benefit from the use of kinesthetic MI as a coadjutant therapy in cardiopulmonary rehabilitation. For example, patients with heart failure in the severest functional classes (III and IV) according to the New York Heart Association (NYHA) usually have little or no tolerance for therapeutic exercises. In this context, it is possible that these patients may benefit from the use of kinesthetic MI as a therapeutic strategy. Thus, more studies are needed to: (1) to understand the cardiopulmonary and hemodynamic behavior of patients in the different functional classes of NYHA; (2) to devise protocols for the use of kinesthetic MI as a daily mental practice to those patients and see if there are beneficial effects in the medium and long term; and (3) to evaluate if those patients are able to improve their functional class with this technic.