Motor Imagery Effect on Gait in Parkinson’s Disease: A Systematic Review

Nélio Silva de Souza1*, Marco Antônio A Leite2, Ana Carolina G Martins3, Isabela da S Carvalho4, Bruna Velasques5, Pedro Ribeiro5, Rossano Fiorelli6, Marco Orsini7,8, Marco Felipe Bouzada7, Carla Ayres5, Silmar Teixeira5, Fernando Silva-Júnior5,9 and Victor Hugo do Vale Bastos5

1Professor of the Graduate and Postgraduate Program in Physical Therapy of University Center Serra dos Órgãos (UNIFESO); Doctoral Student in Neurosciences by the Federal Fluminense University (UFF), Niterói, RJ, Brazil
2Professor of Graduate and Postgraduate Programs of Neurology and Neuroscience – Federal Fluminense University (HUAP/UFF), Niteroi, RJ, Brazil
3Professor of the Graduate Program in Physical Therapy of UNIFESO; Master in Integrated Health of Women and Children, UFF, PT, Msc, Niterói, RJ, Brazil
4Student of the Graduation Course in physiotherapy of UNIFESO, Brazil
5Federal University of Piauí (UFPI) and of Brain Mapping and Functionality Lab (UFPI/LAMCEF), FT, PhD, PI, Brazil
6Federal University of Rio de Janeiro – Brain Mapping – IBUP/UFRJ, Rio de Janeiro, RJ, Brazil
7Master’s Degree in Applied Science in Health, Severino Sombra University, Vassouras, Rio de Janeiro, RJ, Brazil
8Rehabilitation Science Program, Analysis of Human Movement Laboratory, Augusto Motta University Center (UNISUAM), Rio de Janeiro, RJ, Brazil
9Professor of the Master’s Program in Biomedical Sciences (UFPI/LAMCEF), Brazil

*Corresponding Author: Nélio Silva de Souza, Professor of the Graduate and Postgraduate Program in Physical Therapy of University Center Serra dos Órgãos (UNIFESO); Doctoral Student in Neurosciences by the Federal Fluminense University (UFF), Niterói, RJ, Brazil.

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Abstract

Introduction: Motor imagery (MI) represents the cognitive aspect of a motor act and may be defined as the ability to construct a mental action without actually executing it. It may be built mentally through two strategies (visual and kinesthetic). Parkinson’s disease (PD) has an unknown etiology and is probably related to multiple causes. PD has been described as a neurodegenerative disease in which neuronal rarefaction and inclusion of Lewy bodies may occur in the small part of the nigra substance and consequent deficit in dopaminergic transmission. Despite all efforts to understand PD and the identification of several non-motor signs and symptoms, such as cognitive changes, the disease diagnosis still depends on motor manifestations such as bradykinesia, stiffness, and tremor at rest. In this context, with the PD evolution, gait disturbances are verified. MI has been used as a gait management strategy in PD since the technique seems to modulate its characteristics immediately.

Objective: Investigate, through a review, the MI effects on gait in PD.

Methods: To analyze indexed articles in the databases: PubMed/Medline; PEDro and Google Scholar. The studies found were classified according to the PEDro level of evidence and Ochrid Center for Evidence-Based Medicine.

Results: In total, nine relevant studies on this topic were found. Three of the studies suggest that kinesthetic MI is useful in the PD treatment with and without freezing of gait (FOG) when compared to visual MI. One study evidenced discrepancies between motion and MI, indicating that this may contribute to FOG. Another suggests that Levodopa increases activity in the motor regions (midbrain and supplemental motor area), putamen, thalamus and cerebellum, as well as reduces the activity of the premotor, parietal and brainstem regions of patients with advanced PD. A sixth study showed a decrease in the globus pallidus activity and increased activity in the supplemental motor area during the MI of gait in PD. The seventh study showed no benefit in gait improvement when MI associated with physiotherapy or relaxation. Two studies pointed to the efficacy of the questionnaires applied in PD: (1) it addresses the FOG as a gold standard to diagnose PD (NFOG-Q) and (2) analyzed the vividness of the imagined movement by comparing two questionnaires (KVIQ and GIQ).

Final Considerations: It seems that kinesthetic MI has a relevant effect in the PD treatment when compared to visual MI, especially in gait characteristics. However, the results still have to be interpreted with caution.

Keywords: Motor Imagery; Gait; Walk and Parkinson’s Disease

Introduction

Motor imagery (MI) is a cognitive ability linked to the voluntary motor act representation [1,2] and may be defined as the ability to imagine a task without actually executing it [3-5]. MI may be accomplished through two strategies: (1) kinesthetic, where the individual feels mentally performing the task in first-person perspective and (2) visual, where the individual mentally observes the movement being presented in a third-person perspective [5,6]. The imagination and the proprioceptive perception of the same task are related motor skills and may be controlled voluntarily [7]. The observed similarities between execution movement (EM) and MI may occur in two motor act aspects, which are temporal and biomechanical [8-13]. For instance, the time taken to walk a fixed distance (5, 10, and 15 meters) is similar to the time spent imagining walking the same length [8]. Another example would be the similar biomechanical relation of the number of executed and imagined movements of the same task in a fixed time [14-17]. In this context, both temporal and biomechanical relations involve the principle of isochrony [11].

First described by James Parkinson in 1817 [18], Parkinson’s disease (PD) presents a variable prevalence in the active population and higher than 1% in the people over 60 years of age, with no difference between genders [19]. This disease etiology remains unknown, is probably related to multiple causes (genetic, environmental factors, etc.) [20] and its neurodegenerative characteristics present as a rarefaction in the dopaminergic neurons, as well as the presence of intraneural eosinophil, infiltrates in the small part of the nigra substance of the midbrain [21]. Cholinergic changes [22], dopaminergic alterations, among others, lead to neurophysiological modulations in parietal-frontal areas [23-25] and direct pathways (movement facilitation, D1 receptor) and indirect (inhibition of movement, D2 receptor) paths of inhibitory circuits in the base nuclei, especially in the caudate nucleus [26]. These modulations result in motor changes such as stiffness, bradykinesia, resting tremor, postural instability (trunk anteropulsion), gait with short steps and decreased speed with increased cadence (festination) [21]. Another frequent motor manifestation is freezing of gait (FOG), which presents the prevalence of 60% in the PD population and may be defined as an episodic inability to generate an active step [27], lasting less than 30 seconds [28].

MI has been widely used in a variety of clinical conditions, such as amputation disorders [29,30]; lumbar [31] or cervical spine dysfunctions [32] and neurological diseases [33-35], including PD [36-40]. In general, MI is a cognitive task integrated to the motor system (preparation areas and movement programming) that directly interferes with the ability to perform functional tasks [1,2], including the gait characteristics of PD patients [36-37,39,41,42]. In this context, with the PD evolution, gait disturbances are verified. MI has been used as a gait management strategy in PD since the technique seems to modulate its characteristics immediately, relieving their symptoms and improving their quality of life (gait). Therefore, the present study has a goal to investigate, through a review, the MI effects on gait in PD. We hypothesize that MI strategies (visual and kinesthetic) present different and relevant impact on walking in PD.

Materials and Methods

This study is a systematic review, and it has a goal to synthesize and critically evaluate the evidence pertinent to the theme.

Data source

For the proposed theme development, two books were used, one on “Principles of Neural Science” [26] and the other on “The Neurophysiological Foundations of Mental and Motor Imagery” [5]. Articles from a broader period (1955 - 2017) were used, with the most significant volume of information published in the last ten years, to provide a theoretical substrate for the contextualization and discussion of the theme. 32 articles were published in the last ten years (2008 - 2018), and the other references (20 studies) were released over ten years (≤ 2007).

Search in databases and inclusion criteria

This systematic review used only articles indexed in the following databases: PubMed/Medline; PEDro and Google Scholar, using the following keywords: motor imagery; gait; walking and Parkinson’s disease without a predetermined period. The studies found were classified according to the Pedro level of evidence (available at http://www.pedro.org.au/) and Oxford Center for Evidence-Based Medicine (available at http://www.cebm.net/oebm-levels-of-evidence/).
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(7 articles) used a good design criterion (1B - controlled and randomized clinical trial). The impact factor of the journals in 2017 (JCR) varied from 2.2 to 17.0, and the average impact factor was 5.3. Table 2 summarizes the work involving the MI effects on gait in PD patients. Most of the studies analyzed conditions other than PD.

Legend:
1B: Randomized Controlled Trial; 1C: Ecological Study and Cross-Sectional Study; 2: Therapeutic Imagery, including biofeedback and specificity; 20: Observations of Therapeutic Arcs; Ecological Study and JEA Journal Report Criterion.

Table 1: Selectors and criteria.

Table B: Comparison results.

Citation: PD: Parkinson’s Disease; FOG: Freezing of Gait; ME: Movement Execution; MI: Motor Imagery; VI: Visual Imagery; UPDRS: Unified Parkinson’s Disease Rating Scale.

Pickett., et al. (2012) 1C 4.484
Pickett., et al. (2015) 1B 3.866
Braun., et al. (2011) 1C 6.484
El-Wishy., et al. (2011) 1C 12.484
Snijders., et al. (2012) 1B 3.646
Savin., et al. (2013) 1B 4.964

Table A: Database search results.

Author and year Level of Evidence Study population Intervention Methodology Results and Conclusions

El-Wishy., et al. (2011) 1C 12.484
Snijders., et al. (2012) 1B 3.646
Savin., et al. (2013) 1B 4.964

El-Wishy., et al. (2011) n = 47 in total 33 healthy individuals 4 men 39 in total
Snijders., et al. (2012) n = 13 without FOG 10 men, mean age 71 18 patients
Savin., et al. (2013) n = 33 healthy individuals 16 women, mean age 71 19 with PD 10 men, mean age 71 13 with PD (10 women, mean age 71) 20 controls

Participants should perform and imagine a movement strategy of gait. The patients were instructed to imagine and actually perform a gait program and the movement was analyzed by kinemetry.

Participants performed three tasks: (1) calisthenics; (2) specific motor tasks (walking back and forth as well as different distances); (3) relaxation. They were performed three times in five minutes, and the movement was analyzed by kinemetry.

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**Motor imagery effects in different clinical contexts**

Several works in neurosciences have evidenced the MI benefits and propose its use in improving performance and/or functional recovery in different contexts: sports practices [43]; in geriatric patients [44]; amputation disorders [29,30]; lumbar [31] or cervical spine dysfunctions [32]; gait disorders [45]; changes in postural balance [14-16,46] in both unipodal [44,47,48] and bipodal support [49,50], as well as in neurological diseases [33-35], including PD [36-40]. The gait and balance dysfunction are often associated with the PD progression [51], and these changes in motor control are not fully understood [1,52]. Thus, the MI use in gait management in PD has sought to reorganize the motor function of this population (see table 2).

**Motor imagery effect on the motor control of human gait in general**

When analyzing healthy individuals who were to perform ME and gait MI at different distances (2, 4, 6, 8 and 10m), a temporal similarity (mental chronometry) was observed according to the increase in distances [53], showing that neurophysiological processes (primary motor cortex) increase brain activity in the areas of lower limb internal representation (gait) and postural control [45]. These internal gait representations are not affected when compared to elderly individuals with and without PD, although there is a relevant difference between the participants with and without FOG [36]. MI in PD individuals (with and without FOG) during functional magnetic resonance imaging (fMRI) showed that FOG patients had a decrease in parietal-frontal activity and increased activity in the midbrain locus (related to FOG), compared to patients without FOG [37,54]. Also, it has been suggested a decrease in the globus pallidus activity and a higher compensatory activity during the MI walking in PD, specifically in the supplemental motor area [55]. These changes may result in changes characteristic of FOG and postural control observed in PD patients [37]. Thus, the New Freezing of Gait Questionnaire (NFOG-Q) has been suggested as a gold standard (high sensitivity and specificity) for the FOG diagnosis in PD [42].

**Motor imagery effect on the freezing of gait in Parkinson’s Disease**

FOG represents an episodic inability to generate a useful step in the absence of any cause other than secondary parkinsonism [27] and is a relevant factor for the risk of falls [51]. The prevalence of this motor phenomenon is 20% to 60% in the PD population [27]. Usually, the FOG is presented as hesitation of the steps or “getting stuck,” for instance, when passing through a door changing the environment, enter a place with many people, among other conditions [36]. Therefore, this disorder directly affects the quality of life of PD patients [56].

Evidence suggests that PD patients with FOG may present structural and functional alterations in the mesencephalic locomotor region [54], the globus pallidus and the supplemental motor area [55], indicating that specific alterations in these regions may be related to FOG in PD during MI task [37,57]. The brain reorganization exerted by the MI in PD can control sensory and motor feedback during functional tasks [38]. However, it seems that this effect may be related to the MI strategy type (visual or kinesthetic). Specifically, kinesthetic MI has shown a more significant impact on brain activity when compared to the visual MI strategy [57]. Besides, it has been demonstrated that kinesthetic MI has a relevant effect on FOG in PD [36].

The combination between physical practice and MI has presented contradictory results. Although MI combined with physical therapy exercises for six weeks has not shown any significant effect [40], the combination of MI and physical practice may reduce cognitive and motor symptoms in PD, especially bradykinesia [39]. Similar results have been observed using video therapy and MI, noting improvement in the gait of these patients [41].

Traditionally, the work points out similarities between ME and MI of the same task (principle of isochrone) [11], presenting temporal and biomechanical relation in healthy individuals [8-17]. Corroborating these results, similarities were also observed between ME and MI of the gait of PD patients with and without FOG [37,52]. However, when investigating FOG specifically, the participants were slower in the task with the wider port, and no similarities were found between ME and MI in this group. However, this similarity between ME and MI was maintained in the non-FOG and control groups [36]. In this context, studies suggest that MI in PD may be used to improve gait in both patients with and without FOG, but their results to date should be interpreted with caution.

Final Considerations

The present study suggests that kinesthetic MI has a more significant effect on the PD patients’ treatment when compared to visual MI, mainly in gait functional recovery. Probably, the higher impact on the kinesthetic IM strategy was perhaps observed because this modality accesses proprioceptive representations linked to kinesthetic memory, which may result in an improvement in the individual’s locomotor ability. However, one limitation of the studies found was the lack of two MI strategies use (visual and kinesthetic) in the control and PD groups (with and without FOG) to determine their relevance. Although the work involving the topic is still few (nine in total) and the level of evidence (PEDro > 6 and Oxford 1B for most studies), indicate that the results are reliable. However, further studies are needed to deepen knowledge about the subject.

Author Contributions

Nélio Silva de Souza, Marco Antônio A. Leite, Ana Carolina G. Martins, Carla Ayres and Isabela da S. Carvalho participated in the acquisition of data. Nélio Silva de Souza, Marco Orsini, Marco Antônio A. Leite, Bruna Velasques, Pedro Ribeiro, Rossano Fiorelli, Silmar Teixeira, Fernando Silva-júnior and Victor Hugo Bastos guided the design and organization of the study. All authors participated in the revision of the manuscript and gave final approval for the version submitted for publication.

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