Randomised Control Trial

Effect of Motor Imagery on Hand Function in Parkinson's Disease: A Pilot Randomised Control Trial

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Abstract

Background: Parkinson's disease is a neurodegenerative disease characterized byprogressive impairment of motor skills. Parkinson Disease patients often have poorer fine hand skills, reduced hand grip strength, deficits in prehension which deteriorates autonomy in activities of daily living. This study assesses the effect of motor imagery on hand function in Parkinson disease.

Objective: To assess the effect of Motor Imagery on Hand Function in Parkinson's Disease patients using the Jebsen Taylor Hand Function Test

Method: Subjects with Parkinson's Disease were randomised in two groups: Control and Experimental. Both groups were assessed using the Jebsen Taylor Hand Function test. The control group receives conventional treatment consisting of flexibility and strength training whereas the experimental group receives Motor imagery combined with conventional treatment. Both groups were reassessed using the Jebsen Taylor Hand Function test after 3 weeks. The differences in the group were noted and statistically analysed.

Results: Both groups showed significant improvement in hand function post intervention. Although not statistically significant, the difference in experimental group was larger than the control group.

Conclusion: Motor imagery is a promising tool in neurorehabilitation. Motor imagery can have additional benefits when combined with conventional physical therapy to improve hand function in Parkinson's Disease

Keywords: *Action Observation, Jebsen Taylor Hand Function Test, Kinaesthetic imagery, Mental Rehearsal, Motor Imagery, Parkinson's Disease*

Introduction

Parkinson's disease (PD) is a neurodegenerative disease whose cardinal clinical features were first described by the English physician *James Parkinson* in 1817. Clinically, Parkinson's disease is characterized by resting tremor, rigidity, bradykinesia (slowing), and gaitimpairment, known as the "cardinal features" of the disease. In PD, dopamine denervation with loss of dopaminergic tone leads to increased firing of neurons in the STN and GPi, excessive inhibition of the thalamus, reduced activation of cortical motor systems, and the development of parkinsonian features.[1] PD patients exhibit sensory deficits such as decreased spatial and temporal tactile discrimination thresholds of the fingertips, and deficits in proprioceptive acuity. Impairments of reach are seen from the very start as patients tend to exhibit difficulty in movement initiation to a target. During the reach, PD patients exhibit deficits in hand pre-shaping to object geometry.[2]

Motor imagery is a cognitive process, as the patient imagines performing a movement without actually doing it (Lotze and Cohen, 2006).

Motor imagery is divided into:

1. Kinaesthetic imagery: the patient imagines moving their body parts without actually moving them

2. Action observation: watching other individuals performing similar actions (Stinear etal, 2006). [3]

Imaginary movements have been shown to be linked to conscious activation of areas of the brain which are also involved in the preparation and execution of the movement. The structures involved in imaginary movements are the premotor and accessory motor zones (Brodmann field 6), the parietal cortex and cingulate gyrus, the basal ganglia, and the cerebellum [17, 38, 53]. These brain structures are known to have a role in the planning and monitoring of movement execution. Studies have also demonstrated activation of the primary motor cortex (Brodmann field 4). During motor imagery, the excitability of the corticospinal tract was modulated by the same temporal and spatial characteristics as during the actual movements.

Motor imagery ability is assessed by the kinesthetic and visual imagery questionnaire i.e., KVIQ 10 scale.[4] The aim of this questionnaire is to determine the extent to which individuals are able to visualize and feel imagined movements. The subject is asked to rate, on a 5-point ordinal scale, the clarity of the visual image or the intensity of the sensations associated with the imagined movement. The KVIQ 10 scale consists of the following movements: Shoulder flexion, thumb to finger tips, forward trunk flexion, hip abduction, foot tapping

Mental imagery has been used as a training strategy to promote the relearning of daily tasks for people after an acute stroke. A study by *Hua Liu et al*,stated that combining mental practice with physical practice may be a more effective treatment strategy than physical training alone for hand recovery in stroke patients [5] The imagery process is likely to improve the planning and execution of both the trained and the untrained (novel) tasks. The effect of its relearning appears to help patients to retain and generalize the skills and tasks learned in the rehabilitation program.[6] In study with 159 athletes it was shown that motor imagery was a useful tool for sports training, and that elite athletes used motor imagery more than recreational athletes. [7] Motor imagery is not only a non-invasive practice but also does not raise safety risks, does not require sophisticated equipment and can be easily administered in the patient's house.

This pilot study aims to study the effect of motor imagery on hand function in Parkinson's disease and evaluate treatment protocols. The study also intends to test standard outcome measures and ease of administering these tests. This study can be used to assess the feasibility of the research hypothesis before conducting a large trial.

Materials and Method

Subjects clinically diagnosed with Parkinson's disease were selected and randomly allocated to two groups: control and experimental. A total of 6 patients (3 in each group) were recruited as per the inclusion and exclusion criteria:

Inclusion Criteria:

1. Subjects who are clinically diagnosed with Parkinson's Disease

2. Subjects on Stage 1 to Stage 3 of Modified Hoen and Yahr Scale

3. A score of 30 out of 50 on KVIQ-10 scale [8]

4. Subjects with a score more than 24 out of 30 on the MMSE scale

Exclusion Criteria:

1. Subjects with cognitive, visual, auditoryor psychological impairmentsor non- cooperative patients.

2. Subjects with other neurological deficits

3. Subjects on Stage 4 and Stage 5 Of Modified Hoen and Yahr Scale

4. Subjects with Musculoskeletal impairments affecting hand function

A written and informed consent was taken by participants. Materials required for the study included paper, pen, coffee cans, kidney beans, checkers, glass, cones, cards.

Outcome measure: Jebsen Taylor Hand Function Test - The Jebsen Taylor Hand Function Test (JTHFT) is a standardized evaluative measure of functional hand motor skills and is a reliable and easily available assessment tool for assessing the hand function of PD subjects. The scale consists of 7 items that measure: (a) fine motor skills; (b) weighted functional tasks; and (c) non-weighted functional tasks. Each item is scored according to time taken to complete the task. The scores for all 7 items are then summed for a total score.

Intervention:

1. Motor Imagery ability will be assessed by the KVIQ 10 scale whereas the hand function will be assessed by the Jebsen Hand Function Test prior to the intervention.

2. The Control Group will receive the following:

a. Conventional Treatment

i. Exercise training of the Upper Extremity:

· Flexibility: Stretching of the Pectoralis Major, biceps and triceps. Each stretch held for 15 to 60 seconds for 4 repetitions.

· Strength Training: Based on overload principle. Resistance can be added by free weights, dumbbells and resistance bands. 3 to 4 sets of 8 to 12 repetitions.

b. Relaxation Phase

i. Jacobson's Progressive Relaxation: Consists of physically tensing a particular muscle group in a given order and then to relax and let go of the muscle contraction.

ii. Diaphragmatic breathing Exercise

3. Experimental Group will receive the following:

c. Conventional Treatment consisting of flexibility and strength training and for the same duration as the control group.

d. Motor Imagery: Instead of relaxation phase, the experimental group receives Motor Imagery for the same duration. Motor Imagery consists of:

· Action Observation - During action observation, the subject is asked to closely observe the therapist as the therapist performs the exercise. The therapist will perform each exercise twice.

· Mental Practice - For this, the subject has to close his/her eyes and mentally perform the exercise shown to him/her by the therapist previously. The subject has to imagine himself/herself performing the movement without actually doing it.

· Action Execution - After mental rehearsal, the subject opens his/her eyes and now performs the same exercise as shown to him previously by the therapist.

e. Exercise to be administered: 2 repetitions of

each task.[5]

· Pronation - Supination: Subject is in sitting position. Elbows flexed to 90° and hands resting on the thigh. Patient is asked to perform pronation and supination.

· Elbow flexion - extension: Subject is in sitting position. He/she is instructed to bend the elbows and straighten them.

· Making a fist: Subject is in sitting position. Elbows flexed to 90° and hands resting on the thigh. He / She has to open and close his fist.

· Stacking up Cones: Subject is in sitting position, preferably on a chair with back supported. Cones are placed on a table in front of the subject. He / She is asked to stack the cones one upon the other.

· Picking up beans from one plate and placing them on the other: Subject is in sitting position, preferably on a chair with back supported. Two plates are placed on a table in front of the subject. One plate contains beans. The subject is asked to pick up beans from one place and place them into the other.

4. Experimental group will receive conventional Treatment along with MotorImagery for 3 days per week for 3 weeks.[9]

5. Control group receives only Conventional Treatment for the same duration

6. Both groups will be reassessed by the Jebsen Taylor Hand Function Test three weeks later

7. Data will be obtained and statistically analysed.

Fig.1 Action Observation: Subject observes as the therapist performs the exercise.

Fig.2 Mental Practice: Subject mentally rehearses the exercise without actually performing the exercise

Fig.3 Action execution: Subject performs the exercise after mental rehearsal

Results

Time required to complete the Jebsen Taylor Hand Function Test prior to beginning of intervention is noted. Post 3 weeks of intervention, difference in hand function as assessed by the time required to complete the Jebsen Hand Function Test is noted and compared. A reduction in time suggests positive effects. Within the group, a comparison was made using the paired t-test. An independent t-test was conducted for comparison between both groups. Dominant and Non-Dominant hand was analysed separately.

All statistical calculations were carried out using IBM SPSS 28.0

Control Group: Improvement in hand function post-conventional physiotherapy.

The mean difference between pre- and post-intervention time for thedominant hand was statistically significant (p=0.058). Similarly, for the non-dominant hand, significant improvement (p=0.044) was observed.

Table1: Time taken (in mean) by control group to complete JTHFT; SD – standard deviation.

	Pre Time (SD)	Post Time (SD)	Pre-Post (SD)
Dominant Hand	147.33 (36.17)	133.33 (33.47)	14 (6.08)
Non-Dominant Hand	160.33 (42.19)	140.66 (34.93)	19.66 (7.37)

Experimental Group: Improvement in hand function after receiving Motor imagery combined with conventional physiotherapy

There was a significant improvement for both dominant (p=0.046) and non-dominant

(p=0.031) hands.

Table2: Time taken (in mean) by experimental group to complete JTHFT; SD – standard deviation.

	Pre Time (SD)	Post Time (SD)	Pre-Post (SD)
Dominant Hand	174.66 (18.77)	148.33 (22.35)	26.33 (10.11)
Non-Dominant Hand	203.33 (31.08)	175.66 (32.75)	27.66 (8.62)

Comparison between Control and Experimental Group

When the dominant hands were compared, the mean difference of 26.33 sec (SD10.11) of the experimental group was larger compared to the control group of 14 sec (SD 6.08). However, this difference was not statistically significant (p=0.145)

Similarly, for the non-dominant hand, the mean difference between the two groups was not statistically significant (p=0.289). However, the mean difference

for the experimental group

27.66 sec (SD 8.62) was more than control group 19.66 sec (SD 7.37)

Table3: Comparison of the mean difference of the time taken in seconds to complete JTHFT using the dominant hand

	EXPERIMENTAL	CONTROL
MEAN DIFFERENCE	26.33	14
STD DEV	10.11	6.08

Table4: Comparison of the mean difference of the time taken in seconds to complete JTHFT using the non-dominant hand

	EXPERIMENTAL	CONTROL
MEAN DIFFERENCE	27.66	19.66
STD DEV	8.62	7.37

Discussion

In this pilot study, subjects with Parkinson's disease received two different interventions: motor imagery combined with physical therapy and physical therapy alone. The effect of these interventions on hand function was analysed and compared using the Jebsen Taylor Hand Function Test (JTHFT). The JTHFT measures the time taken to complete seven different subtasks. A reduction in time post-intervention suggests positive effects.

Motor imagery refers to a technique where a task/exercise has to be observed and then mentally rehearsed before performing it. The learning effects of motor imagery are not the result of peripheral low threshold activation of muscles but the result of a central mechanism.[7] Since motor imagery is associated with the activation of somatotopically organized sections of the motor cortices,[10] imagery of hand movements will activate the similar regions in the brain which are responsible for actual movement. Similar phenomena have also been reported with observation of tasks. There is not only an increase in regional cerebral blood flow but also enhanced corticospinal facilitation. These changes can be attributed to the mirror neuron system [7]

The preliminary result of this study suggests that both the control and experimental group had a significant change in their hand function post-intervention. Although the mean difference for the experimental group was larger than the control group for both dominant and non-dominant hands, this result is not statistically significant. Observation of the activity in the experimental group may have helped the participants memorize and thus better plan the movement before performing it. Imagination of movement may also act as a simulator providing feedback regarding the movement prior to performing it. Imagery may be used to improve intrinsic

motivation and individual self-confidence.[11]A greater improvement in hand grip strength may have been responsible for improving the hand function in the experimental group, this is supported in a study by*Alejandro Losana-Ferrer et al*, who conducted a randomized control trial to evaluate the effect of motor imagery and action observation on hand grip strength, EMG activity and intramuscular oxygenation. Hand grip strength significantly increased in the motor imagery and action observation groups.[12]Thus, improvement in hand function following a motor imagery session can be the resultof a combination of neurological, physiological and psychological (increased arousal, motivation and confidence) adaptations.

The amount of time spent in a motor imagery intervention needs to be assessed. Even though an average duration of motor imagery has been reported to be 17 minutes [8] levels of education and degree of understanding could affect the results with some people requiring familiarisation with the technique before the beginning of motor imagery intervention in order to achieve positive results. Imagery tasks will therefore need to be trained and described carefully to provide reliable results. It is worth mentioning that subjects are likely to experience mental fatigue over continuous imagery sessions, thus shorter periods of imagery combined with rests or relaxations are likely to have more beneficial effect than longer sessions. Motor imagery of shorter duration has greater effects on muscle strength than mental imagery training performed over longer durations (7-12 weeks). [13]*Wakefield* and *Smith* also indicate that training programs delivered in three sessions per week are more effective than those conducted once or twice per week.[14]

Further research can explore if motor imagery alone can be an alternative to physical training when it is difficult to train physically in the presence of severe debilitating impairments to minimize disuse induced strength and functional losses. Motor imagery is a relatively safe procedure and can be administered even at home. It does not require use of any sophisticated equipment and does not cause undue muscle fatigue. Motor imagery can prove to be beneficialand should be included in rehabilitation programs along with physical training.

Limitations of the study include a small sample size; owing to the small sample size, the results of this study cannot be used in a clinical setting.Another factor that needs to be considered in future studies will be evaluating the effects of motor imagery during the 'ON' and 'OFF' phases of anti-Parkinson drugs. The long-term benefits of the programme between the two groups have not been compared,thus, establishing which group has beneficial sustained effect is difficult.

Conclusion

The results of this study suggest motor imagery combined with physical therapy has additional benefits when compared to physical therapy alone. Motor imagery can be considered a promising rehabilitative tool in this patient group. Larger studies are needed to support this finding and establish the specificity of treatment.

Competing Interest: The authors declare no conflicts of work.

Ethical Clearance: Ethical clearance was obtained from the research ethical committee at DPO's Nett College of Physiotherapy.

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References

1. Kasper D, Fauci A, Hauser S, Longo D, Jameson J, Loscalzo J. Harrison's principles of internal medicine, 19e.
2. Lukos JR, Poizner H, Sage J. Hand function in

Parkinson's disease. InHand Function 2019 (pp. 163-179). Springer, Cham.

3. Mahmoud LS, Abu Shady NA, Hafez ES. Motor imagery training with augmented cues of motor learning on cognitive functions in patients with Parkinsonism. International Journal of Therapy And Rehabilitation. 2018 Jan 2;25(1):13-9.
4. Randhawa B, Harris S, Boyd LA. The Kinesthetic and Visual Imagery Questionnaire is a reliable tool for individuals with Parkinson disease. Journal of Neurologic Physical Therapy. 2010 Sep 1;34(3):161-7.
5. Liu H, Song LP, Zhang T. Mental practice combined with physical practice to enhance hand recovery in stroke patients. Behavioural neurology. 2014;2014.
6. Liu KP, Chan CC, Lee TM, Hui-Chan CW. Mental imagery for promoting relearning for people after stroke: a randomized controlled trial. Archives of physical medicine and rehabilitation. 2004 Sep 1;85(9):1403-8.
7. Mulder T. Motor imagery and action observation: cognitive tools for rehabilitation. Journal of neural transmission. 2007 Oct 1;114(10):1265-78.
8. Kobelt M, Wirth B, Schuster-Amft C. Muscle Activation During Grasping with andWithout Motor Imagery in Healthy Volunteers and Patients After Stroke or With Parkinson's Disease. Frontiers in psychology. 2018 Apr 24; 9:597.
9. Schuster C, Hilfiker R, Amft O, Scheidhauer A, Andrews B, Butler J, Kischka U, Ettlin T. Best practice for motor imagery: a systematic literature review on motor imagery training elements in five different disciplines. BMC medicine. 2011 Dec;9(1):75.
10. Ehrsson HH, Geyer S, Naito E. Imagery of voluntary movement of fingers, toes, and tongue activates corresponding body-part-specific motor representations. J Neurophysiol. 2003 Nov;90(5):3304-16.
11. Guillot A, Collet C. Construction of the motor imagery integrative model in sport: a review and theoretical investigation of motor imagery use. International Review of Sport and Exercise Psychology. 2008 Mar 1;1(1):31-44.
12. Losana-Ferrer A, Manzanas-Lopez S, Cuenca-Martinez F, Paris-Alemany A, La Touche R. 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. Human movement science. 2018 Apr 1;58:119-31.
13. Slimani M, Tod D, Chaabene H, Miarka B, Chamari K. Effects of mental imagery on muscular strength in healthy and patient participants: A systematic review. Journal of sports science & medicine. 2016 Sep;15(3):434.
14. Wakefield C., Smith D. (2011) From Strength to Strength: A Single-Case Design Study of PETTLEP Imagery Frequency. *Sport Psychologist* 25, 305-320.