Original Article

DOI: 10.7860/JCDR/2022/49954.15880

Effect of Water-based Inspiratory Muscle Training on Lung Functions and Respiratory Muscle Strength in Parkinson's Disease: A Longitudinal Study

Physiotherapy Section

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ABSTRACT

Introduction: Water-based exercises are widely accepted exercises due to its acceptance and additional benefits from them. Exclusively, aquatic exercises are more advantageous than Land Exercises (LE), particularly in the early phase after rehabilitation for respiratory benefits.

Aim: To evaluate the efficacy of water-based inspiratory muscle training in respiratory muscle strength, lung functions and functional capacity in patients with Parkinson's Disease (PD).

Materials and Methods: A longitudinal study was conducted on 30 participants with idiopathic PD, at Chandigarh University, Mohali, Punjab, India, between 50-65 years and in stages I-III (Modified Hoehn and Yahr Scale). Respiratory muscle strength was evaluated through inspiratory muscle training and functional capacity was evaluated with a 6-minute walk test. After the assessment, the participants were randomly assigned into two groups. Group A: Along with conventional exercise, water-based inspiratory muscle training was given to the population of this group. Group B: Along with conventional exercise, land-based respiratory muscle training was given to the population of this group.

Results: Mean age of group A was 69±6 years and group B was 69±4 years (p-value=0.90). As per statistical analysis using paired t-test, both the groups showed improvement from baseline in all the parameters {Forced Vital Capacity (FVC)%, Forced Expiratory Volume in one second (FEV1)%, Maximal Expiratory Pressure (MEP) (cmH_2O)} after the intervention. When compared within the groups using independent sample t-test, there was statistically significant change seen in mean value of the parameters and group A was found to be better as compared to Group B.

Conclusion: The study revealed that water-based respiratory muscle training is safe and more effective intervention as compared to land-based exercise. Further, water-based intervention safely helps in improvement of inspiratory and expiratory muscle strength, pulmonary functions as well as for general body activity in patients with mild-to-moderate PD.

Keywords: Forced vital capacity, Hydrotherapy, Maximum inspiratory pressure

INTRODUCTION

Parkinson's Disease (PD) is a progressive disorder of neurodegenerative changes having multifactorial aetiology, resulting from the degeneration of various dopaminergic neurons in the substantia nigra [1,2]. The various characteristics include the presence of multiple dysfunctions including Noradrenergic serotonergic and cholinergic system deficits. Medications used for the treatment of PD, found to alter the functions of cardiovascular, musculoskeletal, and respiratory systems due to decline in functional activity [3].

Reduced lung function, muscle strength, joint mobility, bone quality, and respiratory volumes are few secondary symptoms notes in PD. Respiratory system deteriorations are associated with osteoarticular degeneration postural remodelling and alteration in intercostal muscle tone which results in decreased chest mobility and range of motion [4]. Changes due to restriction in respiratory function, lead to deterioration in the pulmonary ventilation. This further increases the risk of respiratory complications. The correlation of PD and respiratory dysfunctions is poorly understood; however, it has been proven that medulla oblongata, which is known to control respiratory depth and rate, may be affected during the initial neurodegeneration [5]. All this results in a reduction in the levels of lung volume and ventilator function along with variability in inspiratory and expiratory muscle strength [5,6]. There may be obstructive, restrictive, or mixed alteration in pulmonary functions in PD. Respiratory muscle dysfunction is crucial in the depletion of lung functions, making individuals symptomatic with decline in tolerance for functional mobility or exercise [7].

In PD due to decline in physical activity/sedentary lifestyle, there occurs deterioration in physical function and functional capacity of lungs. Many studies have proved the effectiveness of water-based exercises in improving the balance, functional abilities, and gait pattern in various neurological disorders like cerebral palsy, PD and stroke however no study was conducted on patients suffering from PD [8-12]. So, this study aimed to find out whether water-based respiratory muscle training is better as compared to ground training in improving the respiratory function lung function for thoracic mobility and functional capacity in patients with mild to moderate PD.

MATERIALS AND METHODS

This longitudinal study was conducted at Chandigarh University, from June 2019 to December 2020. Ethical approval was dully provided by the University under registration number SGT/FOP/2019/24. All the participants were informed about the details of the study and consents were taken before confirming their participation. Participants were randomly recruited from the Parkinson Society of Chandigarh and were called to the Outpatient Department (OPD) where they received the treatment.

Inclusion criteria: A confirmed diagnosis of idiopathic PD by a neurologist, the ability to understand and respond to verbal and written instructions, a stable medication regimen (dose and type of medication), and stable disease at the time of inclusion in the study.

Exclusion criteria: The presence of concomitant neurological, cardiovascular, and respiratory conditions, current smokers,

participants with difficulties in maintaining a proper mouth seal or unable to avoid air leakage during pulmonary function testing formed the exclusion criteria.

A sample size of 30 was calculated by using G-Power software taking power of the study at 0.95 and standard error of 5%. All study participants were interviewed on their general health, including their cardiovascular and respiratory health and smoking history. The Montreal Cognitive Assessment test was performed on all participants before the commencement of the study [13].

Procedure

The subjects were divided on the basis of chit method into experimental group (group A) and control group (group B). Baseline parameters like height, respiratory functions, and weight were recorded for each individual, one week prior to the intervention, to rule out underlying impairments in respiratory functions. These recorded values of respiratory functions were used as the pre-exercise values {Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1)}. The Maximum Inspiratory Pressure (MIP) and Maximal Expiratory Pressure (MEP), evaluated with a spirometer attached to spherometer using mouth piece [14].

The Hoehn and Yahr Scale was used in Data Collection Form i.e stage I- III parkinsonism patients were included in this study [15]:

Stage I indicates unilateral involvement only,

Stage II indicates bilateral involvement without impairment of balance and

Stage III indicates mild to moderate bilateral disease some postural instability, physical independence.

The UPDRS (Unified Parkinson's Disease Rating Scale) assesses parkinsonism disease related disability and impairment. The UPDRS composed of 42 items grouped under 4 subscales [16].

Respiratory muscle strength was evaluated through inspiratory muscle training and functional capacity was evaluated with a 6-minute walk test. Along with conventional exercise as prescribed by patient's neurologist and the water-based inspiratory muscle training in group A and land-based respiratory muscle training in group B was done. In experimental group (group A), patients were encouraged to walk in the hydrotherapy pool, with water level till 4th intercostal space or above [17]. The exercise intensity was adjusted to maintain the walking speed at 60% of the heart rate and the walking was continued for 40 minutes a day four times a week for four weeks. Heart rate was measured continuously using wrist-type pulsometer. The subjects were provided with proper outfit to carry out the hydrotherapy protocol.

In control group (group B), similar protocols were adopted and subjects were asked to perform this over a levelled ground for 40 minutes a day four times a week for six weeks.

STATISTICAL ANALYSIS

Data was analysed by using the Statistical Package for the Social Sciences (SPSS) version 20.0 for statistical analysis. Shapiro-Wilk test was used to assess the normality of the data distribution. As variables where shown to be parametric, student t-test was used to compare variables within each group and for comparisons between the groups paired t-test was used to analyse within group differences. A level of significance was set at p-value ≤0.05.

RESULTS

Mean age of group A was 69±6 years and group B was 69±4 years (p-value=0.90) [Table/Fig-1]. There was significant change in FVC pretest and post-test (p-value=0.03) in group A and group B (p-value=0.01) [Table/Fig-2,3].

Group A showed significant improvement of FVC (%) (p-value=0.013), FEV1 (%) (p-value=0.04), MEP (cmH_2O) (p-value=0.05) when compared with Group B [Table/Fig-4].

Variables	Experimental (A) Mean value±SD	Control (B) Mean value±SD	p-value
Age (years)	69±6	69±4	0.90
Body mass index (kg/m^2)	25.9±3.2	27.16±3.40	0.59
Hoehn and Yahr	2.50±0.5	2.75±0.25	0.31
UPDRS	31.37±13.8	22.75±4.5	0.58
Duration of illness (years)	8.5±2.5	7±5	0.32

[Table/Fig-1]: Demographic details of the participants.
UPDRS: Unified parkinson's disease rating scale; p-value ≤0.05 using independent t-test

Variables	Pre-test Mean±SD	Post-test Mean±SD	p-value
Forced Vital Capacity (FVC) (%)	83.5±8.5	128±10.25	0.03*
Forced Expiratory Volume in one second (FEV1) (%)	74.50±0.13	76.00±0.27	0.06*
Maximum Inspiratory Pressure (MIP) (cmH_2O)	-65±1.7	-69±2.3	0.04*
Maximal Expiratory Pressure (MEP) (cmH_2O)	60.0±7	73.00±7.6	0.019*

[Table/Fig-2]: Paired sample t-test findings within Group A (n=15).
*p-value ≤0.05 was considered as statistically significant

Variables	Pretest Mean±SD	Post-test Mean±SD	p-value
Forced Vital Capacity (FVC) (%)	91.50 ±8.25	122±10.25	0.01*
Forced Expiratory Volume in one second (FEV1) (%)	71.50±0.25	71.00±0.39	0.05*
Maximum Inspiratory Pressure (MIP) (cmH_2O)	-64.00±2.8	-71.50±3.5	0.027*
Maximal Expiratory Pressure (MEP) (cmH_2O)	58±2	65.00±7	0.03*

[Table/Fig-3]: Paired sample t-test findings within Group B (n=15).
*p-value ≤0.05 was considered as statistically significant

Variables	Control (B) (n=15)	Experimental (A) (n=15)	p-value
Forced Vital Capacity (FVC) (%)	30.5±2	44.50 ±1.75	0.013*
Forced Expiratory Volume in one second (FEV1) (%)	0.50±0.14	1.50±0.14	0.04*
Maximum Inspiratory Pressure (MIP) (cmH_2O)	-7.50±0.7	-4±0.6	0.520
Maximal Expiratory Pressure (MEP) (cmH_2O)	7.00±5	13.00±0.6	0.05*

[Table/Fig-4]: Mean difference in all the parameters between the groups (independent sample t-test).
*p-value ≤0.05 was considered as statistically significant

DISCUSSION

The present study noted the changes in the functional capacity of lungs with remarkable improvement in forced vital capacity in both groups. However, improvement was more with water-based training protocol as compared to the land-based Inspiratory Muscle Training (IMT) training patients. The present study results are in accordance to the result published by McNamara RJ et al., who concluded that water-based exercise training was significantly more effective than land-based exercise training in increasing peak and endurance exercise capacity in people with Chronic Obstructive Pulmonary Disease (COPD) [18-19]. In a systematic review conducted by De Brandt J et al., also concluded the importance of water-based exercises in comparison to land based to improve various parameters [20]. Further, a systematic review with a meta-analysis of Randomised Control Trial (RCT) proved that respiratory muscle training to enhance ventilator function, FEV1, MIP, MEP, and respiratory muscle strength in subjects with Amyotrophic Lateral Sclerosis (ALS) and Multiple Sclerosis (MS), however there was no remarkable benefits in clinical condition, forced vital capacity and six minutes walk test noted with this intervention [19]. A study by

McNamara RJ et al., documented the remarkably high benefits of water based exercises in comparison to the land based exercise in enhancing the peak and endurance exercise capacity among subjects with COPD [19].

The physiological basis for the improvement in respiratory parameters in aquatic medium is explained by the mechanism by of hydrostatic pressure on the abdominal cavity, leads to elevate the diaphragm and to squeeze the lungs. Moreover, hydraulic pressure led to reduction in the thoracic compliance [21,22]. It is found that the chest wall circumference declines approximately by 0.8 cm with the aquatic pressure, due to water at clavicle level as compared to land [23]. Further, expiratory muscle fatigue is instigated more by aquatic movement in comparison to land mobility. Moreover, it is found that the respiratory muscle strength and vital capacity decline with the water level rising above the umbilical level [14]. Consequently, it is viewed that the strength of inspiratory muscles improves in the water since augmented pressure of water expands the thorax during inspiration. This can be the possible mechanism for the improvement of the parameters in water-based group [24,25].

Limitation(s)

The present study was a preliminary investigation which involved small sample size. Further studies which involve higher sample size are needed to confirm these results. Furthermore, the duration of treatment was six weeks, might have been insufficient to promote an optimal response for various parameters for the participants. It remains unknown whether additional benefits can be obtained when this study is carried out with a longer treatment period. Future studies can be done to investigate the possible carry over effects of the therapy.

CONCLUSION(S)

The result of the study concluded that water-based respiratory muscle training is safe and more effective intervention as compared to land-based exercise in improving inspiratory and expiratory muscle strength and pulmonary functions in patients with parkinsons disease.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 17, 2021
- Manual Googling: Sep 07, 2021
- iThenticate Software: Dec 29, 2021 (22%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Apr 16, 2021**
Date of Peer Review: **Jun 09, 2021**
Date of Acceptance: **Sep 22, 2021**
Date of Publishing: **Jan 01, 2022**