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Original Research Article

Effect of Inspiratory Muscle Training in Individuals with Parkinson's Disorder

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ABSTRACT

Aim: Respiratory muscle weakness is a component of pulmonary dysfunction in Parkinson's disease. Objective of the study was to investigate effect of inspiratory muscle strength training on Maximum inspiratory pressure (MIP) and Maximum expiratory pressure (MEP) in people with Parkinson's disease.
Method: Ethical clearance was sought and all participants signed informed consent. Study group included twenty patients with mild to moderate Parkinson's disease classified using modified Hoehn and Yahr scale 1-3. Control group included 20age matched healthy people. Both groups enrolled in Inspiratory Muscle Strength Training (IMST) program for one month. Study group continued to train for six months thereafter. Outcome of strength training was measured using MIP and MEP.
Results: Study group demonstrated 17 % lower pre training MIP (MIP $_P$ 34.2±8.2, MIP $_h$41.70±7.6 cmH_2O, p<0.005), and 22 % lower MEP (MEP $_p$ 42.5 ±9.6 and MEP $_h$54.1±10.2, p <0.001) compared to healthy controls. Post IMST, improvement in MIP and MEP was observed in both groups. However, study group attained lower respiratory pressures compared to healthy group. (Study Group MIP$_p$ 62.9±16.7 and MEP$_p$- 69.1±14.8cm H_2O , Control Group MIP$_h$ 79.5±14.2, and MEP$_h$ 90.0±16.3 (p<0.001) . Study group required 6 months of training to achieve values of MIP and MEP similar to that achieved by control group who were trained for 1 month only.
Conclusion: Inspiratory muscle strength training for 6 months resulted in improved MIP and MEP values in people with Parkinson's disease. Rehabilitation program for patients with Parkinson's disease should include IMST to improve respiratory muscle strength. .
Keywords: Parkinson's disease, maximum inspiratory pressure, maximum expiratory pressure, Incentive spirometer.

INTRODUCTION

Individuals with Parkinson's disease (PD) have an array of respiratory abnormalities with aspiration pneumonia and pulmonary embolism being the main causes of death. [1] The cause of respiratory dysfunction associated with PD is not confirmed. [2] Reported evidence points towards upper and lower airway obstruction, lower airway restriction and decreased effective respiratory muscle strength in a significant proportion of patients. [3,4]

Muscle weakness in individuals with PD restricts ability to overcome rigidity and potentially contributes to reduced lung volume and respiratory pressure. Such changes are known to cause a negative impact on quality of life in individuals with PD. Adequate respiratory muscle strength is critical to establish the necessary balance between ventilatory requirement and ventilatory capacity. Additionally, reduced strength and coordination of respiratory muscles contribute to low lung volumes, [5,6] Degree of impairment of respiratory muscles can be assessed by measuring maximum inspiratory pressure (MIP) and maximum expiratory mouth pressure (MEP). Various studies have reported change in MIP and MEP following respiratory muscle strength training protocols. [7-9] Respiratory muscles being skeletal muscles, share structural and functional characteristics with limb muscles and are similarly affected by rigidity in Parkinson's disease. Respiratory muscles respond to training in a similar manner as limb muscles when appropriate physiological load is applied. [10,11] Researchers have described protocols to enhance expiratory muscle strength and efficacy of cough in patients with Parkinson's disease, multiple sclerosis, sedentary elderly, post- operative patients and healthy young individuals using pressure threshold devices. [12-16]

Conventionally, Physiotherapists aim at improving strength, balance and mobility of patients with Parkinson's yet the vital aspect of respiratory muscle strength training is often overlooked. Limited information is available on effect of inspiratory muscle strength training in Parkinson's disease. A few studies have reported use of flow related devices for training, however use of simple, cost effective, easily available device like Incentive spirometer which can also be used for home based therapy in individuals with Parkinson's disease is not explored. Therefore, the aim of this study was to examine the effect of inspiratory muscle strength training (IMST) in patients with Parkinson's disease using incentive spirometer in comparison to age matched healthy controls

METHODOLOGY

Institutional ethical approval was sought and informed consent as per Declaration of Helsinki was obtained from all participants. Study group comprised of 20 patients with idiopathic Parkinson's disease in stage 1-3 on Modified Hoehn and Yahr scale. Control group consisted of 20 age matched healthy individuals without any systemic illness. Convenient sampling method was used for recruitment of patients from three hospitals in Navi Mumbai and neighboring residential complexes. Study group was on standard medications for treatment of PD and underwent conventional physiotherapy treatment. In both groups, people with systemic illness, known cardio respiratory conditions, musculoskeletal impairment and neurological conditions and smokers were excluded.

Anthropometric measurements i.e. height in centimeters, weight in kilograms and BMI (mass kg/height $(m)^2$ were recorded. Maximum Inspiratory Pressure (MIP) and Maximum Expiratory pressure (MEP) were used to evaluate outcome of IMST. Micro respiratory pressure meter was used to record MIP and MEP values using standard protocol [17-19] Participants were asked to seal their lips firmly around mouthpiece of Micro respiratory pressure meter, exhale slowly and completely, and then pull in hard, as if trying to suck a thick milkshake, for measuring MIP. The method was demonstrated and participant was asked to repeat it thrice. [2,13] MEP was measured by sealing lips around mouth piece and blowing out as hard as possible. A total of five readings were recorded; out of which 3 readings within 5% variation were considered and amongst them, highest value was noted for MEP. Both groups underwent supervised IMST using incentive spirometer for 4 weeks. [20,21] All participants underwent supervised training 4 times/week. Each session lasted for 20 min. They were instructed to perform a total of 4 sessions per day. Training was continued at the same intensity at home for remaining 3 days of the week. The spirometer had settings ranging from 200 ml/sec to 1200 ml/sec. The device was set initially at 200ml with inspiratory breath hold time as per participants comfort. Overload was introduced each week by incrementing the volume inspired and inspiratory hold time as per participant comfort. Control group discontinued after 1 month of IMST whereas study group continued to train for 6 months. Weekly recording of MIP and MEP was carried out for first month, there after MIP and MEP was recorded once a month.

Statistical Analysis

Data were analyzed statistical using SPSS 16.0.Mean differences and standard deviation of scores was calculated for each variable. Kolmogorov-Smirnov test was used for confirming normal distribution of data. Data from all variables were distributed normally except MIP recorded post 4^{th} week of training in Parkinson's group. Friedman test was used to compare MEP. Independent sample t-test was used for comparison of MIP and MEP between subjects with Parkinson's disease and age matched healthy controls. Repeated measures ANOVA was used to compare MIP and MEP within the two groups. Level of significance was set at $p<0.05$ for all analyses.

RESULTS

Demographic variables of both groups were comparable, with mean age of 69 years. Study group weighed marginally more than control group however the difference was non-significant. (refer Table 1).

Mean Pre training values of MIP and MEP in study group were MIP_P - 34.2±8.25cmH_2O , MEP_p -42.55 ±9.68cmH_2O respectively and in control group were MIP_c - 41.70±7.63 cmH_2O and MEP_c- 54.15±10.29 cmH_2O .(Refer table 2). Pre training values of MIP and MEP were 17% ($p<0.005$) and 22% ($p<0.001$) lower in study group compared to control group.

Table 1: Demographic characteristics of Study Group (Parkinson's patients) and age and gender matched healthy Control Group

Variable	Study Group n= 20 Mean (SD)	Control Group n= 20 Mean (SD)
Age years	69.2 (5.1)	68.4 (5.9)
Height cm	166.25 (7.5)	165.00 (6.1)
Weight Kg	63.70 (5.4)	61.35 (5.9)
BMI kg/m^2	23.04 (0.8)	22.43 (1.3)

Table 2: Comparison of MIP and MEP in Study group and Control Group at various durations of four weeks of IMST.

	Group	Mean	SD	Mean Difference	t-stat	DF	p-value
PRE MIP	Study Group	34.2	8.2	7.500	2.983	38	0.005**
	Control group	41.7	7.6				
post1wk	Study Group	40.8	9.5	8.050	2.818	38	0.008**
	Control group	48.9	8.4				
post2wk	Study Group	48.9	10.9	7.650	2.271	38	0.029*
	Control group	56.5	10.3				
post3wk	Study Group	56.5	13.4	9.600	2.27	38	0.029*
	Control group	66.1	13.3				
post4wk	Study Group	62.9	16.7	16.600	3.367	38	0.002**
	Control group	79.5	14.2				
PRE MEP	Study Group	42.5	9.6	11.600	3.669	38	0.001**
	Control group	54.5	10.2				
post1wk	Study Group	48.7	10.2	12.700	3.371	38	0.002**
	Control group	61.4	13.3				
post2wk	Study Group	53.9	10.2	14.500	3.773	38	0.001**
	Control group	68.4	13.7				
post3wk	Study Group	61.4	12.41	14.550	3.472	38	0.001**
	Control group	76	14				
post4wk	Study Group	69.5	14.8	20.550	4.162	38	0.001*
	Control group	90	16.3				

In response to IMST using incentive spirometer, significant increase in MIP ($p<0.001$) and MEP ($p<0.001$) was noted as early as post-2 weeks of training in both groups. (refer Table 4, Figure 1, 2). After 4 weeks of IMST, although there was an increase in MIP and MEP, study group demonstrated lower post training respiratory pressures compared to control group (MIP_c - 79.55±14.28, MIP_p - 62.95±16.79cmH_2O ($p<0.001$), MEP_c - 90.05±16.37 and MEP_p - 69.15±14.80cmH_2O ($p<0.001$) (refer to Figure 1 and 2).

Table 3: Comparison of MIP and MEP of Study Group (n=15) at various durations of 6 month of IMST

MIP cmH_2O	Mean	SD	DF	F-stat	p-value
Pre training MIP	37.1	6.4	1,12	206.665	< 0.01**
Post training MIP after 1 month	69.7	11.1			
after 2 months	72.6	10.6			
after 3 months	75.7	10.3			
after 4 months	78.3	10.9			
after 5 months	80.6	11.9			
after 6 months	84.3	10.1			
MEP cmH_2O					
Pre training MEP	46.3	5.9	1,12	214.402	< 0.01**
Post training MEP after 1 month	73.2	10.2			
after 2 months	75.2	9.4			
after 3 months	76.7	9.4			
after 4 months	78.7	8.8			
after 5 months	80.0	9.0			
after 6 months	82.3	8.9			

*: Significant at 5%, **: Significant at 1% level

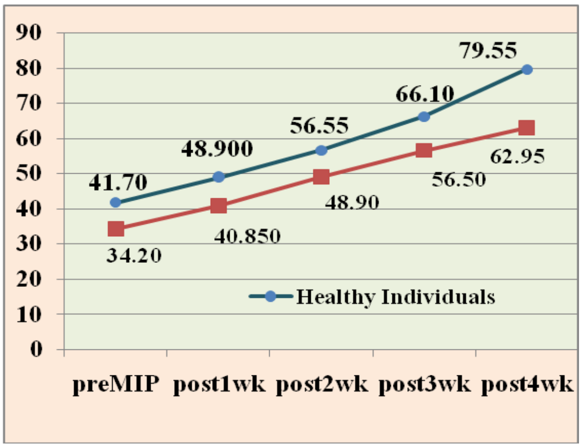

Figure 1: Group-wise Comparison of MIP at Various Durations

Study group continued with IMST for 6 months, however further increments in MIP and MEP were smaller compared to 4-week training duration. After 6 months of training, MIP increased overall by 82-217% and MEP increased by 48-118% compared to pre training value. At the end of 6 months, mean MIP of study group was 84.3 ± 10.1 which was 8% higher than that achieved by control group which trained for 4 weeks only. (79.5 ± 14.2 cmH_2O).However, at the end of 6 months of IMST, MEP in study group was 82.3 ± 8.9 which was still 8% lower than MEP of control group (90 ± 16.3 cmH_2O). (refer Table 3, Figure 3)

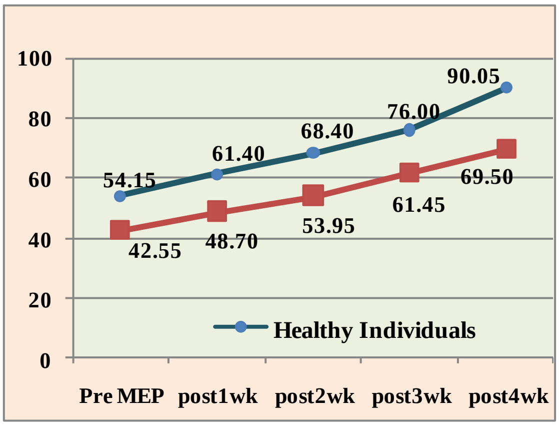

Figure 2: Group-wise Comparison of MEP at Various Durations

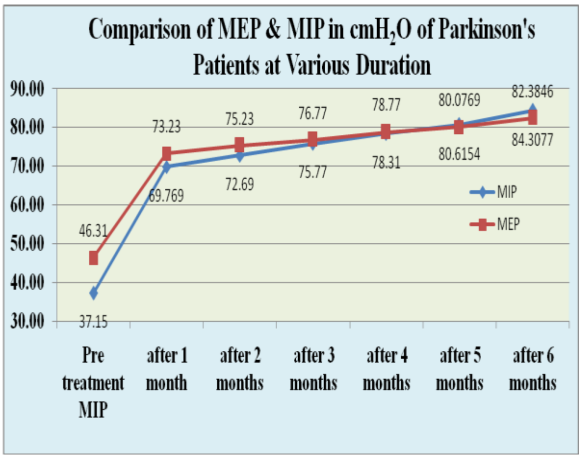

Figure 3

Effectively, after 4 weeks of training, study group demonstrated an improvement of 82% in MIP and 65% in MEP; whereas, control group showed 91% and 69% improvement.

Table 4: Intra Group Comparison of MIP and MEP in Study Group (Parkinson's Patients) and Control Group (Healthy Individuals) at Various Durations of IMST
Post Hoc Multiple Comparisons

Dependent Variable	Level(weeks)	Study Group Mean Difference	Study Group p value	Control Group Mean Difference	Control Group p value
MIP	4 - 0	28.75*	0.000	37.85*	0.000
	1	22.10*	0.000	30.65)	0.000
	2	14.05*	0.004	23.00*	0.000
	3	6.45	0.970	13.45*	0.002
MEP	4 - 0	26.95*	0.000	35.90*	0.000
	1	20.80*	0.000	28.65*	0.000
	2	15.55*	0.001	21.65*	0.000
	3	8.05	0.313	14.05*	0.016

**Mean Difference Significant at 0.05 level*

DISCUSSION

In the present study, although lower baseline values of MIP and MEP were observed in patients with Parkinson's disease, consistent improvement was observed in MIP & MEP with low intensity IMST sustained for 6 months.

Participants included in study group were on stage 1-3 as per modified Hoehn Yahr Scale of Parkinson's disease. [22] They presented with slowness of motion, tremors, rigidity, and unilateral paucity of movement in stage 1 progressing to stage 2 where bilateral affection, slurring of speech and postural abnormalities were seen. Stage 3 patients demonstrated impaired balance, increase in involuntary movements but were completely independent in activities of daily living. Difficulties with breathing, communicating, swallowing, and coughing, as well as cognitive decline, compounded their problems as the disease progressed. [15]

Expectedly, Parkinson's group demonstrated lower baseline values of MIP and MEP in comparison to age matched healthy individuals. Maximum Inspiratory pressure was lower by 17% and MEP by 22% in Parkinson's group. Values of MIP and MEP were lower by 40-50% than reported reference values. [11,17,23,24] In age matched healthy controls (mean age 69 years) , baseline values observed for MIP and MEP were comparatively 22-40% lower than reported values suggesting the influence of age on compliance of thorax which was reported earlier by Sabaté et al and others. [4,25-27]

The cause of respiratory dysfunction associated with PD is not confirmed, [2] however reported evidence points towards lower and upper airway obstruction, lower airway restriction, respiratory muscle weakness and dysfunction and poor compliance of chest wall due to rigidity. [3,4] This could account for lower values of MIP and MEP in Parkinson's group as compared to healthy people.

Study group displayed a slow and steady rise in MIP and MEP values over the 4 weeks of IMST. Over a 4-week period, from the baseline, 82.95% improvement in MIP and 65.45% of improvement in MEP was observed. In age matched healthy controls increments in values were higher and faster. There was a sudden rise in the MIP and MEP graph in 3rd week of training. Improvement in MIP and MEP was about 91.85% and 67.90% respectively which was significantly higher than in individuals with Parkinson's disease.

Strength training of respiratory muscles is hypothesized to be similar to that of limb muscles, in which strengthening is typically seen within four weeks of training, potentially resulting from neural adaptations. [11,4,28] Strengthening of limb muscles results in both neural adaptations in the form of increase motor unit excitability, enhanced coordination, more efficient motor programming and muscular adaptations like increased muscle diameter. The same has been shown to occur in strengthened respiratory muscles. [4,11,29]

The slope of the improvement curve was comparatively flatter in Parkinson's patients. (refer Figure 1and 2) .Similar observations have been reported by other researchers that individuals with PD may experience slower neural adaptation than healthy individuals as seen by the slower rise in values of MIP and MEP values in the participants of this study. [10]

When IMST was continued in Parkinson's subjects for six months, MIP and MEP values continued to increase each month, though the increments were smaller. Highest increase in respiratory pressures was observed in the first month. Overall, values of MIP increased by 85-217% and MEP by 48-118% respectively. MIP showed greater increment than MEP which could be due to primary training of the inspiratory muscles. However Parkinson's patients required 6 months of intense training to reach values of MIP and MEP similar to that of healthy age matched adults who trained only for one month.

The participants demonstrated increase in number of inspirometry repetitions, breath hold time and resistance level .Initially Study group could perform only 5 repetitions which doubled at the end of one month and reached 15 repetitions at the end of 6 months. In the study group, breath hold time increased from 3 to 15 sec and volume inspired increased from 200 to 500ml .Whereas in the control group repetitions increased from 5 to 25, breath hold time increased from 7 to 15 sec and volume inspired increased from 200 to 500ml. These results supported the hypothesis that IMST was effective in increasing respiratory muscle strength.

IMST trained inspiratory muscles, especially the diaphragm, which generates negative intra thoracic pressure and enlarges thoracic cavity during inspiration. Other inspiratory muscles including external intercostals muscles, scalene and sternocleidomastoid muscles that lift the rib cage during inspiration also contribute. Activation of diaphragm and intercostal muscles which are naturally slow to fatigue due to their high content of oxidative type I and type IIA muscle fibers, helped reduce fatigue as was reported by our patients. [28] Age is known to have a negative impact on pulmonary compliance; therefore IMST was instituted in control group as well. [11]

Incentive spirometer, provides the participants visual feedback of volume of air inspired during deep breathing thereby giving an immediate objective measure of improvement to the participant ensuring adherence to protocol. [20,21] Repetitions and inspiratory breath hold provided low level resistive training that increased muscle strength of the inspiratory muscles. [20,21]

The effects of training can be clinically significant when creating long-term treatment goals and determining the need for maintenance programs. Researchers have suggested that intensive training can offer neuro protection and slow, stop or reverse progression of disease through adaptation of compromised pathways of signaling. [8]

Furthermore, participants reported feeling more energetic, sleeping better and reduced shoulder pain which may be a result of improved breathing posture required for IMST. Limitations of the study were that quality of life was not quantitatively assessed and pulmonary functions like vital capacity and total lung capacity were not measured, hence the outcome of IMST on participants' respiratory functions may not be fully represented. Additionally subjects with higher scores on Hoehn and Yahr Scale were not included in the study. Further research in this area is suggested to explore effects of IMST on pulmonary abilities, using longitudinal studies with larger sample sizes.

Practical Application

Inspiratory muscle strength training using incentive spirometer in Parkinson's patients improves respiratory muscle strength with as little as four weeks of training .However six months of training is required to increase respiratory strength comparable to that of healthy age matched adults. Incentive spirometer does not require any special training nor is it expensive. Respiratory muscle training using incentive spirometer should be incorporated routinely in outpatient therapy and home based care in people with Parkinson Disease.

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Abbreviations – Pre training MIP- maximum inspiratory pressure before initiation of inspiratory muscle strength training, MIP post 1 wk – maximum inspiratory pressure after one week of inspiratory muscle strength training, MIP post 1 wk – maximum inspiratory pressure after one week of inspiratory muscle strength training, MIP post 2 wk – maximum inspiratory pressure after two weeks of inspiratory muscle strength training, MIP post 3 wk – maximum inspiratory pressure after three weeks of inspiratory muscle strength training, MIP post 4 wk – maximum inspiratory pressure after four weeks of inspiratory muscle strength training, Pre training MEP- maximum expiratory pressure before initiation of inspiratory muscle strength training, MIP post 1 wk – maximum expiratory pressure after one week of inspiratory muscle strength training, MIP post 1 wk – maximum expiratory pressure after one week of inspiratory muscle strength training, MIP post 2 wk – maximum expiratory pressure after two weeks of inspiratory muscle strength training, MIP post 3 wk – maximum expiratory pressure after three weeks of inspiratory muscle strength training, MIP post 4 wk – maximum expiratory pressure after four weeks of inspiratory muscle strength training,

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