Combining inspiratory muscle training and upper limb exercises. Does it improve outcomes in COPD patients?

A Sciriha *BSc (Hons), MSc (Sheffield) SRP*

Senior Physiotherapist, Mater Dei Hospital, B'Kara Bypass, 65 Main Street, Mosta. MST1012. Malta

K Moore *DipPT, MSc HCP, PGCLT, AHEA*

Senior Lecturer in Physiotherapy, Sheffield Hallam University

S Montefort *MD, PhD., FRCP, FCCP*

Professor of Respiratory Medicine Mater Dei Hospital, Malta and Senior Lecturer University of Malta

Summary

This study aimed to determine if a combination of upper limb exercises with IMT have added effects in dyspnoea management, ADL's, respiratory strength and upper limb endurance, when compared to IMT only and a control group. Outcome measures pre and post treatment included lung function tests, 6-minute walk distance, dyspnoea score and Activities of Daily Living Scale. Statistically significant changes resulted in both exercise groups but this change was more pronounced in the combination group. In this study combining upper limb and inspiratory muscle training shows trends towards positive effects.

Keywords

Pulmonary Rehabilitation, COPD, Inspiratory Muscle Training, Upper limb Exercises

Correspondence details

A Sciriha, Senior Physiotherapist, Mater Dei Hospital, B'Kara Bypass, 65 Main Street, Mosta. MST1012. Malta
Tel: 00356 21412950
anabel.sciriha@gov.mt

Introduction

Dyspnoea and decreased ability to performing activities of daily living (ADLs) and exercise is common in Chronic Obstructive Pulmonary Disease (COPD) (Hill et al 2004). To limit dyspnoea some patients avoid activities leading to a sedentary lifestyle and muscle deconditioning (Maltais et al 2000). Respiratory muscle dysfunction is an important determinant for the increased use of health resources and the survival of hospitalised COPD patients (Decramer et al 1998).

Webber and Pryor (1998) state that dysfunction of the upper limbs due to weak musculature also distresses COPD patients for a given workload since upper limbs require more energy and are accompanied by higher ventilatory demands than lower limbs. In many COPD patients, activities performed in unsupported positions precipitate dyspnoea to a far greater extent than would be expected by that degree of metabolic work.

Inspiratory muscle training (IMT) has been researched in depth to find its optimum effective use with COPD patients (Sturdy et al 2003). Studies investigating IMT alone (Hill et al 2004, Sturdy et al 2003, Weiner et al 2003) or in conjunction with whole body or lower limb exercises (Lotters et al 2002, Smith et al 1992) show improvements in respiratory muscle strength and exercise tolerance. These studies (Sturdy et al 2003, Weiner et al 2003) use loads varying from high (80%) to low percentages (30%) of their participants' maximal inspiratory pressure (PImax). Breathing control throughout the training process also needs to be considered as it may influence the end results (Smith et al 1992).

In the last 20 years there has been interest in upper limb training as part of exercise programmes for COPD patients with much of the available evidence dating back to the early 1990s. The various methodological differences in existing studies, further limits interpretation of results from these studies. Reductions in exercise capacity have been attributed to ventilatory constraints (Criner and Celli 1988, Celli et al 1986); however, during unsupported arm exercise additional mechanical constraints to ventilation occur (Criner and Celli 1988, Celli et al 1986). Previous studies investigated either the effects of arm position on ventilation or else the combination of IMT and lower limb exercises but no studies were retrieved which looked into the combination of upper limb and IMT.

Study aim

To determine if a combination of upper limb exercises with IMT have added effects in dyspnoea management, ADL's, respiratory strength and upper limb endurance, when compared to IMT only and a control group,.

Methods

COPD patients, aged 45 to 75 were recruited from the Chest Clinic, St. Luke's Hospital, Malta by Consultant Respiratory Physicians. A total of 45 patients were recruited. Ethical approval was gained and informed consent obtained from all participants. COPD was defined by the American Thoracic Society (ATS 1995).

Inclusion criteria: Moderate to severe airflow obstruction (FEV_1<65% predicted, FEV_1/FVC<70%), dyspnoea on exertion measured with the Borg scale, medically stable, willing to participate.

Exclusion criteria: History of asthma, COPD exacerbation within the previous 2 months as defined by the ATS, requirement of home oxygen therapy, oxyhaemoglobin desaturation below 85% with exercise, cardiovascular, musculoskeletal or neuromuscular disease that might interfere with exercise.

Sampling: Participants were assigned in equal numbers to one of the two exercise groups, or the control group.

Study protocol: Group 1 (combination group). This exercise group consisted of both an eight week training programme of once weekly supervised sessions of inspiratory muscle training (IMT) and an upper limb exercise programme. The latter included arm exercises for 15 minutes, which included throwing a ball against a wall, arms above horizontal, passing bean bags over the head and shoulder flexion using a dowel. Each exercise was performed for 40 seconds followed by 20 second rest periods, four times in four minutes.

Group 2 (IMT group). This exercise group underwent an eight week training programme of once weekly supervised sessions of IMT only. Both groups 1 and 2 continued the IMT treatment twice daily for five days per week at home.

All participants had a two week practical learning period prior to the assessment phase, to become familiar with the Threshold Trainer (Health Scan Products Inc., NJ, USA: Figure 1), a device which offers a constant load with a controlled breathing pattern. The load applied by the Threshold trainer was adjusted after four weeks to 30% of their new PImax reading. Participants were also encouraged to keep a diary to record their training and monitor progress which was reviewed by the researcher every 10 days by telephone.

Group 3 (control group). This group underwent no formal exercise but was offered an active exercise programme at the end.

Outcome measures: The following outcome measures were recorded at the beginning and end of the 8-week training period in all groups: PImax; respiratory muscle endurance; 6 minute walk test (6MWT); upper limb endurance; dyspnoea; lung function and ADL performance.

Maximal Peak Inspiratory Pressure (PImax) was measured as the maximum negative pressure maintained during a one second inspiratory effort against a closed valve from functional residual capacity repeated four times with the best effort recorded.

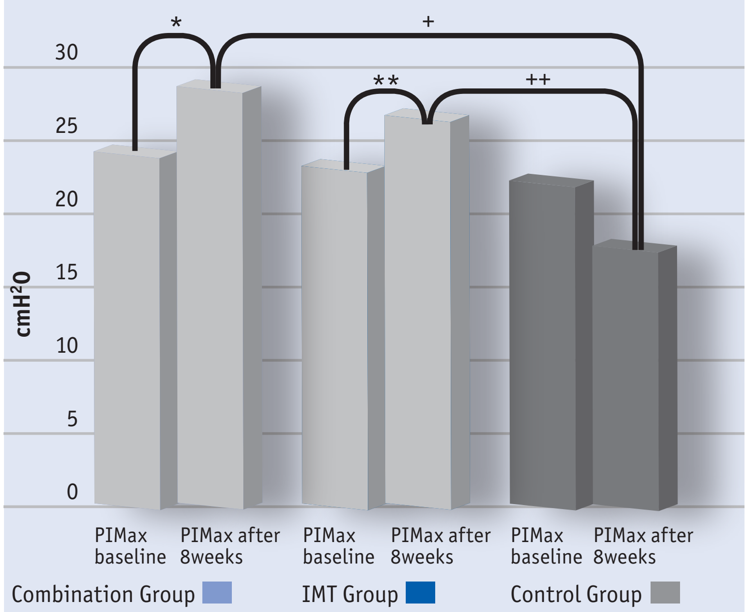
Respiratory muscle endurance was measured using the Discontinuous Incremental Threshold Loading test as described by Larson et al (1999).

The 6MWT distance was measured on three occasions with the furthest distance used for the results. Their oxygen saturation was measured before, during and after the test.

Upper limb endurance was measured by asking the patients to lift their arms above shoulder level for 10 or more repetitions, at a speed starting from 80 beats on the metronome until no more that 10 repetitions could be performed with an increase in speed markings.

Dyspnoea was scored using the Borg Category Ratio Scale (Mahler 1992) to measure patients' perceptions of

Figure 1: Changes in inspiratory muscle strength at baseline and after 8 week intervention.



Abbreviations: IMT: Inspiratory muscle training;
*PImax:- peak inspiratory pressure There was a significant difference in PImax between the exercise groups and the control group. (+ combination versus control group p=0.0002; ++ IMT versus control group p=0.0006). PImax in the combination group increased significantly after training (*p< 0.0406). The change for the IMT group was less (**p=0.0950).*

breathlessness during exercise, respiratory and upper limb endurance tests. During the latter, perceived breathlessness was measured after 2 minute work periods. Breathlessness was also rated before and after the 6MWT.

Lung function analysis consisted of spirometry and plethysmography (ATS 1995). Whole body plethysmography (Jaeger, Germany) was carried out by the constant volume method.

The London Chest Activity of Daily Living (LCADL) scale (Garrod et al 2000) was completed by each participant before and after the exercise programmes to assess the level of ADL performance.

Data analysis: Analysis of variance was carried out to compare between group differences in key outcome measures. The paired student's t-tests were used to compare post treatment with respect to pre treatment values.

Results

Forty participants (30 male, 10 female) completed the study (Table 1). There were no significant differences in baseline measurements between groups at the start of the study. Enquiry concerning adherence suggested that most patients conducted their training sessions regularly. The p value p<0.05 was considered significant.

Inspiratory Muscle Strength (PImax)

When looking at the PImax values post treatment between the three groups, no significant difference in the end results was found when comparing both exercise groups (Figure 1). There was a significant difference in PImax between the exercise groups and the control group. This difference was more pronounced when comparing the combination group to the control group with a 61% difference (p=0.0002), as opposed to a change 44% change when comparing the IMT group with the control group (p=0.0006).

PImax in the combination group increased significantly after training from 24.7cm$H_2$0 ±0.7 to 29.1cm$H_2$0 ±2.2 (p< 0.0406). The change for the IMT group was less (p=0.0950). The control group showed a decrease in PImax by 16% (p=0.0892).

Respiratory Muscle Endurance

Respiratory muscle endurance for both exercise groups was significantly greater compared to the control group for post treatment values (p<0.05) (combination group versus control 22%; IMT group versus control 15%). Compared to baseline post treatment scores for endurance increased significantly in the combination group (p< 0.0039) and in the IMT group (p< 0.0719) but not in the control group.

Dyspnoea scores

There was no significant difference between the groups post treatment in the Borg Category Ratio Scale (Figure 2a and 2b). There were significant improvements in dyspnoea scores from baseline to post treatment in the exercise groups but not the control group.

Exercise test

Comparing the three groups together results in no significant change in the distance covered. Changes in the 6MWT distance though were significant when looking at the pre and post values for the combination group with an increase of 64% (p< 0.0010) (Figure 3).

LCADL

There were no significant

Table 1: Physical characteristics and resting lung function data of the participants of the three groups.

Test Measure	Combination group n = 11	IMT group n = 14	Control group n = 15
FEV_1 % Predicted	63.45 ±3.53	60.08 ±3	59.3 ±1.52
FEV_1/FVC %	72.91 ±1.45	76.64 ±1.7	76.60 ±2.33
PImax @ FRC cmH_20	24.73 ±0.7	24.28 ±0.8	22.33 ±1.3
PEmax cmH_20	20.10 ±1.9	17.14 ±1.6	22.87 ±1.9
Respiratory muscle endurance cm H_20	15.18 ±0.8	17.86 ±1	17.27 +1
6MWT (metres)	223 ± 23.4	274 ±37.4	255 ±28.7
$Sa0_2$ before 6MWT %	94.5 ±0.6	94.6 ±0.36	93.9 ±0.4
$Sa0_2$ during 6MWT %	93.5 ±0.9	94.1 ±0.6	93.6 ±0.6
$Sa0_2$ after 6MWT %	94.9 ±0.5	94.7 ±0.5	93.9 ±0.6
Dyspnoea score before 6MWT	1.91 ±0.5	1.5 ±0.3	1.87 ±0.2
Dypnoea score after 6MWT	5.36 ±0.5	4.43 ±0.4	4.87 ±0.3
Dyspnoea score after UL test	5.5 ±0.3	5.1 ± 0.2	3.5 ±0.3
Dyspnoea score after respiratory endurance test	5.3 ±0.3	3.9 ±0.2	4.2 ±0.3
PEFR (L/min)	257.7 ±23.3	233.6 ±21.2	257.3 ±23.9
Gender (Male / Female)	6M/ 5F	11M/ 3F	13M / 2 F
Height cm	153.8 ±1.8	164.2 ±1.55	162.1 ±2.3
Weight Kg	62.9 ±3.2	75.3 ±4.7	82.1 ±6.4
TLC % predicted	115.6 ±5.8	101.4 ±3.9	101.7 ±4
RV % predicted	172.7 ±14.6	144.6 ±10.7	160.1 ±10
VC % predicted	82.1 ±6	72 ±5	67.5 ±3
LCADL (total score)	18.4 ±3.3	16.9 ±1.2	16.1 ±0.9
UL endurance test (beats)	85.1 ±0.8	90.2 ±3.4	102.7 ±4.3

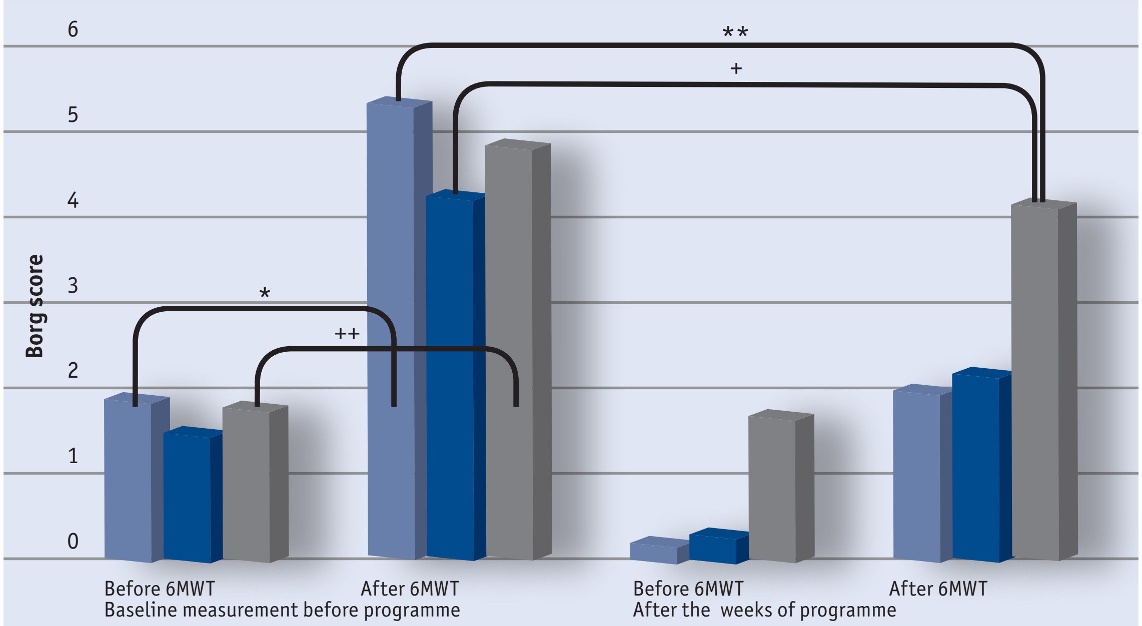
Data presented as mean + SEM.
Abbreviations: 6MWT: 6 Minute Walk Test; FEV1: Forced Expiratory Volume in one second; FRC: Functional Residual Capacity; FVC: Forced Vital Capacity; IMT: Inspiratory Muscle Training;
LCADL: London Chest Activity of Daily Living Scale; PEFR: Peak Expiratory Flow Rate; PEmax: Maximal Peak Expiratory Pressure; PImax: Maximal Peak Inspiratory Pressure; RV: Residual Volume; Sa02: Saturation of oxygen; TLC: Total Lung Capacity; UL: Upper Limb; VC: Vital Capacity.
of Daily Living Score, PEFR: Peak Expiratory Flow Rate; Sa02: Saturation of oxygen, PImax, PEmax,

differences in post treatment total scores between the three groups. There were some significant differences in specific sections, for example the self care (p=0.0351), physical (p=0.0029) and leisure (p=0.0000) sections were better for the combination group compared to the control group. The physical (p=0.0171) and leisure (p=0.0080) sections were significantly better for the combination group compared to the IMT group.

Upper limb endurance

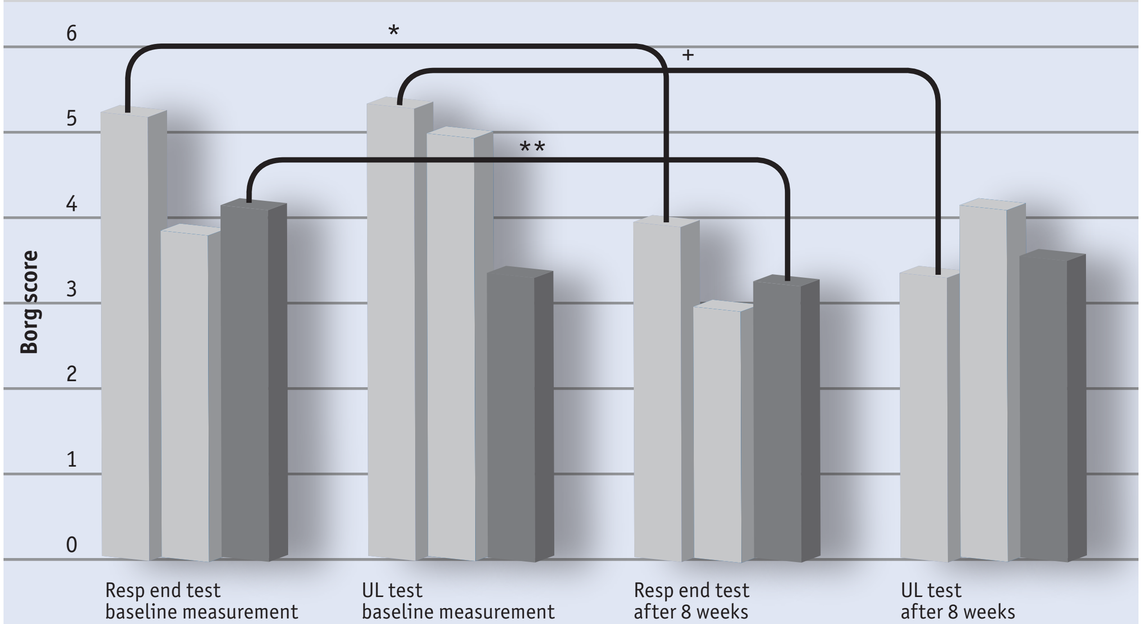
There was no significant difference in upper limb endurance between groups in post treatment scores. For the combination group, there was a significant increase in

Figure 2a: Changes in Borg scale scoring before and after the 6MWT before and after the 8 week programme.
* p < 0.0117, ** p < 0.0020, + p < 0.0002, ++ p < 0.007



Abbreviations: 6MWT: 6 Minute Walk Test; IMT: Inspiratory muscle training

Figure 2b: Changes in the Borg rating score for the respiratory endurance and upper limb endurance test before and after the eight week programme. * p < 0.0078, ** p < 0.0080, + p < 0.0020.



Abbreviations: IMT: Inspiratory muscle training; UL: upper limb; wks: weeks

endurance of 35% between pre and post treatment scores (p< 0.0010) which was not observed in the IMT and control groups.

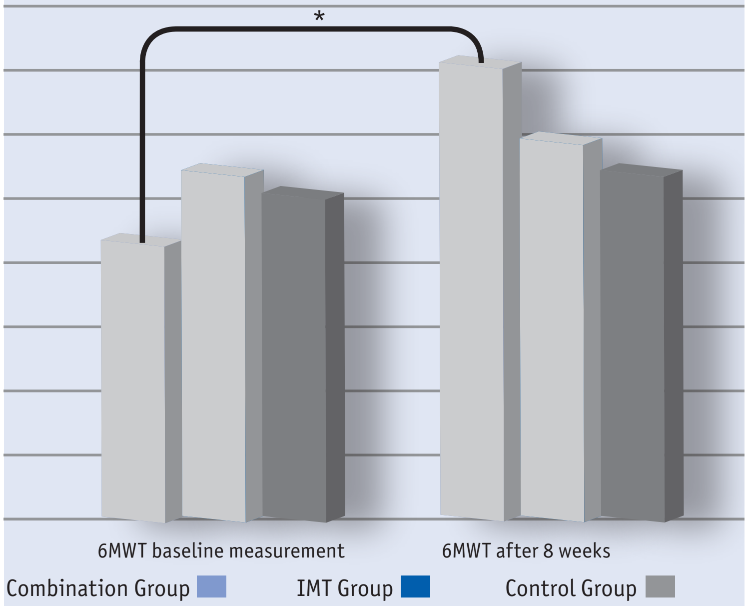
Discussion

There may be added benefit for patients with COPD when combining IMT and upper limb exercises in relation to dyspnoea, respiratory muscle strength and endurance, 6MWT distance, and ADL performance. Improvements demonstrated in respiratory muscle strength compare to other studies using the same training (Larson et al 1999, Villafranca et al 1998, Lisboa et al 1994) or threshold loading (Weiner et al 2003, Larson et al 1999, Lisboa et al 1994). There was a greater improvement in the combination group compared to the IMT group in relation to pre and post treatment data. Study results may have been affected by the participant drop out from the combination group.

Preusser et al (1994) found that participants with the highest degree of hyperinflation and chest wall dysfunction benefited the most from conditioning at high level intensity. However, they found that low intensity training also proved to be beneficial yielding significant results in severely affected patients. As is well known, in order to avoid an increase in resistive work whilst carrying out upper limb activities, patients with COPD become hyperinflated at the expense of greater elastic work (Dodd et al 1984). Criner & Celli (1988) studied the differences in breathing patterns between patients performing supported and unsupported upper limb exercises and noted that changes in breathing patterns were secondary to limitations of the inspiratory muscles' ventilatory capacity,

Inclusion of upper limb exercises in the combination group resulted in a more efficient performance of ADLs. Apart from superior results in PImax values, improvements in lung function and dyspnoea scores were noted in the combination group when compared to the IMT group. When COPD patients perform unsupported arm exercises, as with normal ADLs, there is shortening of the accessory muscles together with passive stretching of the thoracic cage. As Dolmage et al (1993) has indicated, this leads to the muscles becoming less effective, which increases ventilation resulting in rapid, shallow breathing patterns and dyspnoea. The increase in upper limb strength and endurance allows participants to adopt more effective breathing patterns. This may account for the decrease in dyspnoea score reported by the combination group.

Figure 3: Changes in the distance covered in 6 minutes before and after the training programme *p< 0.0010.



Abbreviations: 6MWT: 6 Minute Walk Test; IMT: Inspiratory muscle training

When training loads are controlled, the increment in inspiratory muscle strength and endurance is translated into a clinically meaningful improvement in functional status. The use of threshold loading devices also ensured in this study that each participant reached a constant load sufficient to obtain favourable results. Most previous studies have used external resistive loads which are dependent on breathing patterns, thus making a constant target load impossible (Lisboa et al 1994, Smith et al 1992).

There is very little evidence about the transfer effects of IMT to ADL and dyspnoea. The LCADL score showed significant improvements in the physical and leisure sections, especially for the combination group. This could be attributed to the fact that once dyspnoea decreased, patients felt more confident in increasing their mobility and resuming activities leading in turn to emotional improvement as well as better physiological control of the disease. This may also be applied to the high rate of increase in the 6MWT distance seen in the combination group. This group integrated well, giving each other continuous positive reinforcement throughout the programme.

Limitations of the study

While the sample size was small this study does give some insight into the problems inherent in such studies. The highest drop out rate was from the combination group and this might have influenced the end result, expressed as a mean, when compared with the other groups.

The location and appointment times may also have been a limitation. Since there was no group in this study performing upper limb exercises only, one was not able to compare the effects of this type of exercise on its own as opposed to upper limb exercises and IMT together.

The fact that the researcher was aware of all the patient's groupings and was present during all the tests may have led to biased results especially between the exercise and control groups with the former having weekly appointments for 8 weeks.

Further research

Further study is required to establish the optimal training regime for patients with COPD.

Conclusion

This paper provides some evidence in support of IMT showing that inspiratory muscles can be trained leading to reduction in dyspnoea scores, improvements in lung function and exercise tolerance. It also shows an added trend for improvements when IMT is combined with upper limb training. These are important factors to consider when planning and implementing programmes to help in the management of COPD.

Key Points

- IMT using threshold devices and upper limb exercises may have a role in the management of COPD patients.

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