Eur J Respir Dis (1985) 66, 181-186

Relieving dyspnea with an inexpensive and simple method in patients with severe chronic airflow limitation

P. FALK, A-M. ERIKSEN, K. KØLLIKER & J. B. ANDERSEN

Department of Pulmonary Medicine, Hillerød Hospital, Department of Anesthesia, Hørsholm Hospital and Department of Anesthesia & Intensive Care, Herlev Hospital, Denmark.

Abstract: The effect of inspiratory resistive breathing training using a simple apparatus was tested in 27 optimally medicated consecutive outpatients with severe chronic airflow limitation, randomly assigned to a test and a control group. Patients trained in their homes for up to 10 min thrice daily and increments in resistance were made, if possible, every fortnight. The control group used the same apparatus, but without inspiratory resistance. Three months from the start of training, the following statistically significant differences between the 2 groups were observed: a marked decrease in dyspnea in the trained group, a 60% versus 22% rise in endurance time on a cycle ergometer at 2/3 of maximal work load, a fall in functional residual capacity, and a fall in respiratory frequency both at rest and during exercise.

Soulagement de la dyspnée grâce à une méthode simple et peu coûteuse chez des patients atteints de limitation sévère et chronique des débits aériens

Résumé: L'effet d'un entraînement respiratoire sur résistance inspiratoire au moyen d'un appareil simple a été testé chez 27 patients ambulants, soumis à une médication optimale pour limitation sévère et chronique de leurs débits respiratoires et assignés au hasard au test ou à un groupe contrôle. L'appareillage d'entraînement consistait en un masque facial avec une valve unidirectionelle sur lesquels on pouvait inserer des résistances inspiratoires. Les patients devaient s'exercer à domicile jusqu' à 10', 3 fois par jour, et des augmentations de la résistance étaient appliquées, si possible, chaque quinzaine. Le groupe contrôle a utilisé le même appareil mais sans résistance inspiratoire. Trois mois après le début de l'entraînement, les différences statistiquement significatives suivantes ont été observées entre les deux groupes: diminution marquée de la dyspnée dans le groupe entraîné; augmentation du temps d'endurance sur un cyclo-ergomètre dans 60% versus 22% à 2/3 de la charge maximale de travail; une chute de la capacité résiduelle fonctionnelle; une chute de la fréquence respiratoire, tant au repos qu'à l'effort.

Key words: airflow limitation - airway obstruction - dyspnea - inspiratory resistance - respiratory muscle training.

Submitted in original form 1983-02-07; accepted for publication 1984-09-01

"Patients with chronic bronchitis become increasingly disabled and frustrated by breathlessness on exertion as their disease progresses" (1).

These comments, extracted from a recent editorial, epitomize the problems faced by the clinician, who is going to treat an illness for which there is no cure. The aim of therapy, therefore, is to delay progression and possibly to overcome the functional disturbances that are present, thereby lessening symptoms. Exercise training in

chronic obstructive pulmonary disease has shown definite effect, but the programs advocated have been cumbersome for both patients and therapists and the costs very high (2).

Recent interest has focused on the respiratory muscles and it looks as if an important factor interfering with wellbeing and exercise-tolerance in these patients is the presence of respiratory muscle fatigue with its clinical manifestation in the form of dyspnea (3, 4). This fatigue can be decreased by muscle training and simple at-home training programs have been instituted with both objective and subjective improvement (5, 6).

Reasonably simple rehabilitation seems possible, but these measures have not been evaluated in randomised trials. This study is an attempt to do so in out-patients with severe chronic airflow limitation (CAL) as they present to the clinician.

PATIENTS AND METHODS

Out-patients referred to the chronic bronchitis clinic with symptoms of chronic airflow limitation (MRC questionnaire 1976) were consecutively taken into the study, if on optimal medical treatment they experienced dyspnea which severely interfered with activities of daily life (Table 1) and if they had a maximal voluntary ventilation (MVV) of less than 35 l/min.

Exercise performance was evaluated on a cycle ergometer as endurance-time at 2/3 of maximal work load achieved on an initial progressive exercise test (6).

Twenty-seven patients were randomly allocated to 2 groups; one receiving training with an inspiratory resistance (+R) and the other sham training without an inspiratory resistance (−R). Morphometric and lung function data for the 2 groups are presented in Table 2.

No other rehabilitatory measures were taken during the study period. It was *a priori* determined that if patient medication were substantially changed or if any patient during the study period showed signs of acute exacerbation, they should be excluded from the study. The exclusion criteria were not used.

The training apparatus is shown in Fig. 1 and consists of a face mask and a oneway valve, where inspiratory and expiratory resistances can be mounted. In both groups a 4.5 mm connection was constantly placed on the expiratory side to mimic pursed-lip breathing which most patients used.

In the +R group the resistance producing an inward displacement of the abdomen on some, but not all, inspirations and in addition the one which the patient could breathe against for 2 min without discomfort was placed on the inspiratory side and served as training resistance (5). The schedule used to find this was as follows: After the patients were accustomed to breathe in the apparatus with only the expiratory resistance mounted, a small inspiratory resistance was placed. The motion of the abdomen was observed and the resistance increased over a 15 min period until the training resistance had been determined. A hand was constantly placed on the abdomen to exclude motions related to abdominal muscle contraction. The patients used the apparatus in their homes thrice daily, initially for only 2 min, but later, until the next visit, for up to 10 min.

Every fortnight, they were seen by a physiotherapist, who checked that the apparatus was used appropriately and, if possible, the inspiratory resistance was increased in the training group. Every month, all patients had a medical examination, where the dyspnea questionnaire, Table 1, was filled in and exercise capacity was tested

TABLE 1. *Assessment of dyspnea*

Question	if yes points
Do you have to stop for breath when walking at your own pace on level ground?	1
Do you experience shortness of breath cleaning the house or doing garden work?	3
Do you experience shortness of breath making a cup of tea or coffee?	5
Do you experience shortness of breath on all activities and frequently at rest?	7

Cumulative sum used in analysis.

on a cycle ergometer. After 3 months, pulmonary function was reexamined. The medical examiner was unaware of which treatment the patients had received and all patients were given the impression that they were actually trained.

Statistical analysis consisted of finding the median, range and confidence limits. Non-parametric tests of statistics were used. $p<0.05$ was considered significant.

RESULTS

All 27 patients completed the study as planned; 12 participating in the training group (+R) and 15 serving as controls (−R). No statistically significant differences were observed between the 2 groups, pre-training regarding lung function and morphometric data (Table 2). In addition dyspnea scoring (Table 1) and endurance time at 2/3 of maximal work load on the cycle ergometer did not differ.

Post-training, the following statistically significant differences were observed:

Lung function

Functional residual capacity, FRC, decreased with training in the +R group with a median of 480 ml (range 70-980). In the −R group it was unchanged 20 ml (−1100-2440).

Respiratory frequency decreased in the +R group. At rest from 24 (17-30) to 22 (15-27) and 5 min following exercise at 2/3 of maximal work load 30 (24-36) to 26 (23-30). In the −R group insignificant

TABLE 2. *Morphometric and lung function values of 27 patients with severe CAL.*

	+Insp. R n=12 (4 f, 8 m)	−Insp. R n=15 (7 f, 8 m)
Age years	61 (54-73)	66 (53-74)
Height cm	167 (156-178)	160 (157-179)
Weight kg	58 (41.5-90)	54 (40-92)
VC l	2.60 (1.83-3.87)	2.20 (1.53-2.90)
VC % predicted	72.0 (59.0-92.4)	69.0 (54.5-90.8)
FEV_1 l	0.72 (0.45-1.53)	0.74 (0.44-1.17)
FEV_1 % predicted	27.1 (19.2-53.1)	30.6 (18.6-42.6)
FRC l	3.53 (2.44-5.14)	3.53 (2.79-4.65)
FRC % predicted	102.8 (99.6-141.7)	114.1 (94.0-140.2)
MVV l/min	26.02 (16.90-44.71)	28.13 (18.51-36.16)
MVV % predicted	42.5 (20.4-66.7)	38.0 (25.1-58.1)

Definition of abbreviations: CAL: chronic airflow limitation, + Insp. R: group with inspiratory resistance training, − Insp. R: sham training, VC: vital capacity, FEV_1: forced expiratory volume in the first second, FRC: functional residual capacity (measured with the nitrogen washout method), MVV: maximum voluntary ventilation (measured in 15 s). Values are medians and ranges ( ). Predicted values from Cotes (7).

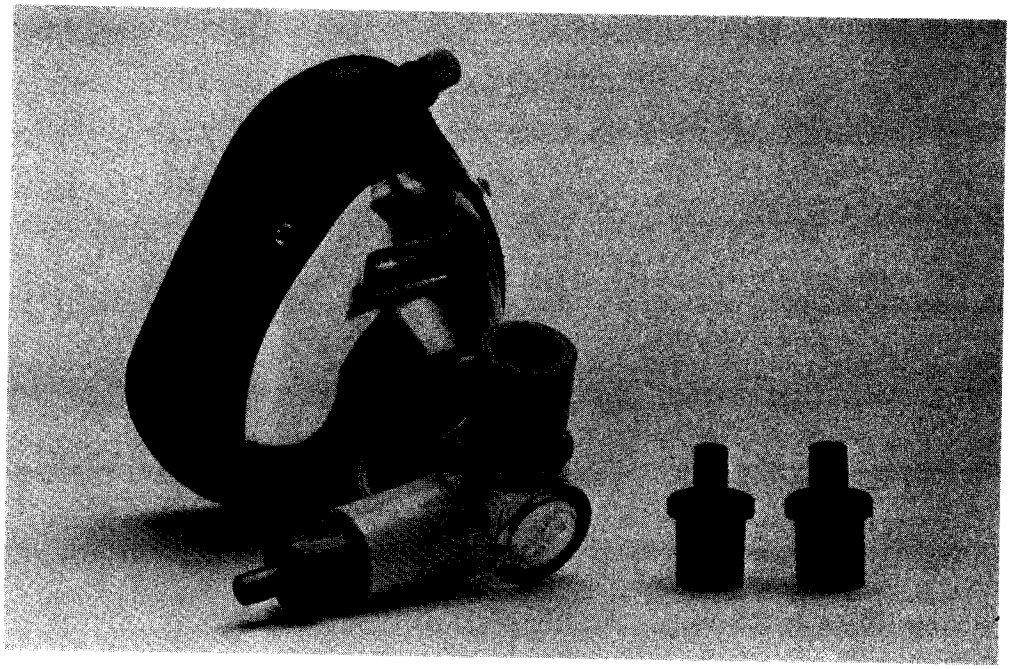

Figure 1. The training apparatus. (RMT - set, ASTRA MEDITEC)

changes were seen; at rest 25 (18-32) and following exercise 30 (24-34).

Exercise performance

Group +R had a pretraining endurance time of 130 s (30-240) at a work load of 250 kpm/min (100-300). In group −R the endurance time was 145 s (57-420) at a work load of 200 kpm/min. At identical work loads the endurance time in the +R group had increased by 60% (7-189), while the increase in the −R group mounted to 22% (−66-121). In both groups this was significant, but +R improved significantly more than −R.

Dyspnea scoring

Pretraining dyspnea score in the +R group was 16 (4-16) and in the −R group 16 (3-16). With training +R patients improved to 4 (1-16). Eleven of the +R patients improved while one was unchanged. Eight of the patients improved beyond the 90% confidence limit. Improvement reached a plateau in 8 patients within 2 months, and in the last 3, within 2½ months.

In the −R group improvement was minimal to 9 (9-16) and this was insignificant. Four improved beyond the 90% confidence limit, 9 were unchanged and one worsened.

Following the initial 3 months, most patients in the −R group were shifted to real training and most of them (12) had an improvement in dyspnea scoring from the above values to 4 (3-16). Lung function did not change.

Inspiratory breathing training was continued in the group as a whole and 22

patients continued to use the method. At 1 year follow-up dyspnea scoring was, for most patients, unchanged.

No side effects of training were observed, apart from 2 patients in the +R group complaining of slight pain in the costal margins at the beginning of training against an increased resistance.

DISCUSSION

The aim of the present study was to evaluate whether our present understanding of dyspnea and exercise tolerance warrants that inspiratory resistive breathing training be used on a routine basis in outpatients with severe chronic airflow limitation, when disabling symptoms are present. It was not at all intended to evaluate how and why this training might work with the backup of a sophisticated respiratory function laboratory.

The study demonstrates that dyspnea can be reduced with this simple training method. Changes in lung function are small and presumably insignificant apart from the fall in respiratory frequency both at rest and following exercise. Exercise performance was increased. The possible causes of these findings will be discussed under different headings:

Lung function.

Whereas another study using the same training principle failed to demonstrate any consistent changes in pulmonary function (6), we observed a decrease in FRC following training. Most patients initially were hyperinflated, thus, placing the diaphragm at a disadvantage during contraction (8). It is conceivable that this could explain the training response, were it not for the fact that FRC was measured with the nitrogen washout method, that in severely obstructed patients is known to give unreliable results owing to changes in volume of trapped gas (7).

A much more interesting observation was the decrease in both resting and post-exercise respiratory frequency. This could imply a change in respiratory pattern. Unfortunately inspiratory and expiratory frequencies were not measured and the matter needs further clarification.

Exercise performance

In normal subjects an increase in endurance time is primarily caused by an improved aerobic capacity, but this is not the case in patients with CAL (9).

Increased motivation and improved mechanical skill could play a role, but a more important factor presumably is desensitization to dyspnea, i.e., the patient learns that even though he experiences dyspnea on exertion he can manage to control it.

Finally, exercise performance would improve if respiratory muscle function improved. Unfortunately, specific measurements of respiratory muscle strength and endurance were not undertaken. However, the progressive increase in the resistance which was tolerated, could be an objective argument for increase in both strength and endurance. It has been proposed that decreased exercise performance might be related to respiratory muscle fatigue (5, 6), which is known to decrease with resistive breathing training. Objective measurements of fatigue, defined as inability to develop a predetermined force on repeated contractions, were not made. It is, however, conceivable that training resulted in more efficient muscle work both in terms of more favorable length-tension relationships, a better metabolism, an improved coordination between different muscle groups and,

thereby, in an improvement of the whole respiratory "act".

Dyspnea scoring

The most marked difference between training and control groups was seen in this parameter. Following training, the patients were able to resume activities of daily life without experiencing dyspnea. Being a subjective symptom dyspnea is very difficult to quantify, but by relating its presence to daily activities it tells about patients' well-being and quality of life.

The patient sample in this study is small and, therefore, the definite conclusions drawn must be cautious. In spite of this, we think that the results of this relatively simple and inexpensive procedure already at this stage should be known to the pulmonary community caring for patients with severe chronic airflow limitation.

REFERENCES

1. Editorial: Exercise and the breathless bronchitic. Lancet 1980: 2: 514-515.
2. Lertzman M M, Cherniack R M. Rehabilitation of patients with chronic obstructive pulmonary disease. Am Review Respir Dis 1976: 114: 1145-1165.
3. Derenne J-Ph, Macklem P T, Roussos Ch. The respiratory muscles: mechanics, control and pathophysiology. Part III. Am Rev Respir Dis 1978: 118: 581-601.
4. Pardy R L, Rivington R N, Despas P J, Macklem P T. The effects of inspiratory muscle training on exercise performance in chronic airflow limitation. Am Rev Respir Dis 1981: 123: 426-433.
5. Andersen J B, Dragsted L, Kann T, Johansen S H et al. Resistive breathing training in severe chronic obstructive pulmonary disease. A pilot study. Scand J Respir Dis 1979: 60: 151-155.
6. Pardy R L, Rivington R N, Despas P J, Macklem P T. Inspiratory muscle training compared with physiotherapy in patients with chronic airflow limitation. Am Rev Respir Dis 1981: 123: 421-425.
7. Cotes J E. Lung function. Assessment and application in medicine. Oxford: Blackwell, 1975.
8. Macklem P T. Respiratory muscles: the vital pump. Chest 1980: 78: 753-758.
9. Belman M J, Kendragan B A. Exercise training fails to increase skeletal muscle enzymes in patients with chronic obstructive pulmonary disease. Am Rev Respir Dis 1981: 123: 256-261.

Address:
J. B. Andersen, MD.,
Dept. of Anesthesia &
Intensive Care I-104,
Herlev Hospital,
DK-2730 Herlev,
Denmark.