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Physical rehabilitation for the chronic bronchitic: results of a controlled trial of exercises in the home

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McGavin, C. R., Gupta, S. P., Lloyd, E. L., and McHardy, G. J. R. (1977). *Thorax*, **32**, 307–311. **Physical rehabilitation for the chronic bronchitic: results of a controlled trial of exercises in the home.** Twenty-four men with chronic bronchitis participated in a controlled trial of a physical training scheme. The training involved progressive stair-climbing exercises carried out over a three-month period unsupervised at home. The twelve men in the exercise group benefited significantly in terms of general well-being and reduced breathlessness. Their exercise tolerance increased significantly as judged by increased walking speed in a simple 12-minute walking test and by a greater work load tolerated in a progressive work load test on a bicycle ergometer. The mean stride length during the walking test increased significantly with training. No significant changes occurred in body weight, ventilatory function tests or heart rate on exercise. There were no important changes in the control group.

It is not clear whether the improvements noted were due to physiological changes such as improved neuromuscular coordination producing a more efficient walking pattern or to predominantly psychological factors such as increased tolerance of dyspnoea. The study demonstrates that a simple training scheme which can be administered from a hospital clinic or family doctor's surgery is safe, feasible, and of benefit to the chronic bronchitic.

There are several reports in the literature of the benefits of physical training for the chronic bronchitic, and these have been reviewed by De Coster *et al.* (1972). However, in the United Kingdom these benefits seem to have been largely ignored in textbooks, reviews, and clinical practice. Most of the published reports of the effects of physical training describe the changes in exercise performance and pulmonary function that occur in chronic bronchitics trained intensively as hospital in- or out-patients. Our aim in this study was to evaluate a training scheme which was simple to organise and which could be carried out by the patient unsupervised at home without recourse to hospital facilities.

Subjects and methods

SUBJECTS

The subjects were men under the age of 70 years with chronic bronchitis according to the criteria laid down by the Medical Research Council Working Party (1965). All had airways obstruction, but no one was admitted to the study if the forced expiratory volume in one second (FEV_1) increased by more than 30% 20 minutes after an inhalation of 200 μg of salbutamol aerosol. No subject was taking corticosteroid medication. Subjects with angina pectoris, intermittent claudication, and disabling musculoskeletal disorders were excluded. No distinction was drawn between those who had, and those who had not had, episodes of right heart failure. The subjects were tested only when their chest condition was considered to be in a stable state. At the start of the study they underwent the tests described below on two separate days; the first day was regarded as practice and the results were discarded. After the tests on the second day the subjects were allocated randomly into control and exercise groups.

TESTS

The FEV_1 and forced vital capacity (FVC) were measured with a low resistance spirometer (McKerrow *et al.*, 1960), the best of three readings being taken (Freedman and Prowse, 1966), and were expressed at body temperature and pressure, saturated.

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Mixed venous P_{CO_2} ($P\bar{v}_{CO_2}$) was estimated by the rebreathing method of Campbell and Howell (1962).

The 12-minute walking distance (12 MD) was measured. This has been described as a simple and reproducible assessment of disability in chronic bronchitis (McGavin *et al.*, 1976); it is the greatest distance that the subject can walk in 12 minutes in a level enclosed corridor, regardless of whether or not he has to stop for rest. The paces taken during the 12 minutes were counted with a pedometer. After the walking test the subjects rested for 20 minutes before undertaking the bicycle exercise test. This consisted of an increasing work load test on an electrically braked bicycle ergometer (Elema) (Spiro *et al.*, 1974). The work load was initially 17 watts (100 kpm min^{-1}) for two minutes, increasing thereafter by 17 W each minute, except in the most severely disabled in whom the initial and incremental loads were 8·5 W (50 kpm min^{-1}). The test continued until the subject could not manage any more work or until the heart rate became excessive. Expired gas was collected in a Tissot spirometer during the last half minute of each work load and was analysed for carbon dioxide and oxygen. The following abbreviations are used for the quantities measured in this test: $\dot{V}_{O_2}$ (oxygen uptake per minute); $\dot{V}_E$ (minute ventilation); WL (work load); fc (heart rate); R (respiratory exchange ratio).

The subscript $_{(ex)}$ denotes a measurement made at the greatest work load that the subject could maintain for one minute: the subscript $_{(st)}$ (standard) denotes measurements made at the greatest work load that was common to both the initial and follow-up exercise tests in any one subject.

TRAINING PROGRAMME

This consisted of graded stair-climbing exercises tailored to suit the individual's ability. The basic principle was to climb up and down a given number of steps for a given number of minutes at least once a day, at least five days a week. The number of journeys that the subject made up and down the steps in the time was recorded day by day on a diary card by the subject. The most disabled, namely those unable to walk further than about 800 metres in 12 minutes, started with two steps up and down for two minutes. The less disabled, those able to walk more than about 1200 metres in 12 minutes, started with five steps for five minutes. The subjects were seen at an outpatient clinic after two weeks and monthly thereafter. At these visits progress was assessed and diary cards were checked so that the exercise programme could be adjusted accordingly. The aim was to build up to climbing 10 steps for 10 minutes at least once daily, although some of the more disabled could not manage exercise for more than five minutes.

The subjects in the control group did not receive exercise instructions or an outpatient check at two weeks. They did attend the monthly clinic when, like the exercise subjects, they answered a simple respiratory questionnaire and had their weight, FEV_1, and FVC measured. Both groups were advised not to smoke.

All subjects were retested after about three months of satisfactory follow-up: if illness interrupted the training scheme, the exercise grade was reduced temporarily on recovery.

Results

DESCRIPTION OF SUBJECTS

Twenty-eight subjects were enrolled: of these, 24 completed the study, 12 in each of the exercise and control groups. All four who failed to complete the study were from the exercise group: two dropped out through lack of enthusiasm, one because of an intercurrent depressive illness, and the fourth died of ventilatory failure during an infective exacerbation. He was the only subject to attempt the training programme as an inpatient.

Data concerning the other 24 subjects are presented in Table 1. There were no significant differences in mean values of age, FEV_1, FVC, initial 12 MD, and $P\bar{v}_{CO_2}$ between the exercise and control groups (unpaired *t* test). Four subjects in each group had a $P\bar{v}_{CO_2}$ in excess of 7 kPa (52 mmHg). Six of the exercise and five of the control subjects were smokers: the remainder were ex-smokers.

The time interval between initial and follow-up tests for the control group was 12–18 (mean 14) weeks and for the exercise group was 13–27 (mean 19) weeks. This difference is due to more illness, respiratory and other, in the exercise group and to the necessity of being in an optimal state of health for the tests. After a period of illness, subjects in the exercise group underwent retraining. The exercise group had an average of 10 days' illness per subject (range 0–25 days), compared with one day per subject in the control group.

Table 1 *Mean initial values ± SD (and range) of age, ventilatory capacity, distance walked in 12 minutes, and mixed venous P_{CO_2} in the two groups of subjects*

	Exercise group *n=12*	*Control group* *n=12*
Age (years)	61·4±5·6 (53–69)	57·2±7·9 (40–69)
FEV_1 (litres)	0·97±0·33 (0·5–1·55)	1·15±0·72 (0·35–2·7)
FVC (litres)	2·81±0·73 (1·65–4·2)	2·89±0·87 (1·6–4·5)
12MD (metres)	1018±313 (274–1416)	1053±132 (823–1289)
$P\bar{v}_{CO_2}$ (kPa)	6·52±0·85 (5·2–8·0)	6·8±0·94 (5·5–9·0)

Conversion factors: metres to yards × 1·09: kPa to mmHg × 7·5.

SUBJECTIVE EFFECTS

Subjective changes are summarised in Table 2. A significant proportion in the exercise group claimed benefit in terms of general well-being, breathlessness, cough, and sputum volume. Half of the exercise group reported an increase in the range of their general daily activities. Significance is assessed by the chi-square method, although some caution is necessary in interpretation in view of the small expected values.

Table 2 *Subjective changes in the two groups of patients after the period of study*

	Group	*Improved*	*Not improved*	χ^2	P
Breathlessness	Exercise	8	4	9·2	<0·01
	Control	0	12		
Well-being	Exercise	8	4	6·4	<0·02
	Control	1	11		
General activities	Exercise	6	6	3·2	NS
	Control	1	11		
Cough	Exercise	8	4	6·4	<0·02
	Control	1	11		
Sputum	Exercise	6	6	5·6	<0·02
	Control	0	12		

OBJECTIVE EFFECTS

There were no significant changes in either group in mean FEV_1 or FVC. Other data are summarised in Table 3. There was a highly significant increase in 12 MD in the exercise group, by a mean of 64 metres, compared with a mean deterioration of 19 metres in the control group. The range of the change in the exercise group was from zero to an increase of 165 metres, and in the control group it was −105 to +55 metres. Expressed as a percentage of initial 12 MD, the ranges were, respectively, 0 to +33% and −9 to +5% in the two groups. In the exercise group this represents an increase in walking speed from 5·09 to 5·41 kilometres per hour (3·16 to 3·36 mph). There was no correlation between distance walked and changes in body weight in individual subjects. The increased distance walked was accompanied by a significant lengthening of stride and not by any uniform change in the rate of stepping.

In the exercise group, mean $WL_{(ex)}$ improved significantly by 14·4 W but the mean increase in $\dot{V}O_{2(ex)}$ of 6 mmol min^{-1} (130 ml min^{-1}) did not reach significance; the decrease in mean $\dot{V}O_{2(st)}$ (0·25 mmol min^{-1}, 5 ml min^{-1}) was trivial.

In the control group, decreases were observed in mean $WL_{(ex)}$ (2·6 W), in mean $\dot{V}O_{2(ex)}$ (5·4 mmol min^{-1}, 121 ml min^{-1}) and in mean $\dot{V}O_{2(st)}$ (2·9 mmol min^{-1}, 65 ml min^{-1}).

There were no significant changes in heart rate, ventilation or respiratory exchange ratio at $WL_{(ex)}$ or $WL_{(st)}$ in either group. Nor were there any alterations in either group in the heart rate or ventilation at the standard values of $\dot{V}O_2$ of 33·4 and 44·5 mmol min^{-1} (0·75 and 1·0 l min^{-1}) described by Spiro *et al.* (1974).

Discussion

In the various reports of the effects of physical training in chronic bronchitis with airways obstruction three conclusions are almost universal. The first is that there is considerable subjective benefit, at times apparently out of proportion to any measurable improvement. Secondly, there is objective evidence of increased exercise tolerance, and, thirdly, this is not accompanied by any change in the ventilatory function tests. Our results are entirely in agreement with these observations in that the subjects in our exercise group experienced greater well-being and less breathlessness, and demonstrated modest but significant improvements in exercise tolerance as assessed by both the walking and the bicycle tests.

Table 3 *Objective measurements in the two groups of patients before and after the study period*

	Exercise group				*Control group*			
	n	*Before*	*After*	P	*n*	*Before*	*After*	P
12MD (metres)	12	1018±313	1082±292	<0·001	12	1053±132	1034±141	NS
Stride (mm)	10	790±90	830±75	<0.01	10	780±80	760±89	NS
Weight (kg)	11	65·9±7·3	66·7±8·4	NS	11	66±11·1	65±10	NS
$WL_{(ex)}$ (Watts)	12	62·6±22·9	77±26·7	<0·05	12	63·9±14·7	61·3±15·7	NS
$fc_{(ex)}$ (min^{-1})	12	118±14	125±10	NS	12	123±10	119±11	NS
$fc_{(st)}$ (min^{-1})	12	118±15	120±11	NS	12	119±10	116±14	NS
$\dot{V}E_{(ex)}$ (l min^{-1})	12	35±13	39±10	NS	12	36±14	34±13	NS
$\dot{V}E_{(st)}$ (l min^{-1})	12	35±4	34±9	NS	12	32±12	33±13	NS
$\dot{V}O_{2(ex)}$ (mmol min^{-1})	12	43·2±13·4	50·0±15·3	NS	12	45·6±7·7	40·3±8·4	<0·05
$R_{(ex)}$	12	0·94±0·082	0·97±0·059	NS	12	0·95±0·117	0·96±0·150	NS

Mean values ±SD are shown. NS = not significant at the 5% level. The abbreviations are described under Methods.
Conversion factor: mmol min^{-1} to l min^{-1} × 0·0224.

Beyond these three basic points, there is disagreement about the physiological changes produced by training, and indeed De Coster and colleagues in their review (1972) concluded that the results are often contradictory. This is presumably related to the small number of subjects, the heterogeneity of the diagnostic criteria and the severity of the disease, the short periods of training, and differences in techniques of both training and testing. For instance, some authors describe a reduction in exercise heart rate at a given work load (Pierce *et al.*, 1964; Holten, 1972), while others (Brundin, 1974), like ourselves, find no change.

Discussion centres particularly on alterations in oxygen uptake and ventilation at equivalent work loads. Pierce *et al.* (1964) report a 23% reduction in oxygen cost of work on the treadmill: Paez *et al.* (1967) ascribe this phenomenon to increased stride length and cite Cathcart *et al.* (1927), who demonstrated in a normal subject that a longer stride constituted a more efficient use of oxygen. Our subjects lengthened their stride significantly with training, and this accounts at least in part for the increased distances walked. The longer stride is considered to result from better neuromuscular co-ordination, and this effect is specific for the activity which the subject is trained to carry out (Paez *et al.*, 1967). There is no obvious counterpart on the bicycle of the lengthening stride, and the absence of change in $\dot{V}O_{2(st)}$ in our exercise subjects after training suggests that there is no increase in bicycling efficiency. Maximum work load increased significantly in the exercise group although the increase in $\dot{V}O_{2(ex)}$ did not reach statistical significance.

As regards exercise ventilation, some authors have observed a reduction in minute volume at equivalent work loads after training (Pierce *et al.*, 1964; Christie, 1968). In these studies, the form of exercise used in training and testing was the same—stepping up and down in Christie's report and treadmill exercise in that of Pierce. Paez *et al.* (1967) observed no change in ventilation at equivalent work loads on the bicycle before and after training on a treadmill. They considered that the decrease observed by Christie and Pierce might be due to reduced proprioceptive reflexes arising from the trained muscles. We found no change in ventilation on the bicycle after training on stairs, and this may reflect different stresses imposed on muscle groups by the two forms of exercise.

The contributions of a number of other factors to the improvement in exercise tolerance must also be considered. We have shown that changes in body weight and ventilatory capacity are not important. Both the motivation of the patient and the enthusiasm of the doctor are of great importance. Physical training probably induces greater confidence in the ability to exercise and increased tolerance of the sensation of dyspnoea. Smoking did not appear to influence the outcome of training, and, with the exception of one subject, the exercise programme with its regular clinic attendances did not act as a stimulus to the patient to give up smoking. Although the numbers are small, there was no difference between the improvements of the smokers and ex-smokers in the exercise group. It seems that inability to give up smoking is not an indication of lack of motivation to carry out a training scheme.

A drop-out rate of 4 in 28 is not unexpected in this sort of study and compares favourably with other reports. The man who died was severely handicapped and was confined to hospital by advanced chronic bronchitis. The greater number of days of illness observed in the exercise group is surprising, but it is difficult to see how stair-climbing at home contributed to this. Some of the illness, such as a leg injury and an exacerbation of duodenal ulcer, seemed entirely unconnected with the training programme.

It is largely irrelevant whether the improved exercise tolerance is due to predominantly physiological or psychological factors: what is important is that improvement does result. Because of the task-specific training effect (Paez *et al.*, 1967), it seems sensible to train the chronic bronchitic at the activity most relevant to his needs, that is to say, by walking and stair-climbing rather than by bicycling. The exercise programme should also aim to influence his general attitude to exercise and breathlessness.

This controlled trial demonstrates that unsupervised exercise carried out at home can be effective in improving symptoms and exercise tolerance in chronic bronchitis. The scheme appears to be safe and sufficiently simple to be administered from a hospital outpatient clinic or a general practitioner's surgery. This is important if physical rehabilitation is to be available to the large numbers of chronic bronchitics in Britain. We feel that the ideal candidate is the person whose breathlessness has begun to impinge on his daily activities enough to motivate him to seek help. Certainly the results of this short-term trial are sufficient to warrant a long-term study of any effects of physical training on work record, acute exacerbations of bronchitis, and mortality rate.

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Addendum

A leaflet entitled 'Exercise can help your breathlessness' is published by the Chest, Heart, and Stroke Association, Tavistock House North, Tavistock Square, London WC1H 9JE. This leaflet contains simple instructions for a physical training scheme suitable for patients with chronic bronchitis.