# Does Unsupported Upper Limb Exercise Training Improve Symptoms and Quality of Life for Patients With Chronic Obstructive Pulmonary Disease?

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- **PURPOSE:** Many patients with chronic obstructive pulmonary disease (COPD) report dyspnea and fatigue when performing upper limb activities. Unsupported upper limb training has been shown to improve upper limb endurance, but its effects on symptoms and quality of life have not been examined. The aim of this study was to compare the effects of upper limb and lower limb training with lower limb training alone on exercise capacity, symptoms, and quality of life with COPD.
- **METHODS:** For this study, 38 patients with moderate to severe COPD were randomly allocated to unsupported upper limb endurance training or to a control group that completed a sham training task. All the patients underwent lower limb endurance training. The 6-minute walk test, the Incremental Unsupported Upper Limb Exercise Test, and the Chronic Respiratory Disease Questionnaire (CRQ) were completed before training and then 6 weeks afterward. Both patients and assessors were blinded to group allocation.
- **RESULTS:** All the patients reported symptoms associated with upper limb activities on the initial CRQ. Both groups showed significant improvements in all domains of the CRQ and in the 6-minute walk test after training. Only the upper limb training group showed improvement in upper limb endurance time (57 ± 75 vs 2 ± 58 seconds; $P = .02$). There were no significant differences between the groups for 6-minute walk test or any domain of the CRQ.
- **CONCLUSIONS:** Unsupported upper limb training for patients COPD improves upper limb exercise capacity, but has no additional effect on symptoms or quality of life, as compared with leg training alone. This type of upper limb training may not adequately address the complex interaction between respiratory mechanics and upper limb function.



**K E Y W O R D S**

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exercise

upper limb

quality of life



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The upper extremities play an important role in many activities of daily living such as bathing, dressing, hanging out the wash, and gardening. Patients with chronic obstructive pulmonary disease (COPD) frequently experience marked dyspnea and fatigue when performing these simple tasks.[1] Upper limb activities commonly require unsupported arm exercise, which poses a unique challenge for patients with COPD whose upper limb muscles also may be required to act as accessory muscles of respiration. During unsupported arm exercise, the participation of these muscles in ventilation decreases, and there is a shift of respiratory work to the diaphragm. This is associated with thoracoabdominal dyssynchrony, severe dyspnea, and termination of exercise at low workloads, especially in patients with more severe bronchial obstruction.[2-4]

Upper limb exercise training for patients with COPD has been shown to increase upper limb work capacity, improve endurance, and reduce oxygen consumption at a given workload.[5-8] Unsupported arm training results in greater improvements in endurance and oxygen consumption than supported arm training with a cycle ergometer.[6] The effects of upper limb training on symptoms, functional status, and quality of life, however, remain unclear. Only two authors have addressed these questions, and the results of their studies are conflicting,[5,7] possibly because of the low patient numbers.

The effectiveness of lower limb (LL) exercise training for patients with COPD has been well documented, with consistent and clinically significant improvements in exercise capacity, symptoms, and quality of life.[9,10] Training effects are specific to the limb trained,[11] and it seems that upper limb training alone is less effective than LL training in improving overall function.[7] The benefits of combined upper limb and LL training, however, are less well defined. It is not clear whether the addition of upper limb training improves symptoms and quality of life more than leg training alone.

The aim of this study was to compare the effects of combined upper limb and LL training with LL training alone on upper limb and LL exercise capacity, symptoms, and quality of life in patients with COPD.

## METHODS

Patients with severe to very severe COPD (GOLD stage 3 or 4;[12] forced expiratory volume in 1 second [$FEV_1$] < 50% predicted) referred to a pulmonary rehabilitation program at a tertiary hospital were recruited. These patients were receiving optimal medical therapy and were clinically stable at the time of their entry into the program. None of the patients had significant bronchodilator reversibility at lung function testing. The study was approved by the institutional ethics committee, and each patient gave written informed consent before participation.

All the patients underwent a standard pulmonary rehabilitation program involving 6 weeks of LL endurance training. Lower limb training involved 30 minutes of treadmill walking or stationary cycling as well as stair training. Intensity of exercise was progressed to maintain a perceived exertion rating of 12 to 14 on the Borg scale[13] and a dyspnea rating of 3 on the modified Borg scale.[14] The patients attended two supervised sessions each week, and a home exercise program was given.

In addition, the patients were randomly allocated to perform either unsupported upper limb endurance training or a control training task. The unsupported upper limb endurance training followed a previously described protocol.[6] It consisted of five upper limb exercises performed in a sitting position with a 500-g stick until each exercise could be performed for 3 minutes. The weight then was increased by 0.5-kg increments to maintain a load that achieved a perceived exertion rating of 12 to 14 on the Borg scale[13] and a dyspnea rating of 3 on the modified Borg scale.[14] The exercises were supervised by a physiotherapist twice a week. The patients were instructed to perform the same exercises daily at home, and to record their exercise in a home exercise diary.

The control group performed the Purdue pegboard test of finger dexterity.[15] This test consists of four timed tasks in which as many pins as possible are placed on a pegboard within a defined time. The test is performed in a sitting position with the arms supported on the table, and thus would be expected to have no effect on unsupported upper limb endurance. However, because in normal individuals performance of the tasks improves with practice,[16] the pegboard test was regarded as sufficiently motivating intrinsically to facilitate repeated performance over the 6-week period. The control task was supervised by a physiotherapist twice a week. The two groups performed the training tasks in physically separate locations at the same time and were instructed not to discuss the nature of the training with one another until the end of the program.

Upper limb exercise tolerance was assessed before training and 6 weeks afterward with the Incremental Unsupported Upper Limb Exercise Test.[17,18] The patients lifted a 200-g stick in time with a metronome at a rate of 30 lifts per minute. The height of the lift was increased by 15 cm every minute according to levels on a wall chart. Once the patient reached his or her maximal vertical height with the lift, the weight of the bar was increased to 0.5 kg, 1 kg, 1.5 kg, and 2 kg in each successive minute.

The patients were instructed to continue the test as long as possible. The test was terminated by the patient because of dyspnea or arm fatigue, or by the therapist if the patient was unable to continue performing the test correctly. Oxygen saturation and pulse rate were monitored continuously during the test with a pulse oximeter and ear probe (Oxypleth, Novametrics; Wallingford CT), and blood pressure was measured before and after the test. The duration of the test, the Borg scale scores for breathing and arm fatigue before and after the test, and the reason for termination of the test were recorded.

Lower limb functional exercise capacity was measured at the same time points with the 6-minute walk test using standardized encouragement.[19] A minimum of two tests were performed, with a break of at least 30 minutes between tests. A third trial was performed if the distances recorded differed by more than 10%. The highest recorded distance was reported.

Health-related quality of life was assessed with the Chronic Respiratory Disease Questionnaire (CRQ)[20] before training and 6 weeks afterward. Scores for the domains of dyspnea, fatigue, mastery, and emotional function were recorded. In addition, the five most important dyspnea-inducing activities, as specified by each patient, were examined, and the number of these tasks requiring the use of the upper limbs was recorded.

The three tests were administered in random order. Measurements were obtained by an independent data collector blinded to group allocation. Differences between groups were compared with independent-samples *t* tests or Mann-Whitney *U* tests as appropriate. Alpha was set at 0.05.

## RESULTS

The baseline characteristics for the two groups are shown in Table 1. Altogether, 40 patients were recruited and randomized to groups. Two patients withdrew because of respiratory exacerbations before completing the training program: one each from the control and upper limb training groups. Follow-up data were obtained from the subject who withdrew from the upper limb training group. One patient in the training group did not attend for final assessment and could not be contacted. One patient in the control group whose primary rehabilitation goal was to improve his golf swing crossed over and began performing upper limb resistive training independently. This was established at the time of the final assessment, and his results were included in the control group. No other failure of blinding was identified by questioning at the final assessment.

An intention-to-treat analysis was performed with the available data from 38 patients: 16 in the control group and 22 in the upper limb training group. There were no differences between the groups at baseline for any of the demographic or outcome variables (Table 1).

The results for UL and LL exercise capacity are shown in Figure 1. Both groups showed a significant improvement in 6-minute walk test distance after training, with a mean improvement of 60.9 m in the control group (95% confidence interval [CI], 35.7-86.2 m) and 68.8 m in the upper limb training group (95% CI, 44.6-93.1 m). There was no significant difference between the two groups in the degree of improvement in the 6-minute walk test after training. The upper limb training group showed significant improvement in upper limb endurance after training. However, there was no change in upper limb endurance in the control group. The mean difference in upper limb endurance between the groups after training was 55.3 seconds (95% CI, 8.3-102.4 seconds; $P$ = .02). There was a trend toward a reduced Borg score for dyspnea in the upper limb training group at the end of the test (Mean ± SD 4.0 ± 2.0 in the upper limb training group vs 2.9 ± 1.6 in the

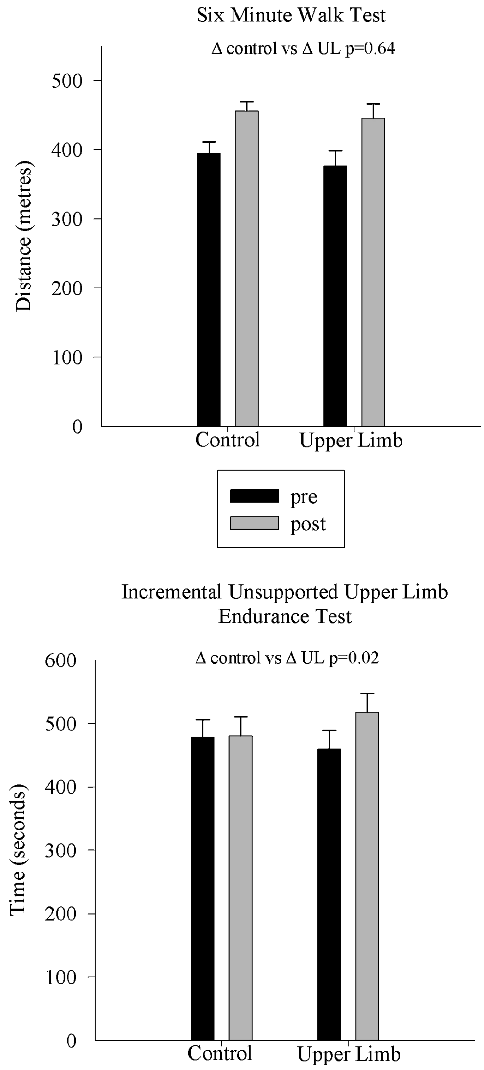


**Figure 1.** Upper limb and lower limb exercise tests. Results are mean and standard error of the mean. UL, upper limb.

**Table 1 • SUBJECT DEMOGRAPHICS**

| | Control | Upper Limb | *P* |
|---|---|---|---|
| Number | 16 | 22 | |
| Men/women | 10 / 6 | 14 / 8 | .90 |
| Age, y | 69.4 (6.6) | 66.6 (8.4) | .45 |
| $FEV_1$, L | 1.02 (0.32) | 0.97 (0.36) | .67 |
| $FEV_1$ % predicted | 39.8 (10.4) | 34.2 (10.2) | .11 |
| FER | 42.0 (11.3) | 38.6 (15.7) | .18 |
| BMI, kg/m$^2$ | 24.3 (5.0) | 22.9 (4.6) | .46 |

Data are mean (SD); *P* values are comparison of groups at baseline–no significant differences.

$FEV_1$, forced expiratory volume in 1 second; FER, forced expiratory ratio ($FEV_1$/FVC); BMI, body mass index.

control group; $P = .06$) despite an increase in the duration of upper limb exercise. There were no differences between the groups in arm fatigue scores. Whereas 34 patients terminated the Incremental Unsupported Upper Limb Exercise Test because of arm fatigue, 4 patients terminated the test because of dyspnea.

The CRQ dyspnea domain showed that all the patients experienced dyspnea with at least one upper limb activity, and 80% of the patients reported dyspnea with two or more upper limb tasks. Frequently reported activities included carrying (for 42% of patients), showering (54%), vacuuming (32%) and gardening (26%). Both groups showed statistically significant improvements for all domains of the CRQ after rehabilitation. However, there were no differences between the groups for any of the four domains (Fig. 2). The dyspnea domain also was analyzed only for the activities that involved the upper limbs. The improvement in dyspnea for upper limb activities after rehabilitation was similar to that seen for the total dyspnea score, and there was no significant difference between the groups when only upper limb activities were included (mean difference between the upper limb training group and the control group, 0.19 points; 95% CI, 0.31-0.68; $P = .42$).

## DISCUSSION

The findings of this study show that unsupported upper limb endurance training for patients with severe to very severe COPD results in improved upper limb exercise capacity, a finding that accords with previous studies.[5,6] However, no additional improvements in health-related quality of life or symptoms over leg training alone could be identified. Although there was a trend toward reduced dyspnea at upper limb testing, this did not translate into an identifiable reduction in dyspnea during activities of daily living.

Upper limb endurance training is a recommended component of pulmonary rehabilitation programs.[9,10,21] These recommendations are based on impaired upper limb performance of patients with COPD,[3] reduction in proximal muscle strength,[22] and the favorable physiologic outcomes associated with upper limb training.[6,8,23] However only two previous studies, with small patient numbers, have evaluated the effect of upper extremity training on symptoms or functional outcomes. The addition of upper limb training to LL training has been shown to improve self-efficacy significantly on the Bandura scale,[7] which measures quality of life, self-confidence,

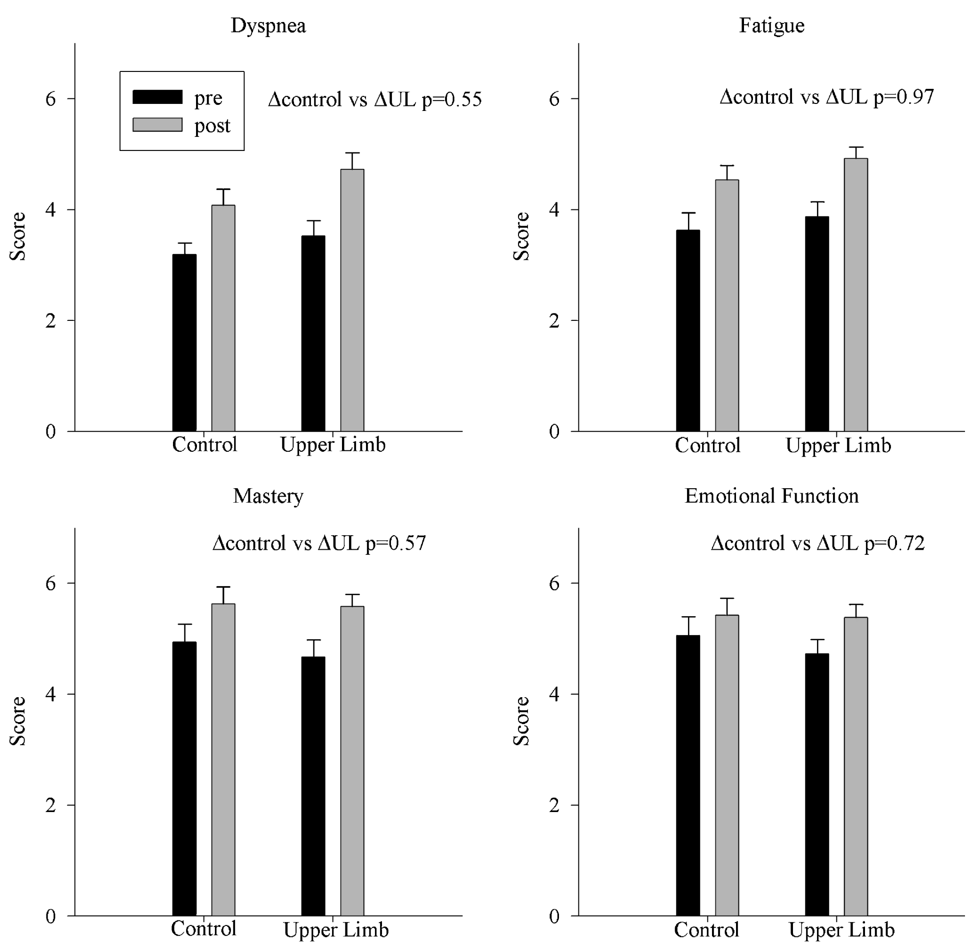


**Figure 2.** Chronic respiratory disease questionnaire. Results are mean and standard error of the mean. UL, upper limb.

and self-esteem. However, a lack of self-efficacy improvement in the group that performed LL training alone is not consistent with other findings.[24] Other investigators were not able to show any reduction in dyspnea on a functional test simulating activities of daily living (dishwashing, cleaning, and grocery shelving) despite improved upper limb endurance after training.[5]

To date, there is no evidence that upper limb training is able to improve these important patient outcomes above what can be provided by LL training alone. Although the improvements in upper limb strength seen after training suggest that it remains a component of pulmonary rehabilitation programs, more work is required to establish whether there are indeed functional and symptom-related benefits.

The current study used a test of upper limb endurance that involved stereotypical, repetitive movements closely related to the training task used. This strategy, which has been used for other studies in which increased upper limb endurance was found,[5,11,23] may be an example of task-specific training that allows patients to perform the test more easily. Epstein et al[23] postulated that improved upper limb endurance after such training is attributable to increased coordination of accessory muscle action rather than an aerobic training effect, suggesting that carryover to more complex upper limb actions may not occur.

Most of the dyspnea-inducing tasks in the CRQ reported by the patients in the current study were complex upper limb activities incorporating a variety of postures and muscle groups and frequently performed in a standing position. The static muscle work required to stabilize the trunk during upper limb movements may be greater in the standing position than in the sitting position with the trunk supported by a chair. Upper limb training performed in the sitting position therefore may not adequately address the complex coordination involved in functional tasks performed by patients with COPD.

Further evidence that the specific nature of the upper limb task influences the perception of dyspnea is provided by a recent study examining metabolic and ventilatory responses to functional upper limb tasks performed by patients with COPD.[25] A task involving coordination, such as screwing in a light bulb, provoked greater dyspnea than the repetitive, stereotypic task of lifting pots, despite lower peak exercise oxygen consumption. The authors postulate that such coordination tasks are more dyspnea-inducing because of breath holding or a reduction in blood flow to muscle during static contractions. The upper limb test did not incorporate a coordination component or static muscle contraction, which may explain the low incidence of dyspnea. Only four patients in the current study terminated the Incremental Unsupported Upper Limb Exercise Test because of breathlessness, with the remainder terminating the test because of arm fatigue.

Given the close association between the muscles of the shoulder girdle and the ribcage, it is likely that respiratory mechanics play an important role in determining the response to upper limb exercise in individuals with COPD. Celli et al[3] noted a strong association between dyspnea during upper limb exercise and the onset of thoracoabdominal dyssynchrony, which occurred during arm, but not leg, exercise. In five of the seven patients who terminated their upper limb endurance test because of dyspnea, a dyssynchronous breathing pattern was observed within 2 minutes of exercise commencement. In the remaining five patients, exercise was terminated at higher workloads because of arm fatigue, and was not associated with dyssynchronous breathing. Patients with dyssynchrony had more severe airflow obstruction, as measured by $FEV_1$/forced vital capacity, and their duration of arm exercise was significantly shorter.

Because only four patients in the current study terminated the test because of dyspnea, it was not possible to determine any differences between this small group and the rest of the patients in terms of demographics or exercise performance. Our patients, however, had less severe lung disease overall than the group described by Celli et al[3] (mean, $FEV_1$, 0.99 L, as compared with 0.68 L). It is possible that the functional implications of upper limb training may differ for patients with severe COPD who exhibit dyssynchronous breathing during upper limb exercise, as compared with those in whom respiratory mechanics are comparatively less affected.

The instrument used to detect changes in symptoms and health-related quality of life, the CRQ, may have been less responsive to changes in functional activities performed outside the rehabilitation program. However, this tool has been recommended for evaluation of the effects that dyspnea has on functional status and daily activities.[9] In addition, the dyspnea domain of this questionnaire requires that patients specify their five most important dyspnea-inducing activities, a feature allowing confirmation that all the current patients did indeed experience significant and distressing symptoms during one or more upper limb tasks. Nonetheless, it may be that the CRQ is not sensitive to changes in upper extremity exercise capacity, and that as a result, no improvements in symptoms or quality of life were evident. It is possible that instruments with a more specific focus on functional status, such as the Pulmonary Functional Status Scale, may provide additional information. However, as yet, there are limited data regarding its responsiveness to exercise training.[26] Additional information also could be provided by a upper limb endurance test that more closely reproduces activities of daily living. However, to date, a reliable and valid test of this nature has not been developed.

It is possible that including a larger number of patients in this study may have shown significant differences in symptoms or quality of life. It was noted, however, that the data showed no trends with very high *P* values ($P > .5$) for all of the CRQ domains. In addition, the current study represents the largest trial of upper limb training for patients with COPD. Previous controlled trials upon which training recommendations have been made[9,10] have included 7 to 32 patients.[6,11] It may be useful to repeat this study with larger patient numbers to validate the findings. However, the need to do so shows that any effect size related to upper limb training is likely to be small, contrasting with the relatively few patients required to find an effect of LL training on symptoms and quality of life experienced by patients with COPD.[9]

In conclusion, this randomized double-blind controlled trial shows that although unsupported upper limb training enhances upper limb exercise capacity for patients with moderate to severe COPD, no additional improvement in symptoms or health-related quality of life beyond that obtained with LL training alone is evident. Further research is required to determine the clinical significance of upper limb training for patients with COPD.


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