

## Research Article

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# A Cohort Study to Evaluate the Feasibility of Low Load/High Repetition Elastic Band Resistance Training for People with Chronic Obstructive Pulmonary Disease

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## Abstract

**Background:** Resistance training is an important component of pulmonary rehabilitation in people with Chronic Obstructive Pulmonary Disease (COPD). A vast majority of resistance training studies in COPD have focused on increasing muscular strength with use of weight machines and has been found to be a feasible approach in COPD. However, regarding feasibility of resistance training equipment other than weight machines, such as elastic resistance equipment, information is scarce. In addition, little is known regarding other trainable muscle characteristics, such as peripheral muscular endurance in COPD. We therefore aim to evaluate the feasibility of a low load/high repetition elastic band Resistance Training (RT) regimen in people with moderate to severe COPD. We also aim to evaluate if the RT regimen is feasible for the physiotherapists, conducting the intervention.

**Methods:** Twenty-two participants with moderate to severe COPD (mean forced expiratory volume in one second, FEV<sub>1</sub> 58.7% predicted) and five physiotherapists participated in the study. Measurements of attendance, assessment and progression of exercise intensity, adverse events, participant and compliance (participant and physiotherapist) were collected for assessment of feasibility.

**Results:** The mean (95% confidence interval) attendance rate was 94% (91-97) and mean exercise intensity was 79% (74-83) of the predicted maximum intensity. Furthermore, the median (interquartile range) compliance was 96% (94-96) and 100% (94-100) for the people with COPD and the physiotherapists respectively. Exercise intensity increased on all exercises and any recorded adverse events were considered minor and temporary.

**Conclusions:** Low load/high repetition elastic band resistance training appears to be feasible for both people with COPD and the physiotherapists performing the intervention. These results indicate that elastic bands could be a feasible alternative to weight machines in resistance training for people with COPD.

**Keywords:** Pulmonary disease; Chronic obstructive; Feasibility; Resistance training; Peripheral muscular endurance; Single limb; Elastic resistance

## Introduction

Pulmonary rehabilitation is effective for people with Chronic Obstructive Pulmonary Disease (COPD) with regard to symptoms, function, participation, and health-care resource utilization [1]. One of the components of this evidence-based comprehensive intervention is resistance training that has been found to be beneficial in improving muscular strength, cycle endurance capacity [2-4] and upper extremity functional capacity [4]. In COPD, the predominant choice of exercise equipment in resistance training regimens has been weight machines. However, lack of access to this exercise equipment can be a barrier to maintenance of exercise capacity. This has highlighted the need to examine effects and safety of alternate exercise equipment [3]. Elastic resistance equipment such as elastic bands and tubing offers an alternative that has shown comparable results to weight machines regarding both upper and lower extremity exercises in healthy adults [5,6]. In people with COPD, O'Shea et al. [7] found that a predominantly home-based resistance training regimen with elastic bands could be used to increase knee extensor strength. Nevertheless, they did not find any effect on upper extremity strength and walking ability. The authors argued that the high attrition rate, with more than 40% of participants unable to complete the exercise program, to some extent may have influenced the effectiveness of the exercise regimen. This is, to our knowledge the only published study that have used elastic bands as primary resistance in people with COPD. In addition the study did not report any information about feasibility of the exercise

program such as adverse events and compliance. Therefore, knowledge concerning the feasibility of using resistance training with elastic bands as resistance is limited for this group of people.

A majority of previous resistance training studies in COPD have primarily focused on increasing muscular strength. Little is known regarding other trainable characteristics, such as peripheral muscular endurance which may be of importance since quadriceps muscular endurance has been shown to be reduced to a larger extent in comparison to quadriceps strength in people with COPD [8].

We have recently submitted a paper on the effects of an eight week low load/high repetition (i.e. peripheral muscular endurance) elastic band resistance training regimen that showed promising results, including increased functional upper and lower extremity exercise capacity, maximal strength and peripheral muscular endurance for the

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people with COPD. However the feasibility of this exercise regimen in people with COPD is still unknown.

Therefore, the aim of the present study was to investigate if:

1. A low load/high repetition elastic band Resistance Training (RT) regimen is feasible in people with COPD?
2. The RT regimen is considered feasible for the physiotherapists supervising and conducting the intervention in clinical settings?

## Method

### Design

The study was performed on people with COPD who were randomly assigned to participate in an eight week RT regimen [9]. The present study was approved by the Regional Ethical Board, Umeå University, Umeå, Sweden (Dnr: 2010-344-31 M) and was registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (NCT01354067). The study is reported in line with strengthening the reporting of observational studies in epidemiology guideline [10]. Recruitment, data collection and follow-up were performed from August 15, 2011 to May 3, 2012 [9].

Eligibility criteria for patients included having stable COPD stage II-IV according to the Global Initiative for Chronic Obstructive Lung Disease guidelines [11], ex-smoker, on stable medication and randomized to participate in the RT regimen. Eligibility criteria for physiotherapists included at least two years' experience of working as a physiotherapist, one year experience of working with cardio-respiratory patients, and at least one year experience of leading training groups [9]. Written informed consent was obtained from both patients and physiotherapists.

### Interventions

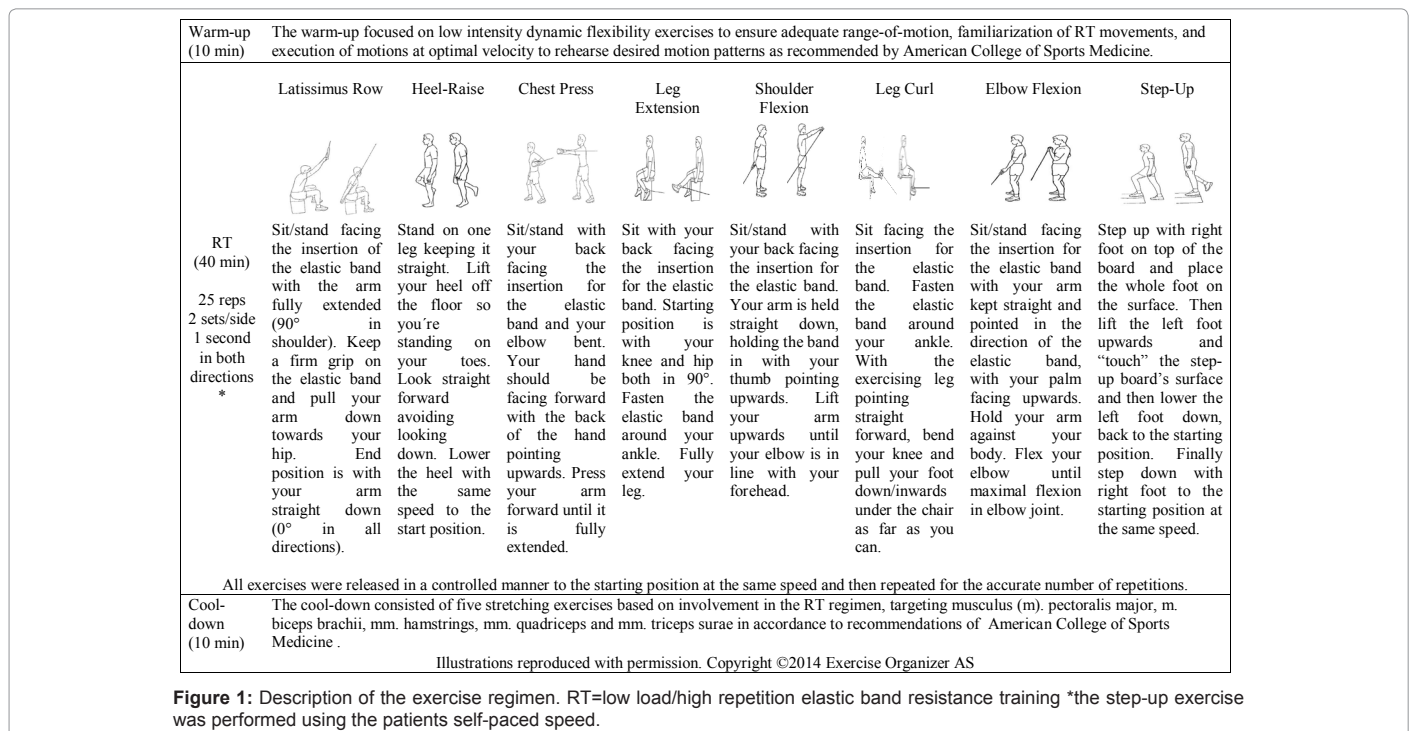
The RT regimen is a standardized resistance training regimen which consists of eight upper and lower extremity exercises performed with one leg/arm at a time. Six exercises are performed with elastic

bands (Thera-Bands®, The Hygenic Corporation) and two with body weight (heel-raise and step-up) as primary resistance (Figure 1).

The RT regimen was conducted in a group format and supervised by physiotherapists. Each group consisted of three to seven patients who attended three sessions per week during eight weeks. The sessions lasted approximately 60 minutes including warm-up, exercise and cool-down, each part designed in accordance to American College of Sports Medicine recommendations [12-14]. Volume, initial load, rest periods, frequency, repetition velocity, and progression in the RT regimen were standardized in accordance with recommendations for increasing peripheral muscular endurance [9,14]. The exercises within the RT regimen target muscles with decreased strength/endurance (compared to healthy individuals), muscles which are important for upper extremity activities of daily living, and muscles which are important for walking [15-18]. All exercises were executed using a single limb at a time, alternating left to right side in order to minimize the risk of a central constraint [19]. Execution of all exercise was standardized to optimize activation of targeted muscles, and included execution in the most clinically effective portion of elastic resistance [2,9,20-22]. The length of each individual elastic band, patient position from elastic resistance insertion and, start and stop positions for each exercise, were also standardized [9,23]. All components were individually determined and progressed with use of Borg category ratio (CR10) scale [24], according to a specified protocol to optimize individual tailoring of the exercise regimen [9]. The physiotherapists were given a standardized education session in order to deliver a uniform intervention and the exercise protocol was given to both people with COPD and physiotherapists to enhance adherence and familiarization. Written commitments to follow to the assigned protocol were signed by all physiotherapists. Further description on the components and standardization of the exercise regimen are available [9].

### Outcomes and follow-up

Feasibility of the RT regimen was assessed by the attendance rate,



exercise intensity, compliance and occurrence and severity of any adverse events. All outcome data was collected between the baseline tests and within three weeks after the end of the eight-week intervention.

Attendance was evaluated by calculating an attendance rate for each patient as the number of attended sessions divided by total number of sessions.

Exercise intensity was evaluated through assessment and progression of the intensity. Mean muscle fatigue rating on the Borg CR10 scale during the whole intervention period was divided by muscle fatigue rating at a baseline 25 repetition maximum test to determine exercise intensity. The ratings during exercise training were done independently by the patients by pointing to a Borg CR10 scale for dyspnea and muscle fatigue, noted by the physiotherapist. Progression of exercise intensity was evaluated by comparing exercise intensity between the first and last exercise session.

Information about adverse events was collected from exercise diaries and post training interviews with the physiotherapists who led the interventions. Two independent pulmonologists and one physiotherapist who were not involved in the study evaluated the adverse events. The severity of them was assessed and rated into four different categories: (1) minor and temporary, (2) serious symptoms (potential risk of severe injury or life threatening), (3) manifest injury or disease, and (4) death as previously used [25]. An adverse event rate was calculated for each patient as the total number of sessions in which any adverse events occurred divided by the total number of attended sessions.

Compliance was evaluated by a standardized questionnaire. The questions, ranging from 1 to 5, focused on the extent to which they could follow the instructions on the different components of the intervention. A rating of 1-3 was defined as a small extent and 4-5 large

extent. The dichotomization was used to simplify the understanding of the interpretation of compliance to the exercise regimen.

### Statistical analysis

Data analyses included all patients using intention-to-treat analysis. Data was missing on the compliance questionnaire from one participant with COPD due to an exacerbation after the end-of-intervention period. This missing data was considered Missing Not At Random (MNAR). Missing ratings was due to the physiotherapists forgetting to note the rating, which was considered Missing At Random (MAR) [26]. MNAR and MAR data was imputed using the overall mean [27]. A sensitivity analysis was performed comparing the results with imputed data to a complete case analysis [10]. Comparison between participants and physiotherapists regarding compliance were performed using the Chi-square test. Paired sample t-test and Wilcoxon signed rank test was used for exercise intensity and complete-case comparisons when appropriate. Data is presented in mean (95% confidence interval (95%CI)) or median (interquartile range (IQR)) depending on distribution of data unless otherwise stated. No additional analyses were made. A p value of <.05 was considered statistically significant. For data management and statistical analysis the IBM Statistical Package for Social Sciences (SPSS) version 20.0 was used. Additional details of the methods used are provided in study protocol [9].

### Results

The RT regimen was implemented and administered according to trial protocol [9]. All participants completed the intervention (Figure 2). All data was collected within three weeks after completing the intervention. Participant characteristics are presented in Table 1 and experience of the five physiotherapists is presented in Table 2.

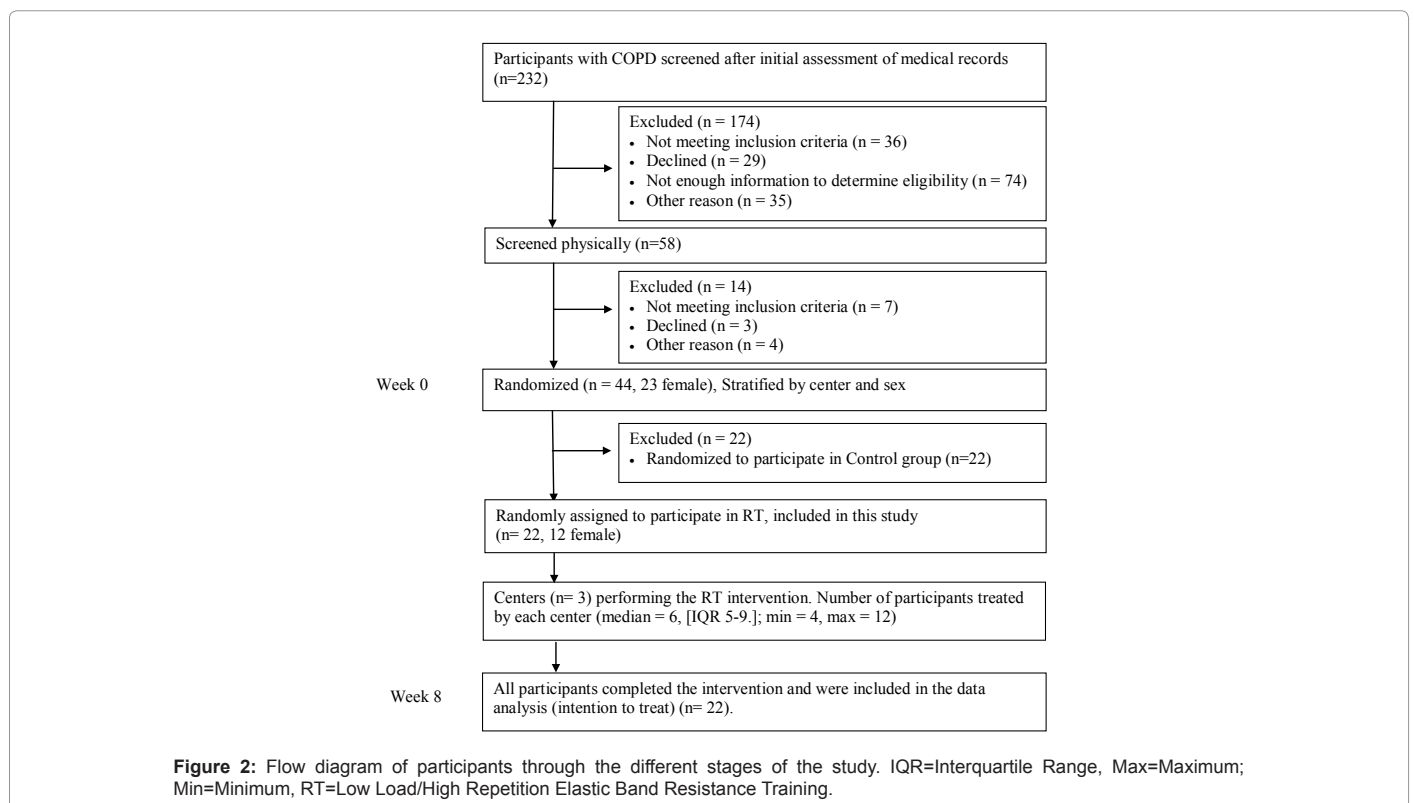


Figure 2: Flow diagram of participants through the different stages of the study. IQR=Interquartile Range, Max=Maximum; Min=Minimum, RT=Low Load/High Repetition Elastic Band Resistance Training.

<b>Participants</b>	
Age (years)	69 (5)
Sex (female)	12 (55%)
Body mass index (BMI)	26 (4)
<b>Disease severity (GOLD)</b>	
Stage II	18 (82%)
Stage III	4 (18%)
GOLD stage	2.2 (0.4)
MRC score	2.0 (1.1)
6MWT (meters)	515 (80)
<b>Pulmonary function</b>	
VC (% predicted)	98 (18)
FEV <sub>1</sub> (liters)	1.6 (0.5)
FEV <sub>1</sub> (% predicted)	59 (11)
FEV <sub>1</sub> /FVC	47 (9)
TLC (% predicted)	108 (17)
RV (% predicted)	134 (34)
<b>Smoking status</b>	
Years smoked	38 (12)
Pack Years	30 (7)
<b>Occupation</b>	
Retired	18 (82%)
Employed	3 (14%)
On sick-leave	1 (4%)

Data are presented as means (SD) or frequencies (%). 6MWT: 6 Minute Walk Test; FEV<sub>1</sub>: Forced Expiratory Volume During The First Second; FVC: Forced Vital Capacity; GOLD: Global Initiative For Lung Disease; MRC: Medical Research Council Dyspnea Scale; RV: Residual Volume; TLC: Total Lung Capacity; VC: Vital Capacity

**Table 1:** Characteristics of participants at study entry (n=22).

Center (Number of physiotherapists)	Umeå (n=2)	Huddinge (n=2)	Örnsköldsvik (n=1)
Experience (in years):			
As a physiotherapist	12 (10.5-13.5)	13.5 (8.75-18.25)	19
With cardio-respiratory patients	7 (5.5-8.5)	6 (4-7)	7
Of group training	11 (10.5-11.5)	12 (6.5-17.5)	19
Of using elastic bands	2.5 (2.25-2.75)	3 (3-3)	3
No of treated patients in the study	6	12	4

Data is median (interquartile range) if applicable. RT=low load/high repetition elastic band resistance training

**Table 2:** Experience of physiotherapists conducting the RT regimen at each center.

## Attendance

Twenty-four RT sessions were conducted during the eight-week intervention period. An additional exercise week was offered to enable everyone to reach the minimum goal of 20 exercise sessions. The mean attendance rate was 22.5 out of 24 sessions, i.e. 94% (91-97) [9,28]. The mean attendance rate without the additional week was 91% (87-94).

## Exercise intensity

The mean exercise intensity measured as rated muscle fatigue during the intervention was 4.4 out of 5.6 obtained from the baseline 25 repetition maximum test [9], i.e. 79% (74-83) of the predicted maximum intensity. An increase in resistance, exemplified for the knee extension exercise, of mean 1.7 kg (0.9 to 2.6) (p<.001), i.e. a 28% increase in resistance, was seen between the first and last exercise session for all elastic exercises. All participants started at level one in the heel-raise and the step-up exercise. At week eight the median level was 2 (1-2.25) (p<.001) and 1 (1-2) (p=.003) for single leg heel raise and single leg step-up, respectively.

## Adverse events

Eight participants reported a total number of 28 adverse events distributed over 18 (3.6%) of the attended exercise sessions. The median rate of sessions in which they experienced adverse event per attended session was 0% (0-9) for all participants. All adverse events were minor and temporary as judged by the independent pulmonologists as well as by the physiotherapist. There was no disagreement between assessors on any adverse event. The adverse events were musculoskeletal (such as pain or soreness: 64%), related to the elastic resistance bands (such as bruising, pain, laceration, swelling: 32%), and dizziness (4%). Seven out of the nine (78%) adverse events related to the elastic resistance bands was reported during the first seven sessions.

## Compliance

All physiotherapists and all but one patient filled out a questionnaire about the RT regimen. The questions focused on the participants and physiotherapists ability to follow the instructions on the different components of the RT regimen. When rating their own ability to follow the instructions of the RT regimen (when looking at all components together) 96% (94-96) of participants and 100% (94-100) physiotherapists, could follow the instructions to a large extent. Regarding compliance to the individual components of the RT regimen, all physiotherapists felt that they could follow the instructions to a large extent with regard to the whole regimen, the eight exercises, the warm-up, the no of repetitions and the ratings of exertion. Fifty percent of the physiotherapists thought that they could follow the instructions to a large extent on the cool-down component of the RT regimen, 71% regarding the speed of movement component and 88% regarding the progression component of the RT regimen. There was no difference between the participants and physiotherapists' ratings on any of the different components of the RT regimen regarding the participants' ability to follow the instructions to a large extent (Table 3). In addition, compliance was 96% and ranged between 88%-100% for the participants and physiotherapists respectively on the components of the RT regimen related to the elastic bands. The results did not differ when compared to the complete case analysis on any of the components of the RT (p=.624-.744).

## Discussion

The RT regimen evaluated in this study was feasible for people

	Participants ability to follow the instructions to a large extent according to participants themselves	Participants ability to follow the instructions to a large extent according to physiotherapists	P
The whole RT regimen	100%	100%	.a
The warm-up	96%	100%	p=.733
The eight exercises*	96%	100%	p=.733
The cool-down	82%	63%	p=.261
The speed of movement*†	96%	88%	p=.469
The no. of repetitions*	96%	100%	p=.733
The ratings of exertion*‡	91%	100%	p=.531

\*Questions related to the elastic bands, †one second in each direction for all but the step-up exercise, ‡ muscle fatigue and dyspnea. Data is presented in percent. N/A=Not applicable, P=p-value, RT=low load/high repetition elastic band resistance training a. No statistics are computed because the question is a constant.

**Table 3:** The percentages of participants who could follow the instructions on the different parts of the RT regimen to a large extent according to a questionnaire (n=22).

with moderate to severe COPD. There was a high attendance rate, high mean exercise intensity with a significant progression, and a high compliance with the RT regimen for both people with COPD and the physiotherapists performing the RT regimen. Furthermore, there were few adverse events and these were considered minor and temporary.

This study adds to the body of knowledge regarding feasibility of resistance training in general and of elastic band resistance training in specific in people with COPD. The results from this study indicate that an elastic band resistance training regimen is feasible in people with COPD, when performed as low load/high repetition resistance training supervised by physiotherapists in an outpatient setting.

The feasibility of elastic resistance equipment in resistance training for people COPD is of importance since it, in comparison to weight machines, offers a portable and inexpensive alternative that is easy to use and more accessible [29,30].

The attendance rate in the present study was much larger (94%) than in the elastic band study by O'Shea et al. (56%) [7]. However, the present RT regimen was performed in group and in an outpatient setting which previously has been shown to have higher completion rates than an individual exercise regimen performed in a home setting [31]. Nevertheless, also in comparison to other studies of resistance training performed in groups of people with COPD the attendance rate was high [3].

We identified a number of adverse events in this study, of which a third (9 out of 28) was related to the elastic bands. A pilot study on one individual with COPD was executed to test the RT regimen in general and the elastic bands in specific [22,23]. However, this may not have been sufficient. The majority of adverse events related to the elastic bands occurred within the first seven exercise sessions. All were considered minor and temporary and were related to how the elastic band was fastened on the exercising limb. Small alterations were made that minimized the rate of adverse events in upcoming sessions. A more comprehensive pilot testing before start of intervention could have identified the initial problems with the elastic bands which may have reduced the number of adverse events related to the equipment.

Compliance to the RT regimen was excellent for both the participants in the RT regimen and the physiotherapists conducting the intervention on the RT in general and on the components of the RT related to the elastic bands in specific. As far as we know this is the first study to evaluate compliance to the different components of a specific exercise regimen in COPD. The enrollment of the physiotherapists as a control on the questionnaire with regard to the participants' ability to follow the instructions of the RT regimen may be considered a bias on the study outcome. The reason for using the physiotherapists as a control was that we anticipated that the participants may have an excessively positive approach to the exercise regimen only for being selected to participate in the study. By comparing the participants' opinions with the opinions from the physiotherapists regarding the participants' ability to follow the instructions of the RT regimen we believed that we would get a more balanced and correct result.

Strengths of the present study were the rating of severity of adverse events, the use of raters not involved in the study and the assessment of compliance to the different parts of the RT regimen in both participants and physiotherapists. Other strengths were the comprehensive and standardized description of the RT regimen which facilitates reproducibility and implementation of the intervention. Furthermore, the whole design of the RT regimen focused on clinical applicability.

One limitation in the present study was that no particular

instructions were given to the physiotherapists at baseline to note adverse events which may imply a possible underestimation for the occurrence of adverse events. Nevertheless, adverse events were registered and collected from exercise diaries and post-intervention interviews with the physiotherapists and all adverse events that were reported were considered minor and temporary by the independent raters.

Other limitations were that the majority of patients included in the intervention were people with moderate disease and that no participant with very severe COPD was included, as originally intended. This precludes generalization to people with COPD with larger ventilator restraints and muscular dysfunctions. Nevertheless, the results are of importance since people with moderate disease are one of the larger groups in the COPD population [32]. However, it would be of interest to investigate the feasibility of the exercise regimen also in people with severe disease as adherence to pulmonary rehabilitation has been shown to be lower in those with larger ventilator restraints [33,34]. Also, there were some missing data which may have led to bias [26]. However, no differences were seen in comparison with complete case data and there were generally only a few missing observations, which may be considered as a minor disruption [10,26].

The main clinical implication of this study is that this low load/high repetition elastic band resistance training regimen is feasible for both people with moderate to severe COPD and physiotherapists conducting the intervention. This indicates that elastic bands could be an alternative to weight machines in resistance training for people with COPD. Further studies are needed to evaluate whether the results can be reproduced in a broader range of disease severity and different settings.

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#### Conflicts of Interest

Andre Nyberg has no conflict of interest

Britta Lindström has no conflict of interest

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