Pulmonary Rehabilitation Exercise Prescription in Chronic Obstructive Pulmonary Disease: Review of Selected Guidelines

AN OFFICIAL STATEMENT FROM THE AMERICAN ASSOCIATION OF CARDIOVASCULAR AND PULMONARY REHABILITATION

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Chronic obstructive pulmonary disease (COPD) is associated with disabling dyspnea, skeletal muscle dysfunction, and significant morbidity and mortality. Current guidelines recommend pulmonary rehabilitation (PR) to improve dyspnea, functional capacity, and quality of life. Translating exercise science into safe and effective exercise training requires interpretation and use of multiple guidelines and recommendations. The purpose of this statement is to summarize for clinicians 3 current chronic obstructive pulmonary disease guidelines for exercise that may be used to develop exercise prescriptions in the PR setting. The 3 guidelines have been published by the American College of Sports Medicine, the American Thoracic Society/European Respiratory Society, and the American Association of Cardiovascular and Pulmonary Rehabilitation. In addition to summarizing these 3 guidelines, this statement describes clinical applications, explores areas of uncertainty, and suggests strategies for providing effective exercise training, given the diversity of guidelines and patient complexity.

K E Y W O R D S

COPD

exercise

exercise prescription

pulmonary rehabilitation

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Chronic obstructive pulmonary disease (COPD) is associated with disabling dyspnea, skeletal muscle dysfunction, exercise intolerance, and significant morbidity and mortality.[1-4] This may be, at least partially, due to physical inactivity.[5] Indeed, dyspnea during daily activities and physical exercise is common in COPD. This often results in patients not wanting to participate in regular physical activity or exercise because of the discomfort associated with dyspnea. A decrease in the amount of regular physical activity or exercise over time leads to further physical deconditioning, which precipitates the onset of dyspnea at lower levels of exercise and physical activity. This downward spiral of decreasing exercise and increasing dyspnea on exertion can result in greater levels of functional impairment and disability.[6] Physical deconditioning due to physical inactivity provides a major rationale to consider exercise training as part of comprehensive pulmonary rehabilitation (PR).

The current Global Obstructive Lung Disease document recommends PR to improve dyspnea, functional capacity, and quality of life.[7] Many PR exercise programs are based on guidelines/statements from the American College of Sports Medicine (ACSM),[8] American Thoracic Society (ATS)/European Respiratory Society (ERS),[9] and/or American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR).[10] Detailed descriptions of these 3 guidelines are beyond the scope of this article but provide important insights into exercise in COPD. Guidelines and recommendations are also available from the British Thoracic Society,[11] the Canadian Thoracic Society,[12] and the American College of Chest Physicians/AACVPR.[13,14]

Health care professionals developing exercise prescriptions and supervising exercise training in persons with COPD may be challenged by patient disease variability and severity, as well as interpreting and using diverse guidelines. Indeed, the content of PR programs varies globally.[15]

Translating exercise science into safe and effective exercise training requires interpretation and the use of multiple PR guidelines and recommendations. The purpose of this statement is to summarize 3 exercise recommendations for patients with COPD and their clinical applications from 4 leading professional societies. This statement is not intended to be an evidence-based guideline but rather is a summary of selected published exercise prescription guidelines. The statement also provides a brief description of areas of uncertainty and suggests strategies for providing effective exercise training, given the diversity of guidelines and patient complexity.

METHODS

Professional members and expert reviewers were identified from ACSM, ATS, ERS, AACVPR, and American Association for Respiratory Care. Three pulmonary exercise guidelines from the ACSM, AACVPR, and ATS/ERS were reviewed and summarized, as well as a limited literature search to establish current science and practice of exercise recommendations and prescription in COPD.

Current evidence-based guidelines from all major pulmonary and exercise science societies recommend PR for improving disabling dyspnea, functional capacity, and health-related quality of life in persons with COPD. The exercise guidelines for persons with COPD developed by ACSM,[8] ATS/ERS,[9] and AACVPR.[10] are summarized below and in Table 1.

SUMMARY OF EXERCISE PRESCRIPTION GUIDELINES FOR PATIENTS WITH COPD

American College of Sports Medicine

The current ACSM guidelines[8] include recommendations for exercise prescription for COPD patients. Additional background and resource information was obtained from the current edition of ACSM's *Resource Manual for Guidelines for Exercise Testing and Prescription*, 7th edition (*RM7*).[16]

The ACSM recommends exercise training as part of a comprehensive treatment and medical management plan for persons with COPD. Recommendations include an assessment of COPD patients before beginning an exercise training program. This should include pulmonary function testing, arterial oxyhemoglobin saturation based on direct arterial oxygen saturation (SaO_2) or indirect peripheral oxygen saturation measured by oximetry (SpO_2), and dyspnea monitoring using the Borg CR 10 scale.[17] Exercise testing is an important element of the initial PR assessment. A cardiopulmonary exercise test including ventilation and gas exchange assessment and a standardized ramp protocol may be used. Submaximal exercise testing may be used depending on the rationale for the test and the patient's clinical status. Persons with chronic lung disease may have ventilatory limitations to exercise; therefore, peak oxygen uptake estimated using age-predicted heart rate may not be appropriate. Modifications of traditional testing protocols, including smaller increments and/or slower progression, may be warranted depending on functional

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Table 1 • Summary of Exercise Recommendations

	ACSM	ATS/ERS	AACVPR
Endurance exercise			
Modality	Walking and/or cycling	Cycling or walking (ground-based or treadmill)	Walking (treadmill, track, supported walking via walker or wheelchair), cycling, stationary bike, arm ergometry, arm lifting exercises with/without weights, step exercises, rowing, water exercises, swimming, modified aerobic dance, seated aerobics
Frequency	3 to 5 days per week (minimum)	3 to 5 times per week	3 to 5 times per week
Intensity	Light intensity: 30%-40% peak work rate	>60% maximal work rate	High intensity (60%-80% peak work rate)
	Vigorous intensity: 60%-80% peak work rate		
	Alternative criterion: dyspnea rating 4-6 on Borg CR10 scale		
	Light-intensity exercise improves symptoms, health-related quality of life, and performance of ADL		
	Vigorous-intensity exercise optimizes physiologic improvements		
Duration	No specific recommendation for total length of session. Duration recommendations are based upon severity of COPD; individuals with moderate to severe COPD may be able to exercise at a specific intensity for only a few minutes during the initial stages of training and may require intermittent interval training initially	20 to 60 min per session	20 to 60 min per session for 4-12 wks
Progression	Individualized on the basis of health and fitness status. These are general guidelines for older adults that may apply	Titrate to symptoms	Options include titrating to selected RPE level, dyspnea scale rates, or predetermined MET level
	Initial: increase duration by 5-10 min every 1-2 wks during first 4-6 wks	4 to 6 on Borg scale or 12 to 14 on RPE scale	
	Thereafter, gradual increase in duration, frequency, and/or intensity		
Comments	Intermittent training may initially be used until individuals can tolerate longer duration exercise	For individuals who cannot tolerate continuous training due to intolerable symptoms, interval training should be considered	Interval training should be considered for individuals who cannot sustain extended continuous periods of high-intensity exercise
	Shorter, intermittent bouts involving vigorous exercise intensity have been reported to decrease symptom ratings		Warm-up before and cool-down after exercise

(*continues*)

Table 1 • Summary of Exercise Recommendations (*Continued*)

	ACSM	ATS/ERS	AACVPR
Resistance exercise	Note: The ACSM guidelines do not include specific recommendations for resistance training and flexibility exercises in patients with COPD but refer to the recommendations for use with older and healthy adults. The following statements reflect those recommendations	Resistance exercise should follow the same FITT principle of exercise prescription for healthy and/or older adults	Not stated
Modality	Emphasize functional activities (eg, stair-climbing) Free weights, machines with stacked weights or pneumatic resistance, resistance bands	Repetitive lifting of relatively heavy loads	Weight lifting: hand and ankle weights, free weights, machine weights, elastic resistance, using one's body weight (stair-climbing, squats)
Frequency	≥2 d/wk	2 to 3 times per week	Not stated.
Initial intensity	Light intensity: 40%-50% 1RM Moderate intensity: 60%-70% 1RM	60%-70% 1RM or 100% of 8-12 RM	Begin with lower weights/resistance and higher repetitions to increase muscle endurance On individual basis, higher weights and fewer repetitions may be indicated to promote strength development
Duration	1-4 sets; 8-10 exercises; 10-15 repetitions to improve muscular strength/endurance	Not stated	Not stated
Progression	Gradual progression increasing resistance and/or repetitions and/or frequency	Increase weight, number of repetitions per set, number of sets per session or reduce rests when individuals can perform 1 to 2 repetitions over the desired number on 2 consecutive sessions	Monitor RPE plus muscle/joint fatigue, soreness, and pain
Comments	Rest 2-3 min between sets; use proper techniques for each exercise; move through entire range of motion; use proper breathing technique; exercise each major muscle group using multijoint and single joint exercises	Endurance training is the main stay of pulmonary rehabilitation. However, resistance exercise will confer greater gains in muscle mass and muscle force and evoke less dyspnea	For osteoporosis: Caution with spine flexion/rotation and heavy weight training For pulmonary hypertension: Low resistance training with paced breathing, aerobic training is acceptable
Upper limb exercise			
Modality	Not stated	Endurance exercise (eg, arm ergometry) and/or Resistance exercise (ie, free weights and elastic bands)	Task-specific training of muscles involved in functional living
Frequency	Not stated	Not specifically stated, but would be consistent with above recommendations	Not stated

(*continues*)

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Table 1 • Summary of Exercise Recommendations (*Continued*)

	ACSM	ATS/ERS	AACVPR
Initial intensity	Not stated	Not stated	Not stated
Duration	Not stated	Not stated	Not stated
Progression	Not stated	Not specifically stated, but would be consistent with above recommendations	Not stated
Comments	Not stated	Improves upper limb function (eg, strength and performance during upper limb tasks)	Not stated
Flexibility exercise			
Modality	Any physical activity that maintains or increases flexibility using slow movements that involve sustained stretches for each major muscle group	Stretching of major muscle groups	Balance training and stretching to increase range of motion (eg, modified yoga for whole-body stretching with coordinated breathing)
Initial intensity	Stretch to point of feeling tightness or slight discomfort	Not stated	Not stated
Duration	10-30 s static stretch; holding stretch for 30-60 s may increase benefit in older patients	Not stated	Not stated
Progression	30-60 s of total stretch for each exercise 2-4 repetitions for each exercise	Not stated	Not stated
Frequency	≥2 d/wk	2-3 times per week	Not stated
Program duration	Not stated	Longer programs are thought to produce greater gains and maintenance of benefits; a minimum of 8 wks is recommended to achieve a substantial effect	4-12 wks
Comments	Series of stretches for each major muscle-tendon group (chest, shoulders, upper and lower back, abdomen, hips, and legs)	No clinical trials to support the inclusion of this component. Nevertheless, it is commonly included in pulmonary rehabilitation programs	Goal of increasing ROM. Target specific muscle groups to ensure good posture and proper body mechanicals and minimize joint and muscle injury

Abbreviations: AACVPR, American Association of Cardiovascular and Pulmonary Rehabilitation; ACSM, American College of Sports Medicine; ADL, activities of daily living; ATS, American Thoracic Society; COPD, chronic obstructive pulmonary disease; CR, category-ratio; ERS, European Respiratory Society; FITT, frequency, intensity, time, type; MET, metabolic equivalent; RM, repetition maximum; ROM, range of movement; RPE, rating of perceived exertion.

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limitations, early onset of dyspnea, etc. Test duration of 5 to 9 minutes should be used for graded exercise testing in severe to very severe disease. The testing mode is typically walking or stationary cycling. Submaximal exercise testing (smaller increments, slower progression) may be indicated depending on the rationale for the test and the patient's clinical status. The 6-minute walk test is often used for assessing functional exercise capacity in patients with more severe pulmonary disease and/or in settings lacking exercise testing equipment.

Aerobic Exercise Training

During aerobic exercise training, the recommended intensity of exercise ranges from 30% to 80% of peak work rate on an incremental test, with a frequency of at least 3 to 5 sessions per week. Intermittent exercise may be used until sustained periods of longer duration are tolerated. No specific duration is given for those able to tolerate continuous moderate-intensity exercise. However, ACSM's *RM7*[16] describes a duration that is generally greater than 30 minutes on the basis of severity of COPD. Typical modes of aerobic exercise are walking or cycling.

Resistance Exercise Training

There are no specific resistance training guidelines for patients with COPD. Therefore, recommendations follow the same frequency, intensity, time, type (FITT) principles of exercise prescription as used for healthy adults and/or older adults.[8] The recommended format for resistance training exercises includes using resistance equal to 40% to 50% of 1 repetition maximum (1RM) for 1 to 4 sets with 10 to 15 repetitions per set on ≥2 days per week. Some patients may be able to progress to moderate-intensity resistance training utilizing 60% to 70% of 1RM. Resistance exercises should involve major muscle groups and include multijoint and single-joint exercises. Ratings of perceived exertion (RPE) of 5 to 6 of 10 (moderate) and 7 to 8 of 10 (vigorous) may be used to help guide intensity.

Flexibility Training

There are no flexibility guidelines specifically for persons with COPD so the recommendations follow ACSM recommendations for healthy adults and/or older adults.[8] Flexibility training should be performed at least 2 days per week and involve each major muscle-tendon group. Each static stretch is held for 30 to 60 seconds, with 2 to 4 repetitions of each exercise.

Other Recommendations

The ACSM recommends that SpO_2 should be >88% during exercise. If SpO_2 is ≤88% while breathing room air, supplemental oxygen should be used to maintain SpO_2 at >88%. The ACSM guidelines state that a physician's prescription is required for the use of supplemental oxygen. Protocols for the use of oxygen or titration during exercise may vary by program and may be based upon physician prescription or department-specific protocol.

American Thoracic Society/European Respiratory Society

The ATS/ERS statement[9] notes that the principles of exercise prescription for people with chronic respiratory disease are the same as those applied to healthy elderly individuals. To be effective, training loads must exceed loads encountered during daily life and should progress throughout the program.

Endurance Exercise Training

The aims of endurance training are to condition the muscles of ambulation and improve cardiorespiratory fitness. High-intensity exercise at more than 60% of peak work rate in an incremental test, performed for 20 to 60 minutes, is required to achieve these goals. Training intensity may also be set and/or titrated according to Borg dyspnea scores (4-6, moderate to very severe)[17,18] or the RPE scale (12-14 of 20, somewhat hard).[17] A frequency of 3 to 5 sessions per week is recommended. Walking is considered to be the best training modality if the goal is to increase walking endurance.[19]

Interval training is proposed as an alternative to continuous training, especially for individuals who are unable to tolerate high-intensity continuous endurance training due to intolerable symptoms. The outcomes of interval and continuous training are not different when the same total work is performed.[20] The statement suggests that short intervals of less than 1 minute in duration may be required to achieve lower symptom scores than achieved during continuous training.

Resistance Exercise Training

Optimizing muscle strength is an important goal of PR. While acknowledging that the optimal resistance training prescription for people with chronic respiratory disease has not been determined, the statement refers to the ACSM guideline for resistance exercise prescription (see Table 1). The principle of overload is emphasized, which involves increasing the exercise dosage over time to maximize gains in muscle strength and endurance. This could occur by increasing the weight, increasing the number of repetitions per set, increasing the number of sets of each exercise, and/or decreasing the rest period between sets or

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exercises.[21,22] The statement notes that more sophisticated progression models may also be useful, such as periodized resistance training; however, little data is available on those strategies in people with chronic respiratory disease.

Upper Limb Exercise Training

The statement indicates that upper limb training increases upper limb function in people with COPD. However, its impact on broader outcomes such as symptoms and health-related quality of life is less clear. The optimal modality for upper limb training is not known. The statement provides examples of aerobic upper limb training (arm cycle ergometer) and resistance training (free weights and elastic bands). Muscles that may be involved are biceps, triceps, deltoids, latissimus dorsi, and pectorals. No specific details of starting loads or progression are given, although for resistance training it may be assumed that these would follow the principles outlined earlier.

Flexibility Training

The statement acknowledges that while there are no trials to demonstrate the efficacy of flexibility training in chronic respiratory disease, it is commonly used in PR. One approach is reported, which includes upper and lower limb flexibility exercises performed 2 to 3 days per week, including major muscle groups such as calves, hamstrings, quadriceps, and biceps. Specific details on intensity and duration of stretches are not provided.

Program Duration

Although the optimal duration is unclear, the statement indicates that a minimum of 8 weeks of training is required for clinically important changes in exercise capacity and quality of life. Improvements in functional exercise capacity seem to plateau after 12 weeks of exercise training. The statement notes that longer programs may enhance longevity of training-related improvements and optimize the likelihood of behavioral changes upon program completion, such as increased daily physical activity.

Other Recommendations

The acute benefits of oxygen therapy on exercise performance are reported, but the statement acknowledges the inconsistent results from trials that have examined the effect of using supplemental oxygen to optimize the gains made during PR.[23] It suggests that individuals who are receiving long-term oxygen therapy should continue this during training and may require a higher flow rate than their usual prescription. Individual oxygen titration trials are proposed to identify individuals with COPD who might benefit from oxygen during training. Regarding the use of noninvasive ventilation, a systematic review concluded that the use of this adjunct during exercise training can augment exercise benefits in people with severe COPD.[24] However, the statement notes that because of its complexity, this may be available only in hospital-based PR programs. There is limited evidence to support the inclusion of breathing strategies such as pursed lip breathing, yoga breathing, and computer-aided breathing retraining,[25] but no recommendations on their use are made in the statement.

American Association of Cardiovascular and Pulmonary Rehabilitation

The AACVPR recommendations for exercise training in PR are to include both upper and lower extremity endurance and strength training with a focus on muscles involved in functional living.[10] Duration, frequency, mode, and intensity of exercise should be individualized and based on disease severity, level of conditioning, functional evaluation, and exercise test data.

The AACVPR recommends assessment of functional performance, balance, orthopedic and musculoskeletal limitations, strength, range of motion, and posture. Functional performance evaluation should include assessment of respiratory muscle function, breathing mechanics, and thoracic mobility (ie, diaphragmatic excursion, accessory breathing patterns, and rib cage flexibility). Balance assessment should include evaluation of activities of daily living (ADL), such as transitioning from lying to standing and climbing steps. Exercise should target improved balance and coordination to reduce fall risk.

Aerobic Exercise Training

Aerobic endurance training may be performed at high or low intensity. High-intensity training of at least 60% to 80% of peak work rate is associated with maximal physiologic improvements in aerobic fitness, endurance, and ventilation at submaximal work rates.[26-30] For those patients unable to tolerate sustained high-intensity exercise, working at the individual's maximal tolerated exercise level will achieve gains over time. Interval training is an effective training option for persons who cannot sustain extended continuous periods of higher-intensity exercise. Recommendations for duration are 20 to 60 minutes per session for 4 to12 weeks. Options for progression include titrating to a selected RPE level, intensity of dyspnea, or predetermined MET level.

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Resistance Exercise Training

Strength training improves muscular strength and symptoms with ADL and only marginally improves endurance. Modalities may include the use of weights (hand, ankle, free weights), elastic band resistance or using one's body weight such as stair climbing or squats.

Other Recommendations

The AACVPR advises monitoring SpO_2 which should be maintained above 88% to 90% during exercise. Assessment of oxygenation, while the patient is performing ADL using his or her own portable oxygen system, is ideal to accurately determine the amount of supplemental oxygen that is needed for each individual. Maximal-intensity exercise during ADL should be based on patient evaluation. Optimizing medical management (eg, oxygenation, bronchodilation, noninvasive positive pressure ventilation) in obstructive lung disease may enhance exercise training. Long-term adherence to exercise is a major priority in PR, with a goal of translating gains from PR into increased physical activity.

The AACVPR offers a national peer-reviewed certification for PR programs[31] that requires an individualized exercise prescription that includes exercise mode, frequency, duration, intensity, exercise progression, oxygen saturation, and oxygen titration. An updated clinical competency statement for health care professionals working in PR has recently been published by AACVPR.[32]

SUMMARY

Comprehensive PR results in improvement in exercise capacity, dyspnea, and quality of life. Exercise recommendations are available from at least 3 major US and international organizations. Table 1 compares and contrasts exercise recommendations from ACSM, ATS/ERS, and AACVPR. All guidelines recommend aerobic and resistance training with exercise prescriptions that include domains of exercise frequency, duration, and intensity. None of the guidelines make clear and specific recommendations for progression of endurance training over the course of the program. Recommendations for progression of resistance exercise are not consistent across guidelines. All 3 guidelines state that peak work rate is a useful guide in determining initial exercise loads yet do not give clear direction on estimating peak work rates based on 6-minute walk testing. Nevertheless, exercise prescriptions differ between guidelines/statements, in particular those from the ACSM. Whether and to what extent this is due to ACSM guidelines emphasis on training protocols for healthy adults and persons with cardiac disease remains to be determined.

Areas of inconstancy across the 3 guidelines include recommendations for flexibility training, which is seen as a core component in the ACSM and AACVPR guidelines, while the ATS/ERS statement notes that there is no specific evidence for its benefits. Both ATS/ERS and AACVPR suggest high-intensity endurance training for 20 to 60 minutes per session, while the ACSM indicates that training can be of high or low intensity and indicate that duration depends on disease severity. The ATS/ERS and AACVPR make specific recommendations for upper limb training whereas the ACSM does not. Recommendations for progression of exercise are inconsistent between societies. Areas of uncertainty and limitations include lack of applicability for non-COPD patients. Patients with other lung diseases, including fibrotic lung disease, pulmonary hypertension, and other disorders, are commonly cared for in the rehabilitation setting. It is beyond the scope of this statement to describe exercise recommendations in non-COPD patients. Readers are referred to "an ATS/ERSociety statement"[9] for further description of considerations in non-COPD patients.

In the absence of 1 optimal exercise prescription strategy for COPD, health care professionals should be familiar with all major, evidence-based PR guidelines. The core components of exercise training programs for COPD are endurance and resistance training; these should be included in all exercise prescriptions. Guidelines agree that endurance training at least 3 to 5 times weekly with ultimate targets >60% of maximal peak exercise should be used in all programs. While there is no consensus of initial workloads, pace of increasing the exercise load or session or program duration, it would seem reasonable to provide exercise of at least 20 minutes in duration, if the patient is able, and a target program duration of up to 12 weeks. US providers should note that insurers, including Medicare, may limit the number of sessions paid for by the patient's medical insurance. In the absence of 1 clear protocol to guide practice, clinicians should use clinical assessment and provide carefully monitored and supervised exercise and a collaborative, multidisciplinary team approach to individualized exercise training, prescription, and progression. A baseline and ongoing assessment that includes disease and symptom severity, comorbidities, and patient goals should be emphasized. This should be coupled with individual and aggregate measurement and analysis of patient-centered outcomes and exercise capacity. Finally, PR should emphasize sustainable exercise that translates into long-term

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increased physical activity. Future research considerations include evaluating and comparing efficacy of various PR guidelines to aid clinicians in selecting optimal practice strategies.

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