Increasing exercise capacity and physical activity in the COPD patient

Antarpreet Kaur[1], Jean Bourbeau[2], Lisa Brighton[3], Bartolome Celli[4], Rebecca Crouch[5], Heleen Demeyer[6,7], Daniel A. Gerardi[1], Hideki Katsura[8], Paula Meek[9], Mike Morgan[10], Mara Paneroni[11], Sally Singh[12] and Michael K. Stickland[13]

[1]Section of Pulmonary, Interventional Pulmonary, Critical Care, and Sleep Medicine, Saint Francis Hospital and Medical Center, Hartford, CT, USA. [2]Respiratory Epidemiology and Clinical Research Unit, Department of Medicine, McGill University Health Centre (MUHC), Montreal, QC, Canada. [3]Cicely Saunders Institute of Palliative Care, Policy and Rehabilitation, King's College London, London, UK. [4]Pulmonary and Critical Care Division, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA. [5]Duke University Hospital and Medical Center, Department of Physical and Occupational Therapy, Durham, NC, USA. [6]Department of Rehabilitation Sciences, KU Leuven, Leuven, Belgium. [7]Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium. [8]Department of Respiratory Medicine, Tokyo Women's Medical University, Tokyo, Japan. [9]University of Utah College of Nursing, Salt Lake City, UT, USA. [10]Retired, Department of Respiratory Sciences, University of Leicester, Biomedical Research Centre, Leicester, UK. [11]Istituti Clinici Scientifici Maugeri IRCCS, Respiratory Rehabilitation Unit of the Institute of Lumezzane, Brescia, Italy. [12]Department of Respiratory Sciences, University of Leicester, Biomedical Research Centre, Leicester, UK. [13]Division of Pulmonary Medicine, Department of Medicine, University of Alberta and G.F. MacDonald Centre for Lung Health (Covenant Health), Edmonton, AB, Canada.

Corresponding author: Antarpreet Kaur (Antarpreet.Kaur@trinityhealthofne.org)

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Different categories of interventions for increasing physical activity and exercise capacity in the COPD patient are discussed in this review: pharmacological, pulmonary rehabilitation, behavioural and web-based interventions. https://bit.ly/4dh2NyR

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Abstract

Higher levels of exercise capacity and physical activity are desired outcomes in the comprehensive management of the COPD patient. In addition, improvements in exercise capacity and physical activity are instrumental to optimising other important therapeutic goals, such as improved health status, reduced healthcare utilisation and increased survival. Four general approaches towards increasing exercise capacity and physical activity in individuals with COPD will be discussed in this review: 1) pharmacological intervention, especially the administration of long-acting bronchodilators; 2) pulmonary rehabilitation, including exercise training and collaborative self-management; 3) behavioural interventions; and 4) web-based interventions. These are by no means the only approaches, nor are they mutually exclusive: indeed, combining them, as necessary, to meet the needs of the individual respiratory patient may promote optimal outcomes, although further research is necessary in this area.

Background and concepts

Physical activity consists of bodily movement produced by skeletal muscles that results in energy expenditure, while exercise is generally a structured subset of physical activity, undertaken with the goal of achieving physical fitness [1]. Both are beneficial behaviours in everyone, including individuals with COPD. While physical activity and exercise have these accepted definitions, their opposites (physical inactivity and exercise limitation) are generally ignored or simply taken for granted in the medical literature. One attempt at defining physical inactivity rests on its structural implications, such as a lack of sufficiently strong muscle contractions to stimulate its rebuilding, resulting in atrophy and loss of oxidative capacity [2]. Alternatively, physical inactivity can be defined pragmatically as "the non-achievement of physical activity guidelines" [3]. When people do not meet the recommended levels of physical activity, they are considered inactive and at increased risk for musculoskeletal, cardiovascular and metabolic comorbidities. Based on large databases with objective assessment of physical activity, subjects accumulating fewer than 5000 steps per day can be classified as "sedentary" and subjects with 5000–7499 steps per day as "physically inactive" [4].

Physical inactivity and exercise capacity limitation, commonly seen in individuals with COPD, must be addressed holistically, as systemic effects and common comorbid conditions often add substantially to limitations imposed by airflow obstruction, hyperinflation and exertional dyspnoea [5, 6]. One view, expressed in an American Thoracic Society/European Respiratory Society statement on research questions in COPD [7], is that COPD can be considered as simply the pulmonary component of a multimorbid condition consisting of concomitant chronic diseases and systemic effects. Examples of the former cited in the statement are hypertension, atherosclerosis, chronic heart failure, lung cancer, osteoporosis and depression. Examples of systemic effects include impairment in ambulatory muscle function and structure (from disuse or chronic inflammation) [8] and lingering effects of exacerbations [9].

Beside the negative effects of the respiratory condition, its systemic effects and comorbidities, environmental conditions [10] and co-existing socioeconomic challenges [11] may also play a significant role in contributing to the frailty and decreased mobility that characterises ⩾20% of individuals with COPD [12–14]. In addition, people with COPD face low levels of self-efficacy and motivation, which also contribute to low physical activity levels. Addressing these psychological and behavioural factors can take time [15]. As noted by Polkey and Rabe [16] in their editorial, “one needs 3 months to train the muscle, but 6 months to train the brain”.

Higher levels of physical activity and exercise capacity are related to better health status, reduced healthcare utilisation and increased survival in COPD patients. Therefore, clinicians should strive to increase exercise capacity and physical activity levels in these patients. This article reviews four general approaches towards achieving these ends: 1) pharmacological intervention, especially the administration of long-acting bronchodilators; 2) pulmonary rehabilitation (PR), including exercise training and collaborative self-management; 3) behavioural interventions; and 4) web-based interventions. These are by no means the only approaches, nor are they mutually exclusive. Combining them may improve outcomes, although results from further research will be necessary to make firm conclusions regarding any potential additive or even synergistic benefits of this type of enhanced therapy.

Pharmacotherapy

Background

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2024 report [17] considers inhaled bronchodilators to be central to symptom management for individuals with stable COPD, with long-acting preferred over short-acting agents in all except those with only occasional dyspnoea. Long-acting bronchodilator treatments for COPD include long-acting β-agonists (LABAs), long-acting anti-muscarinic agents (LAMAs) and combinations of these. This section will focus primarily on long-acting bronchodilator therapy. While these agents provide symptomatic relief in COPD, their effectiveness in exercise capacity limitation and physical inactivity is not straightforward.

A study by Saey *et al.* [18] provides an example of the importance of systemic effects influencing the effects of pharmacological therapy on exercise capacity in COPD. The investigators had 18 individuals with COPD perform two constant work rate cycling exercise tests to exhaustion: one preceded by nebulised ipratropium (an anticholinergic bronchodilator), the second preceded by nebulised placebo. Muscle contractile fatigue was tested in all individuals by measuring post-exercise reduction in quadriceps twitch force. As anticipated, the bronchodilator resulted in increased endurance exercise time compared to placebo (mean±SD 440±224 *versus* 322±188 s, respectively), although the difference was not significant (p=0.06). However, in the nine individuals who had demonstrated baseline contractile fatigue, ipratropium did not increase the endurance time despite bronchodilation, while it did in those without contractile fatigue. Thus, the presence of contractile fatigue of ambulatory muscles (a systemic effect of COPD and treatable with exercise training) can limit bronchodilator effectiveness in increasing exercise capacity [7].

Pharmacological therapy to increase exercise capacity in COPD

While the presence of expiratory airflow limitation, which increases resistive work of breathing, is a *sine qua non* in COPD and is essential to its diagnosis [19], hyperinflation occurring during exercise is arguably more important as a cause of dyspnoea in this condition [20]. Dynamic hyperinflation in this context refers to the temporary increases in operating lung volumes that result from the imbalance between the increased ventilatory demand during exercise (and resultant increased respiratory rate) and the prolonged expiratory time in flow-limited patients with this disease [21]. Hyperinflation increases the elastic work of breathing, causes an inspiratory pressure load (auto-positive end-expiratory pressure), reduces the effectiveness of the inspiratory respiratory muscles, and (through greater swings in intrathoracic pressures) may have negative effects on cardiopulmonary interaction [22].

Bronchodilators, through increasing airway calibre and reducing hyperinflation in COPD, have the potential to reduce ventilatory limitation as a factor in exercise capacity limitation. Illustrating this, a 2018 systematic review and meta-analysis evaluating the effect of long-acting bronchodilators (*versus* placebo) on exercise endurance time in COPD [23] found 22 studies that met inclusion criteria. Inhaled bronchodilators included LABA and LAMA drugs, administered alone or together or with inhaled corticosteroids. Mean duration of treatment was approximately 9 weeks. Of the 2898 individuals in this study, 65% were male, mean age was 63 years, and baseline forced expiratory volume in 1 s (FEV_1) was 50% of predicted. By the end of the study, the weighted mean increase in trough FEV_1 (measurement shortly before the next dose) was 144 mL (95% CI 126–162 mL) and inspiratory capacity was 157 mL (95% CI 138–175 mL). Following exposure to LABA, inspiratory capacity measured at iso-time during exercise increased by 195 mL (95% CI 162–229 mL), indicating a decrease in hyperinflation. In conjunction with these beneficial respiratory effects, exercise endurance time (most studies used cycle ergometer exercise testing at 75–90% of maximal workload) increased by 67 s (95% CI 55–79 s). Subgroup analyses revealed the following: 1) since the post-bronchodilator increases in minimum and iso-time inspiratory capacity were of similar magnitude, it appeared that decreases in resting (trough) hyperinflation were responsible for decreases in dynamic (*i.e.* exercise) hyperinflation; 2) LABA and LAMA produced similar increases in exercise capacity, although there was a trend towards a greater beneficial effect with LAMA; and 3) patients with higher degrees of hyperinflation and lower baseline FEV_1 had the greatest benefit from bronchodilators.

This review demonstrates that long-acting bronchodilators result in a significant increase in exercise endurance time in patients with COPD, especially in those who had moderate to severe airflow obstruction and more hyperinflation [23]. While we could find no direct comparisons between bronchodilators and exercise training on constant cycle endurance time in COPD, it appears that exercise endurance training results in considerably greater improvements. For example, a study by Spruit *et al.* [24] found a mean±SD 352±276 s within-group increase in endurance time at 75% of maximal capacity in 48 individuals with severe COPD who were given exercise training. Bronchodilators and exercise training, however, are not mutually exclusive, as both modalities could be given to most, if not all, patients.

Combining different classes of long-acting bronchodilators in COPD is preferable to single-agent therapy, not only in increasing airway calibre [25] but also in increasing exercise endurance capacity. The added effect of dual bronchodilation in this outcome area was documented in a meta-analysis of eight randomised trials that included 1632 individuals, with a period of treatment ranging 2–12 weeks [26]. Combined LABA/LAMA therapy was significantly more effective than either agent alone, increasing both exercise endurance time (42 *versus* 22 s) and inspiratory capacity (*i.e.* reducing hyperinflation) (107 *versus* 87 mL). These combinations have a proven long-term safety profile [27, 28].

Studies testing the potential benefits of other medications on exercise capacity in individuals with COPD have included sildenafil [29], opioids [30], β-alanine [31], beta blockade [32] and theophylline (added to long-acting bronchodilator therapy) [33]. Despite some rationale for their use in COPD, these medications did not significantly increase exercise capacity in people with COPD.

Pharmacological therapy to increase physical activity in COPD

A 2021 narrative review provides data on objectively measured physical activity as an outcome in placebo-controlled COPD clinical trials [34]. This review, which included only studies with ⩾7 measurement days and ⩾4 valid days of ⩾8 h of monitoring with activity monitors, reported on seven studies of behaviour change programmes, nine with electronic health interventions, nine with rehabilitation exercise, three using lung volume reduction procedures, and six involving inhaled bronchodilators, either individually or in combination. Daily activity was assessed in three ways: 1) time spent in moderate to vigorous physical activity, 2) energy expenditure, and 3) step counts. With respect to the bronchodilator studies, duration of treatment ranged 3–12 weeks; physical activity was the primary outcome in only one study. In general, inhaled long-acting bronchodilator therapy, provided either as a single-agent or combination therapy, failed to show consistent improvements in physical activity. This negative result undoubtedly reflects the complex nature of physical activity, which is strongly influenced by factors other than airflow limitation. Putting this into perspective, the review also documented similar, mostly negative, results from the other interventions with regard to increasing daily activity by more than the minimal clinically important difference (MCID) of 600 to 1100 daily steps [35].

Another recent systematic review and meta-analysis of people with COPD evaluated both non-pharmacological and pharmacological interventions (compared to usual care) on physical activity [36]. Steps per day, daily walking time, and movement intensity were the most common outcomes assessed.

Interventions, which ranged from 3 to 48 weeks, included behavioural modification therapies (13 studies, 1535 patients), exercise training (eight studies, 737 patients), combining behavioural modification and exercise training (six studies, 659 patients), and the use of bronchodilators, either individually or in combination (four studies, 1159 patients). Exercise training alone did not significantly affect physical activity (+287 steps per day; p=0.30). Both behavioural modification and bronchodilators resulted in significantly increased steps per day, although the beneficial effect of the former was greater: 1035 *versus* 396 steps per day, respectively.

Summary

Given the complexity of factors contributing to morbidity in COPD, it is understandable that bronchodilator administration as the sole intervention to increase exercise capacity and physical activity may not be sufficient to achieve optimal outcomes in these areas [18]. Evidence is strong that long-acting inhaled bronchodilators increase exercise endurance time in patients with COPD, with dual bronchodilators being more effective than single agents. This effect is probably mediated by increases in airway calibre and reductions in hyperinflation. Although comparative studies are lacking, the gain in endurance time with bronchodilators is probably modest compared to that from exercise training. However, these two modalities of treatment are, of course, not mutually exclusive and can be used together. To date, other forms of pharmacotherapy have not proven effective in increasing exercise capacity in COPD. The relatively small effect of bronchodilators on physical activity likely reflects the fact that this outcome is complex, being influenced not just by lung function, but by other factors such as motivation, psychology, comorbid conditions and environment. The long-term effectiveness of these interventions is a fertile area for future investigations.

Pulmonary rehabilitation

Background

PR, recognised worldwide as a standard of care and core component of COPD management [37, 38], is defined as “a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behaviour change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence of health-enhancing behaviours” [39]. PR is implemented by an interdisciplinary team of healthcare providers that can include physicians, nurses, physical therapists, respiratory therapists and behavioural specialists. The PR model varies widely, depending on geographical setting, space, equipment and available staff [40]. Arguably, the greatest issue PR faces today is its underutilisation [41], especially in the period following hospital discharge for a COPD exacerbation, when substantially less than 2% of US Medicare patients received this treatment within 90 days [42].

The coronavirus disease 2019 (COVID-19) pandemic resulted in large-scale disruption to standard PR services and led to the temporary or even permanent closure of some PR programmes. This accelerated the development of remote, in-home PR sessions utilising available technology such as smartphones with internet connection. Now that the impact of the pandemic is subsiding, telemedicine may serve as a tool to augment PR delivery and application to a wider audience [41, 43].

Pulmonary rehabilitation to increase exercise capacity

As exercise training is a cornerstone of comprehensive PR, it is not surprising that there is strong evidence underpinning its positive effects across exercise outcomes, including both functional and maximal exercise capacity in COPD. Illustrating this, a 2015 Cochrane review [44] compared the effect of PR exercise training *versus* usual care across multiple outcomes, including exercise capacity. The review analysed data from 65 studies, with 2090 patients who had been randomised to some form of exercise rehabilitation for a minimum of 4 weeks, and 1732 randomised to usual care. Treatment ranged from 4 weeks (the reviewers' lower limit for inclusion in the study) to 1 year. The unidimensional definition the authors used for PR, “exercise training for at least 4 weeks with or without education and/or psychological support”, is at odds with the prevailing concept emphasising the comprehensive nature of the intervention [39, 41], but does give useful information on outcomes related to exercise training. In the 16 trials (n=779 individuals) utilising cycle ergometry as the exercise training modality, individuals with COPD had a significant, 6.8-W greater increase in maximal exercise capacity compared to those receiving usual care. For perspective, the MCID for this outcome is 4 W [45]. With respect to functional exercise capacity, these investigators included 38 trials (1879 individuals) utilising the 6-min walk distance and eight trials (694 individuals) utilising the incremental shuttle walk distance. For the 6-min walk test, the mean treatment effect was approximately 44 m, which exceeded a proposed 30-m MCID threshold [46]. Furthermore, the lower end of the 95% confidence interval of the treatment effect (33 m) also surpassed this threshold. For the incremental shuttle walk test, the mean treatment effect was ∼40 m, which was statistically significant but lower than a proposed MCID of 47.5 m [47].

Research by Porszasz *et al.* [48] provides some insight into factors underpinning this outcome in individuals with COPD. The study involved 24 patients with severe COPD, but without significant resting or exercise hypoxaemia, who underwent high-intensity exercise training three times a week for 7 weeks. By the end of the study, the group with high-intensity training had a mean±SD increase in constant work rate time of 11.6±8.1 min ($p<0.01$), which represented an almost 300% increase over baseline. Noted at iso-time during the constant work rate testing, respiratory rate decreased and inspiratory capacity increased. An increase in inspiratory capacity in this setting indicates less dynamic hyperinflation, an important finding since dynamic hyperinflation is a strong predictor of exercise capacity limitation in COPD [49]. An interpretation of these findings is that the physiological benefits of exercise training on the ambulatory muscles led to less ventilatory demand, resulting in a lower respiratory rate that allowed for greater emptying of the lung with each exhalation, less dynamic hyperinflation, less dyspnoea and, therefore, greater exercise tolerance.

While exercise training leads to increased exercise capacity in the short term, its long-term effectiveness is far less established, as evidenced by a 1995 controlled trial of 8 weeks of comprehensive PR (*versus* an education-only control intervention) in 119 outpatients with COPD [50]. Although short-term gains in exercise tolerance in the treatment group were observed, the treatment difference waned at 1 year and was lost by 2 years. Maintaining exercise capacity requires regular exercise and may decrease after the formal PR programme is over. One approach to this problem is to offer supervised maintenance exercise therapy to those finishing the formal programme. Unfortunately, this has not resulted in a substantial maintenance of exercise capacity, as indicated in a 2021 systematic review of 21 studies involving 1799 individuals with COPD and assessing multiple outcomes [51]. Supervision included in-person, remote, and combinations of the two. In the 10 studies (639 individuals) utilising the 6-min walk test to assess functional exercise capacity at 6–12 months, the treatment–control mean difference in the 6-min walk distance was 26 m, which is less than the 30-m MCID for this outcome [46]. Similarly, long-term treatment–control differences in the incremental and endurance shuttle walk tests did not meet their respective MCIDs. Thus, maintenance programmes to promote long-term benefits in exercise capacity have not had consistently positive results.

It is not clear whether other commonly utilised (and recommended) components of PR, such as didactic education, self-management training, psychological support and integration of care, add to positive exercise outcomes. A randomised controlled trial by Blackstock *et al.* [52] addresses this question to some extent. The investigators randomised 267 individuals with COPD to either exercise training alone or exercise training plus education (including self-management training) in an outpatient setting. Both groups were given similar exercise training twice weekly for 8 weeks. The primary outcome measures, COPD-specific quality of life and the 6-min walk distance, improved significantly in both groups at post-intervention, 6 and 12 months. However, there were no between-group differences in these outcomes at these time-points, leading the researchers to conclude that exercise training is the key component in effecting positive changes in functional capacity and health-related quality of life in individuals with COPD.

Pulmonary rehabilitation and physical activity

In a 1994 article, Leidy [53] places exercise capacity and physical activity within the broader context of functional status. In this conceptualisation, functional status is "a multidimensional concept characterising one's ability to provide for the necessities of life; that is, those activities people do in the normal course of their lives to meet basic needs, fulfil usual roles, and maintain their health and well-being". Functional status is subdivided into four components: 1) functional capacity, one's maximal potential; 2) functional performance, what one actually does; 3) functional reserve, the difference between capacity and actual performance; and 4) functional capacity utilisation, to what extent functional potential is utilised. This is depicted in figure 1.

Applying this schema to exercise capacity and physical activity in COPD, functional capacity ("can do") is similar to exercise capacity, both of which are limited by the extent of the respiratory disease, comorbid conditions, and untoward systemic effects [54–56]. This limitation to exercise capacity should be reduced by exercise training. Functional performance ("do do"), similar to physical activity, is what people actually do within the bounds of capacity limitation.

Only mild to moderate correlations have been observed between exercise capacity and functional performance (physical activity) in COPD, which underscores the importance of other factors that have an

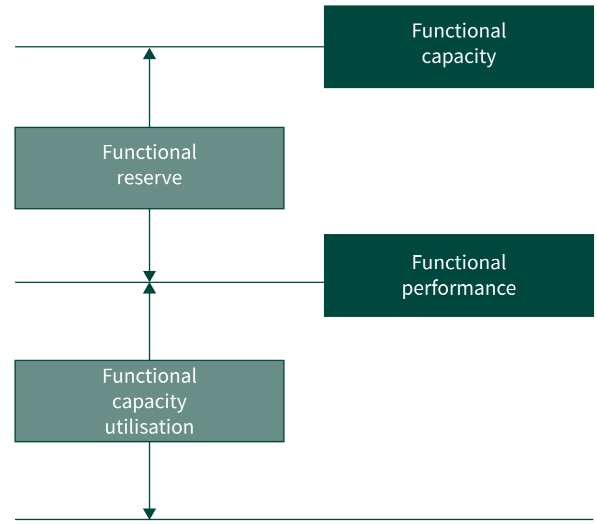

FIGURE 1 The Leidy model of functional status, consisting of capacity, performance, utilisation and reserve. Reproduced and modified from [53] with permission.

impact on this relationship [57]. Physical activity, viewed as a behaviour, can be influenced by multiple factors [58]. The COM-B model of behaviour [59] suggests that there are three key types of influence on behaviour: 1) capability (including physical and psychological capability), 2) opportunity (including physical and social opportunity), and 3) motivation (including reflexive and automatic motivation). Limitations in the latter two of these areas are not related to exercise capacity.

While questionnaire- or survey-assessed physical measures may be suitable for large epidemiological studies of physical activity [60], measurement using wearable activity monitors is now commonly used for clinical trials in COPD. In general, physical activity (expressed as either steps per day or minutes of at least moderate physical activity) is limited in those with COPD compared to healthy individuals [61] and even to smokers without demonstrable airway obstruction [62].

Compared to exercise capacity outcomes in PR, physical activity outcome data from wearable activity monitors are considerably less robust, as indicated in a 2015 review of PR's effect on physical activity in individuals with COPD [63]. In this review, investigators identified three studies with positive results [64–66], five with negative results [67–71] and three with mixed results [72–74]. This inconsistency may be attributable to heterogeneity in measurement devices, physical activity outcomes and study methodologies [34, 35]. This inconsistency led to recommendations by an international task force to standardise methods on measuring activity, which was published in 2021 [60]. These recommendations included: 1) amount of activity, typically as steps per day, with assignment to the categories "sedentary", "low active", "somewhat active", "active" and "very active"; 2) intensity, with assignment into "light", "moderate" and "vigorous" categories, or time spent in moderate or greater levels of physical activity intensity; and 3) estimates of daily energy expenditure.

Increasing physical activity in individuals with COPD participating in PR will require behaviour change resulting from collaborative self-management interventions [75–77]. While self-management strategies directed at positive behaviour change are major components of comprehensive PR, these will be discussed in the next main section of this article, entitled "Behavioural interventions".

Summary

The comprehensive nature of PR positions it as a potentially useful approach towards increasing exercise capacity and physical activity. The effectiveness of its exercise training component on exercise capacity is now so established that further research comparing it to usual care is no longer warranted [44]. The effect of PR on physical activity is less established. Increased exercise capacity can be considered permissive of physical activity, but the latter is undoubtedly influenced by other factors. Collaborative self-management that includes pedometer feedback holds promise in increasing physical activity in the COPD patient.

Behavioural interventions

Background

Behaviours can be defined as physical events that occur in the body and are controlled by the brain [78]. As mentioned, the COM-B model of Michie *et al*. [79] outlines three key types of influence on behaviour: capability, opportunity and motivation. Behavioural interventions typically comprise a collection of behavioural change techniques aimed at addressing the key influences on the target behaviour. With respect to increasing exercise capacity and physical activity in individuals with COPD, the most common types of behavioural interventions are: 1) facilitated opportunities to participate in physical activity and exercise (*e.g*. PR or walking programmes), 2) using feedback from pedometers and other wearable activity monitors, and 3) coaching or counselling to promote physical activity and regular exercise (*e.g*. motivational interviewing or goal setting) [80–82]. Although each type involves multiple behaviour change techniques, including some areas of overlap, these broad groupings each have a slightly different emphasis.

Facilitated opportunities for promoting exercise and physical activity

PR is the most established intervention for increasing exercise capacity in people with COPD [44]. It is often hoped that the structured and supervised environment of PR will also provide a platform to facilitate increases in physical activity. However, despite its effectiveness in increasing exercise capacity, PR consistently shows a lack of effects on long-term physical activity [63]. The distinction between exercise capacity and physical activity outcomes in COPD is underscored by a study by Wootton *et al*. [83], who found that, while their walking intervention increased exercise capacity, it had no effect on physical activity or sedentary time. This may be because, while increasing exercise capacity can support higher levels of physical activity (addressing "capability"), additional interventions may be needed to focus on barriers relating to "opportunity" (*e.g*. unfavourable environments for walking) and "motivation" (*e.g*. fears of becoming breathless).

Using feedback from pedometers and other wearable activity monitors to increase physical activity

Feedback from wearable devices that measure activity, such as pedometers or accelerometers, can support individuals with COPD to set goals, make plans, and self-monitor daily steps, time and intensity of exercise [63, 83–85]. A recent meta-analysis of 15 randomised controlled trials involving 1316 individuals and with study durations ranging 1–12 months found that individuals with COPD who wore wearable activity monitors had more meaningful improvement in daily step counts compared with those who used other technology-based interventions (*e.g*. smartphone applications and/or website resources alone) [86].

A systematic review and meta-analysis evaluating physical activity feedback from pedometers to increase activity in COPD identified 19 randomised clinical trials that included 1677 individuals [87]. 12 studies were of standalone programmes employing pedometer feedback, and seven were of PR programmes comparing pedometer feedback to no feedback. Across the studies, the mean age was 66 years, average FEV_1 ranged from 43% to 78% predicted, and individuals were relatively inactive with a mean of 4365 steps per day. Duration of the interventions ranged from 1 to 12 months. Feedback (compared to no feedback) led to an increase of ∼1000 steps per day, a magnitude that falls within the suggested MCID range of 600–1100 steps per day [35]. This indicates that feedback from pedometers as part of a collaborative self-management strategy can result in clinically meaningful increases in physical activity, at least in the short term. Moreover, feedback with the standalone approach and alongside PR were about equally effective. Since PR participation is limited by poor uptake across many medical systems, the standalone approach may be applicable to a wider audience, perhaps augmented by newer technologies.

Coaching and counselling around physical activity

Coaching and counselling approaches typically involve the clinician and individual with COPD working together to promote behaviour change through in-depth discussion. A common technique in this context is motivational interviewing: a collaborative and person-centred approach where individuals are supported to identify their own values and motivations for change, rather than have change imposed on them by others. A systematic review and meta-analysis of 21 trials (2344 individuals) of motivational interviewing interventions in COPD found that this approach led to improvements in self-efficacy and quality of life, but not in exercise capacity, and no findings were reported for physical activity [88]. This evidence base is challenging to disentangle, as nine of the 21 trials incorporated other components alongside motivational interviewing, making its direct contributions unclear. Examples of other studies that mainly focused on coaching and counselling approaches (without other behaviour change techniques) had mixed impacts on physical activity [89, 90] and little effect on exercise capacity [90–92].

These inconsistent results may reflect, in part, the confounding influence of psychological factors such as self-efficacy. In a randomised trial of 49 individuals with COPD, Larson *et al*. [93] found that a self-efficacy-enhancing approach (incorporating feedback, graphic progress, videos of others benefitting from exercise, and verbal and social persuasion) was more effective in increasing light physical activity at 4 months than a health education approach. In a randomised trial of two physical activity promotion approaches in 112 US veterans with COPD, Robinson *et al*. [94] found that their pedometer-based intervention was effective only in those with high baseline self-efficacy. In contrast, combining this intervention with access to a self-efficacy-enhancing website was effective regardless of baseline self-efficacy. As such, promoting self-efficacy can enhance the effects of coaching and counselling, especially for those with low baseline self-efficacy.

Maximising impact through combined interventions

Activity feedback plus counselling or coaching appear to be effective in promoting both exercise and physical activity in COPD [95–98]. In a multi-component, 12-week semi-automated telecoaching intervention including 343 participants, Demeyer *et al*. [98] demonstrated significant improvements in physical activity. The most utilised component of this intervention was the step counter. In another study, participants highly valued the interactions with the coach [99]. Finally, Mendoza *et al*. [100] found that including a pedometer added value to a programme using counselling and an activity diary, in terms of improvements in both physical activity and exercise capacity. These findings are consistent within PR, where combining self-monitoring (*e.g*. pedometer or activity diary) and motivational approaches (*e.g*. health contract or motivational interviewing) alongside usual PR led to greater improvements in physical activity, while retaining similar effects on exercise capacity [84, 85], immediately after PR [84] and at 3 months but not at 6 months [85].

Future directions for long-term change

While combined interventions currently show the most consistent benefits in exercise capacity and physical activity, there are still challenges relating to engagement with interventions, sustained behaviour change, and our understanding of which interventions are mainly responsible for these benefits. Patient non-engagement is important, as an urban training approach to increase physical activity was only effective in those who adhered to the intervention guidance [101]. Therefore, approaches aimed at optimising intervention engagement and incentivising use may be helpful. Such approaches may also help with longer-term behaviour change, as drop-off in effects beyond the most interactive period of the intervention are common [85, 93, 102]. As work in this area progresses, streamlining interventions to include the most effective components and/or personalising content to match individuals' key barriers to behaviour change may be beneficial. Engagement with frameworks such as the behaviour change wheel [79] to specify target behaviours and select appropriate intervention functions and behaviour change techniques may also strengthen this work.

Summary

Examples of behavioural interventions that may be used to increase exercise capacity and physical activity in individuals with COPD include structured programmes, self-monitoring approaches that may incorporate feedback to the individual, and coaching or counselling. The structured and supervised aspects of comprehensive PR result in significant increases in exercise capacity; however, long-term improvements in physical activity are not consistently demonstrated with this treatment. Individuals with COPD using activity monitors for feedback have shown increases in daily step counts and more meaningful improvement in this area than those using other technology-based interventions. Coaching, commonly utilising motivational interviewing approaches, leads to increases in self-efficacy but not exercise capacity, and effectiveness in relation to physical activity is yet to be established. Combining interventions, such as activity feedback from a pedometer and counselling, may yield more substantial results than from either component alone.

Web-based interventions

Background

Rapidly developing technology has provided the opportunity for emerging web-based/telehealth models of care to support increasing exercise capacity and physical activity in people with COPD. Telerehabilitation is broadly defined as using information and communication technologies to provide clinical rehabilitation services from a distance [103], typically involving interactions between the patient and healthcare providers. Examples of these technologies include teleconsultation (for PR, this might include initial assessment and goal setting), remote education and self-management sessions (including transmission of disease management information), and telemonitoring (including remote monitoring of exercise at home) [104]. For individuals with COPD, the effectiveness of PR to improve dyspnoea, quality of life and exercise tolerance has been well established [44]; however, access and capacity of PR programming remains a major issue worldwide. Web-based/telehealth programmes may increase PR capacity through reducing barriers to participation.

Studies involving web-based interventions

A recent systematic review of 15 studies with a total of 1904 individuals examined the effectiveness of telerehabilitation for people with chronic respiratory disease (most had COPD) [105]. Requirements for this review were: 1) the telerehabilitation intervention must have included exercise training, and 2) at least 50% of the rehabilitation intervention had to be delivered by telerehabilitation. Five different forms of telerehabilitation were utilised. The review showed similar improvements in the 6-min walk distance compared to in-person rehabilitation, with patients more likely to complete the telerehabilitation programme compared to traditional PR. The authors, however, noted that the certainty of the evidence was limited because of the varying telerehabilitation models used. This review included studies from 2008–2020, reflecting considerable technological advances that occurred over that period, including the development of user-friendly videoconferencing systems such as Zoom.

Since this initial review, a few other relevant studies have been published, such as a randomised controlled trial of exercise training using a cycle ergometer, with some patients randomised to centre-based PR with a physical therapist and other participants at home using an internet link *via* a tablet computer and Zoom. The investigators demonstrated equivalent improvement in 6-min walk distance with telerehabilitation compared to traditional in-centre PR [106]. A recent cohort study during the COVID-19 pandemic demonstrated that a PR programme with whole-body group exercise sessions and delivered exclusively *via* Zoom showed similar improvements in sit-to-stand repetitions over 30 s and in 6-min walk distance, compared to in-person PR [107]. Importantly, neither the systematic review nor these more recent trials reported adverse events above what was observed with in-person PR, suggesting these telerehabilitation/virtual approaches are likely to be safe in individuals with COPD.

Outside of PR, various technological tools/web-based interventions have been used to help support individuals with COPD with exercise and remote clinical monitoring. These technologies have the potential to help control rising healthcare costs, improve efficiency of care, and address staffing challenges that may be present in PR. Two recent systematic reviews examined the effectiveness of remote home monitoring devices (smartphones, apps and tablets) on outcomes that included exercise capacity and physical activity [108, 109]. The lengths of the monitoring periods in these two reviews ranged from 1 to 12 months. While the body of evidence to date is generally small and of low quality [108, 109], there is some evidence suggesting the use of these devices may facilitate improvements in these two outcome areas. For example, use of a smartphone-type self-management app resulted in an increase in the 6-min walk distance from baseline, but the degree of improvement was similar to that observed in the control group not using the smartphone [110]. Of note, physical activity, including moderate-to-vigorous physical activity, was increased in the smartphone arm compared to controls [110]. In a separate trial involving individuals with COPD using telemonitoring over 9 months, individuals increased their 6-min walk distance compared to those without this intervention [111]. When telemonitoring *via* motivational phone calls was used to support an unsupervised home exercise programme, the telemonitoring was associated with greater daily exercise time compared to exercise without monitoring [112]. Initial findings from these small studies suggest that technological tools/web-based interventions have the potential to increase physical activity and exercise capacity, but this needs to be confirmed in larger higher-quality trials [108, 109].

Implications for using web-based interventions in pulmonary rehabilitation

The recent American Thoracic Society clinical practice guideline for PR strongly recommended that adults with stable chronic respiratory disease be offered the choice of either centre-based or telerehabilitation PR (moderate quality evidence) [41]. Whilst the data are encouraging, a few important considerations remain with respect to web-based/telehealth approaches focusing on increasing exercise capacity and physical activity. The aforementioned systematic review on telerehabilitation [105] comprised a relatively small number of trials differing considerably in their approaches, thereby compromising comparisons and overall conclusions. Two of the larger studies, interventions lasting 8 and 10 weeks, respectively [106, 113], were designed as comparisons between conventional centre-based rehabilitation and a real-time videoconferencing rehabilitation programme. These two studies reported similar outcomes in the 6-min walk distance in both arms; however, the values reported were less than the agreed MCID [46]. Furthermore, recruitment to "digitally based" rehabilitation programmes can be challenging. In one study, <5% of seemingly eligible candidates consented to participate [41]. The low recruitment rate creates challenges for widespread implementation. However, as digital awareness improves in the population, incorporating technological advances into healthcare should improve access and reduce health inequalities.

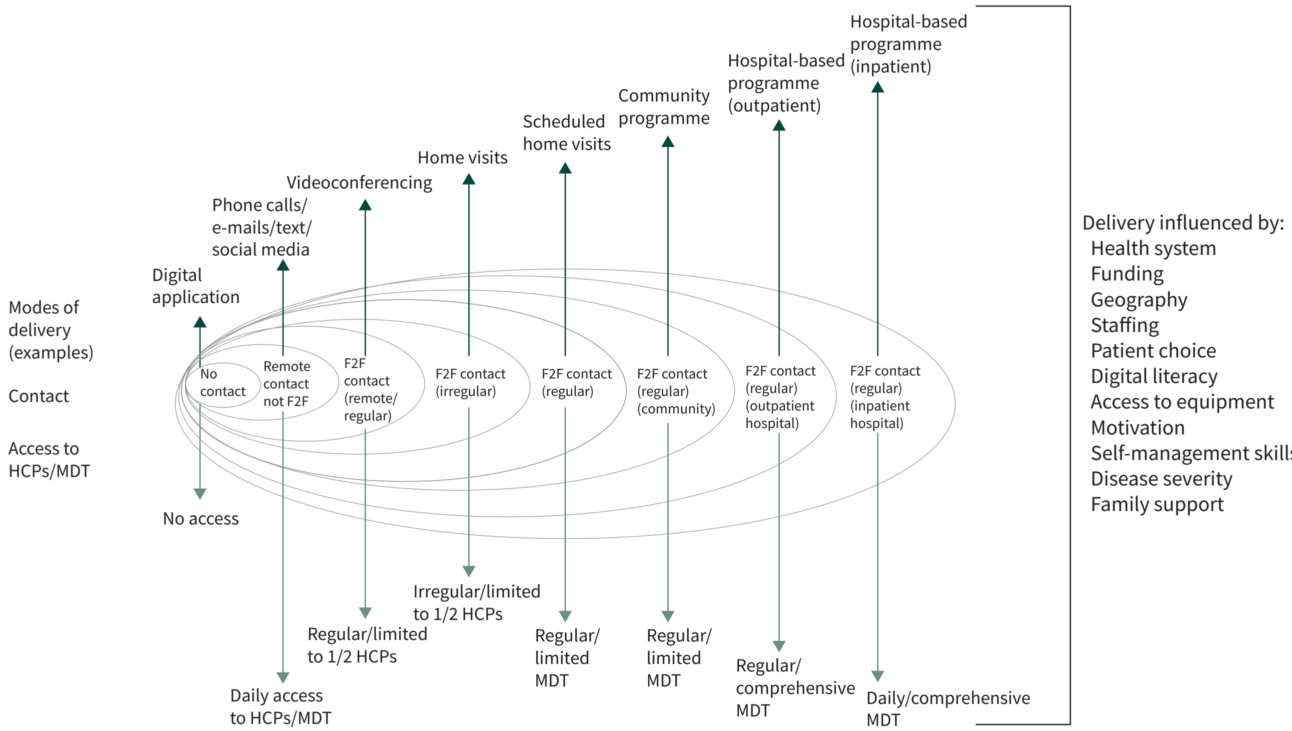

FIGURE 2 A proposed taxonomy of interventions and consideration of what might influence their delivery. HCP: healthcare professional; MDT: multidisciplinary team; F2F: face-to-face. Adapted from [115].

Summary

Emerging data from web-based interventions to increase exercise capacity and physical activity (as well as other patient-centred outcomes) suggest that this type of intervention holds promise, both as a standalone treatment or as an adjunct to PR. Given the heterogeneity of approaches tested so far and potentially low acceptability [114], it is important to consider how we match the choice of rehabilitation intervention to the users' needs and system factors (figure 2). Considerations might include disease severity, digital competence, access to the necessary equipment (*e.g.* smartphone or personal computer), family support, ability to self-manage, and (most important) patient choice.

Conclusions

Physical activity and exercise are interrelated yet distinct concepts, with exercise being a subset of physical activity performed with a goal in mind, such as physical fitness or competing in a sport. This narrative review discussed four approaches to enhancing outcomes in individuals with COPD in these two outcome areas: 1) pharmacological interventions, especially bronchodilators, alone or in combination; 2) PR; 3) behavioural interventions; and 4) web-based interventions. Categorisation into these four interventions is arbitrary as there is considerable overlap among them. Achieving optimal outcomes in the COPD patient may require several of these approaches. Data supporting combining these treatment areas are still a work in progress, but, as discussed, there is some support that combining behavioural or web-based interventions with PR may add further benefit, especially in physical activity promotion.

Key points

- Evidence is strong that both long-acting bronchodilator therapy and PR increase exercise capacity in individuals with COPD, although indirect evidence suggests that the magnitude of gain is greater with rehabilitation.
- The relatively small effect of bronchodilators and PR on physical activity likely reflects the complex and multiple factors that influence this behaviour.
- Collaborative self-management strategies, including regular feedback from physical activity monitors, are a promising approach to increase physical activity; this can be part of PR or a standalone approach.
- Emerging evidence suggests that telerehabilitation may be as safe and effective as traditional, centre-based programmes in improving some measures of exercise capacity.
- While evidence is limited, web-based interventions outside of PR have the potential to increase exercise capacity and physical activity in individuals with COPD.

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