

1 **Abstract**

2 It is well acknowledged that levels of physical activity in patients with COPD are
3 considerably lower than healthy-age matched individuals, with physical inactivity recognised
4 as a key predictor of hospitalisation and mortality. Pulmonary rehabilitation has become a
5 major tool for managing symptoms of COPD and the associated extra-pulmonary effects.
6 However, inconsistencies surrounding its effectiveness in terms of improving physical activity
7 remain due to the complex nature of physical activity. To overcome these inconsistencies, both
8 pharmacological and behavioural interventions have been documented to aid improvements in
9 physical activity, with the benefits of behavioural interventions alongside PR found to be the
10 most effective tool to promote levels of physical activity. Healthcare professionals must
11 therefore look to incorporate an interdisciplinary approach in order to best achieve
12 improvements in physical activity levels in patients with COPD.

13

14 **Introduction**

15 Chronic Obstructive Pulmonary Disease (COPD) is a highly prevalent respiratory
16 disease that is characterised by persistent respiratory symptoms and airflow limitation,
17 primarily affecting individuals with a history of exposure to cigarette smoke and/or other
18 noxious particles and gases (GOLD, 2020). The most common respiratory symptoms include
19 dyspnea (breathlessness), cough and/or sputum production (GOLD, 2020). In addition to
20 progressive chronic airflow limitation and the associated levels of dyspnea, many patients also
21 suffer extra-pulmonary effects, including skeletal muscle dysfunction/wasting and weight loss,
22 leading to reductions in functional capacity and physical activity (Watz et al., 2014). Although
23 regular physical activity is recommended by the European Respiratory Society (ERS)
24 statement on physical activity, it remains well acknowledged that levels of activity are
25 significantly lower in patients with COPD compared to healthy age-matched individuals

1 (Troosters et al., 2010; Watz et al., 2014). Furthermore, physical activity levels have been
2 recognised as a key predictor of mortality and hospitalisation in patients with COPD, making
3 physical inactivity a key risk factor that healthcare professionals must consider when
4 prescribing management goals to patients with COPD (Garcia-Aymerich, Lange, Benet,
5 Schnohr, & Antó, 2006).

6

7 **The mechanisms associated with physical inactivity**

8 The fundamental mechanisms of physical inactivity in COPD are poorly understood,
9 with a number of published theories available (Barnes & Celli, 2009; Troosters et al., 2013).
10 One widely accepted theory known as “the vicious cycle of physical inactivity model” was
11 developed by (Troosters et al., 2013). Based on this theory, symptoms of dyspnea and leg
12 discomfort, that are associated with physical inactivity, are a result of skeletal muscle wasting
13 and airway remodelling that limit airflow and increase the requirements of ventilation. A
14 greater prevalence of these symptoms makes conducting activities of daily living an unpleasant
15 experience, creating fear of performing such activities. The associated fear factor naturally
16 inclines those individuals to become more sedentary and depressed. The subsequent inactive
17 lifestyle advances a decline in the ability to conduct activities of daily living and may further
18 reduce cardiovascular functions and skeletal muscle deconditioning as well as deteriorating
19 peoples physical state and increasing the frequency of breathlessness. Thus, patients are forced
20 into a more sedentary lifestyle, creating a vicious cycle of inactivity and worsening symptoms
21 (Troosters et al., 2013).

22

23 **COPD symptoms and physical inactivity**

24 There is a consistent association between levels of physical activity and the clinical and
25 functional determinants of COPD, with symptoms of dyspnea and leg discomfort found to have

1 a significant negative impact on an individual's ability to conduct activities of daily living
2 (Spruit, Pitta, McAuley, ZuWallack, & Nici, 2015). Specifically, physical activity and the
3 extent of dyspnea have been well linked in COPD patients, with a worsening experience of
4 breathlessness while performing activities of daily living a major indicator for avoiding overall
5 activity (Watz et al., 2014). Qualitative data reported that subjective dyspnea displayed a strong
6 correlation with daily life activities, assessed via a questionnaire ($r = -0.37, P < 0.01$) (Katajisto
7 et al., 2012). Similar results were reported in two quantitative studies using accelerometer
8 derived physical activity, with significant associations between Medical Research Council
9 (MRC) dyspnea scores and physical activity levels (Waschki et al., 2012; Watz et al., 2009).
10 Subjectively measured leg discomfort, measured through the 'Multidimensional Fatigue
11 Inventory', was associated with reduced levels of physical activity. (Wong, Goodridge,
12 Marciniuk, & Rennie, 2010). Meanwhile, patients who reported spending less time outdoors
13 were associated with greater levels of leg discomfort during activities of daily living in a
14 separate study from Baghai-Ravary et al. (2009). With these findings in mind, it is well
15 recognised that providing improvements in levels of physical activity can significantly benefit
16 symptoms associated with COPD.

17

18 **Pulmonary rehabilitation**

19 Pulmonary rehabilitation (PR) has become a major tool for managing symptoms of
20 COPD and the associated extra-pulmonary effects. This multidisciplinary program consists of
21 supervised exercise training, self-management education that is relevant to the needs and
22 requirements of the individual patient, nutritional counselling, as well as psychological and
23 social support from a range of practice nurses and healthcare professionals (Bolton et al., 2013;
24 Spruit et al., 2013). The primary objectives of PR are to reduce symptoms of dyspnea and leg
25 discomfort and improve levels of functional capacity and health related quality of life (Bolton

1 et al., 2013; GOLD, 2020; Spruit et al., 2013). To achieve these objectives, PR covers a scope
2 of non-respiratory problems including; muscle deconditioning and cardiovascular limitations,
3 anxiety and depression, social isolation and malnutrition (Bolton et al., 2013; Spruit et al.,
4 2013). Based on these objectives, it has been extensively documented that PR is effective in
5 reducing symptoms of dyspnea and leg discomfort as well as improving exercise capacity and
6 health related quality of life (Egan et al., 2012; Ries et al., 2007; Verrill, Barton, Beasley, &
7 Lippard, 2005). Moreover, it is commonly reported that PR emphasises behaviour change
8 through collaborative self-management and education, which alongside increased exercise
9 capacity, may translate into improvements in physical activity levels (Spruit et al., 2015).
10 Despite this rationale, studies have shown inconsistent findings surrounding the benefits of
11 physical activity after PR, even though concomitant improvements in exercise capacity and
12 health related quality of life have been reported (Egan et al., 2012; Mador, Patel, & Nadler,
13 2011; Pitta et al., 2008). This disparity highlights the fact it remains unknown how to
14 effectively translate gains in exercise capacity, that PR commonly provides, into enhanced
15 levels of physical activity. One of the primary reasons for this mismatch is associated with
16 physical activity being a complex health behaviour, with determinants of physical activity
17 influenced by personal, interpersonal, environmental and global factors (Bauman et al., 2012).
18 Furthermore, although physical activity is now listed as one of the primary outcome measures
19 of PR, many healthcare professionals fail to identify physical activity as a key outcome
20 measure of PR, limiting the analysis of physical activity throughout PR programmes (Spruit et
21 al., 2015). In order to address the complex nature of physical inactivity in patients with COPD,
22 practice nurses, healthcare professionals and researchers must look towards additional
23 interventions that may promote a more physically active lifestyle.

24

25 **Alternative approaches to improve physical activity:**

1 *Behaviour change modification*

2 An understanding of the behavioural factors related to both participation and the long-
3 term adherence to physical activity in patients with COPD has become more common, leading
4 researchers and healthcare professionals to develop numerous exercise and behavioural
5 modification tools that target both the physical and behavioural aspects of physical activity
6 (Bauman et al., 2012; Mantoani, Rubio, McKinstry, MacNee, & Rabinovich, 2016). In order
7 to produce effective behavioural tools, a number of key components are required including;
8 goal setting, action plan development, support with problem solving, relapse prevention, self-
9 motivation and self-esteem. In addition, motivational interviewing has been documented as an
10 effective strategy to collaborate and communicate with patients surrounding their challenges
11 towards behaviour change (Greaves et al., 2011).

12 The effectiveness of behavioural modification tools through the implementation of physical
13 activity coaching/counselling on levels of physical activity in COPD have been reported by
14 numerous randomised controlled trials, with the implementation of goal setting and pedometer
15 feedback documenting a significant improvement in steps per day, greater than the minimal
16 important difference of 600 steps per day (Armstrong et al., 2019; Demeyer et al., 2016).
17 Incorporating physical activity coaching/counselling into a patient's treatment plan provides a
18 healthcare professional with the ability to assess a patient's physical activity and provide
19 structured feedback, as well as develop individualised activity goals that can be supported by
20 motivational interviewing, to best cover all aspects of this complex behaviour (Armstrong et
21 al., 2019). Patients are able to use these skills to understand successes and failures surrounding
22 their activity levels, in order to develop behavioural traits towards achieving future activity
23 goals (Mantoani et al., 2016). The implementation of physical activity coaching/counselling
24 alongside PR has gained increased knowledge over the last few years. Specifically, the pooled
25 analysis of randomised controlled trial's implementing goal setting and pedometer feedback

1 alongside exercise training as part of comprehensive PR provided improvements in steps per
2 day greater than both exercise training alone and physical activity coaching/counselling alone
3 (Armstrong et al., 2019; Lahham, McDonald, & Holland, 2016).

4 Tele-coaching is another widely accepted physical activity coaching tool, with a 12 week
5 programme of semi-automated tele coaching found to be well accepted and feasible in patients
6 with COPD (Loeckx et al., 2018). In addition, improvements in steps per day have been
7 reported by (Demeyer et al., 2017) following a 12-week semiautomated tele coaching
8 programme, with the addition of improvements in walking time and movement intensity.

9 - *Pharmacotherapy*

10 Pharmacological therapies are prescribed to reduce symptoms of COPD and reduce the
11 frequency and severity of exacerbations, influencing the functional capacity and health status
12 of individual patients (GOLD, 2020). Bronchodilator therapy is a well-known treatment to
13 improve dynamic hyperinflation, with studies clearly demonstrating improvements in patients
14 experiences of breathlessness and health status during rest and exertional activity. Interestingly,
15 a number of studies have demonstrated the impact of bronchodilator therapy on levels of
16 physical activity (Kesten, Casaburi, Kukafka, & Cooper, 2008; O'Donnell et al., 2011;
17 Troosters et al., 2014). Of those studies, a randomised controlled trial from Kesten et al. (2008)
18 specified improvements in physical activity after the delivery of bronchodilators, albeit
19 physical activity was assessed using self-reported questionnaires. Meanwhile, two further
20 randomised controlled trials were unable to demonstrate any effects of long-acting
21 bronchodilator therapy on physical activity levels (O'Donnell et al., 2011; Troosters et al.,
22 2014).

23 - *Oxygen therapy*

24 Knowledge surrounding the influence of ambulatory oxygen therapy as a treatment tool
25 for physical activity is limited, with the bulk of literature surrounding improvements in exercise

1 tolerance in hypoxemic patients (Bradley, Lasserson, Elborn, MacMahon, & O'Neill, 2007). In
2 a small number of randomised controlled trial's that have assessed physical activity, long-term
3 oxygen therapy was in fact independently associated with lower levels of physical activity
4 (Casaburi et al., 2012; Garcia-Aymerich et al., 2004).

5

6 **Barriers to the implementation of such interventions:**

7 As discussed in this clinical article, the ability of PR to improve levels of physical activity
8 remain inconclusive, with heterogeneous effects across studies. To ensure patients make
9 significant improvements in physical activity moving forward, longer durations of PR,
10 pharmacological therapies' and the inclusion of targeted behavioural interventions to PR may
11 be needed, however, barriers towards their effectiveness should be noted.

12 In targeted behavioural interventions, specifically physical activity coaching/counselling, the
13 existence of heterogeneity, predominantly due to methodological variables (types of goal
14 setting, feedback provided and length of intervention) and patient demographics (severity and
15 baseline levels of physical activity), have caused a barrier towards its effectiveness (Armstrong
16 et al., 2019; Qiu et al., 2018). To uncover these barriers, a recently published meta-analysis
17 from our research group uncovered the specific aspects of physical activity
18 coaching/counselling in order to outline the optimal way to deliver this intervention
19 (Armstrong et al., 2019). It was found that regardless of the way physical activity
20 coaching/counselling was implemented, improvements in steps per day were greater than the
21 documented minimal important difference (Demeyer et al., 2016). However, it was noticed that
22 interventions of this nature were more effective in patients with greater baseline physical
23 activity levels (>4000 steps/day) (Armstrong et al., 2019). This theory was previously proposed
24 by which patients with COPD exhibiting greater exercise capacity prior to PR were more likely
25 to achieve greater improvements in physical activity levels after an intervention of physical

1 activity coaching (Osadnik et al., 2018). Such theories portray that for patients with very low
2 baseline physical activity levels, the most effective intervention to improve physical activity
3 levels may involve a combination of PR and physical activity coaching/counselling. A
4 combined intervention of this nature can provide patients with the ability to build both muscular
5 strength/endurance and cardiovascular fitness as well as implement behaviour change
6 strategies that can assist the complex pathway between improved levels of functional capacity
7 and physical activity. Moreover, therapies such as Cognitive Behavioural Therapy (CBT) that
8 have been found to be effective in reducing high levels of anxiety and depression (Heslop-
9 Marshall et al., 2018), may provide an additional tool towards combatting physical inactivity
10 in more severe patients.

11 Consequently, in line with the findings of our research team, those patients with worsened
12 disease state may require an interdisciplinary approach, that incorporates aspects of exercise
13 training, pharmacological therapies and behavioural interventions to best manage symptoms
14 and improve levels of physical activity.

15 Finally, the implementation of semi-automated tele coaching as a tool to promote physical
16 activity has provided promising findings, however it remains difficult to fully implement due
17 to the dependency of technology, with many COPD patients unable to afford such technologies.
18 It is envisaged that this intervention will become more clinically and cost effective in the
19 broader healthcare system alongside smartphones in the future (Loeckx et al., 2018).

20

21 **Conclusion**

22 Improving levels of physical activity in patients with COPD has become increasingly important
23 due to the relationship between physical inactivity and greater risk of hospitalisation and
24 mortality. PR remains the most effective tool to modify symptoms of COPD and the associated
25 extra-pulmonary effects, however its ability to influence physical activity remains
26 inconclusive. Well known pharmacological therapies have documented improvements in

1 physical activity, however it is the use of physical activity coaching/counselling that has
2 provided the most effective improvements in physical activity in patients with COPD.
3 Therefore, the ability to modify physical activity behaviour in COPD patients' needs to involve
4 an interdisciplinary approach, bringing together pulmonary rehabilitation, behavioural
5 modification and pharmacological therapies.

6

7 **Recommended strategies to promote physical activity in the clinical setting:**

- 8 ▪ Health care professionals should talk to patients about the option of buying cheap
9 pedometers or using mobile phone apps to record and track steps per day.
- 10 ▪ Health care professionals may incorporate physical activity diaries into home-based
11 patient care, whether that involves reporting daily step counts or simply reporting time
12 spent conducting physical activity.
- 13 ▪ Provide weekly goal setting to patients who exercise the use of a pedometer or mobile
14 app for tracking steps per day. This can be implemented in person during PR sessions
15 or over the telephone as a remote tool.
- 16 ▪ Employ motivational interviewing to discover patients' barriers and enablers towards
17 promoting greater levels of physical activity. This tool will allow healthcare
18 professionals to understand patients favourite activities and plan goals around those
19 activities.

20

21 **Key points to take home:**

- 22 ▪ Levels of physical activity are significantly lower in patients with COPD compared to
23 age-matched healthy individuals.
- 24 ▪ Increased physical inactivity is associated with worsening COPD symptoms, greater
25 hospital admissions and mortality rates.
- 26 ▪ Pulmonary rehabilitation remains the most effective tool to modify symptoms of
27 COPD, however its ability to modify symptoms of physical activity remains
28 inconclusive.
- 29 ▪ Both pharmacological and behavioural interventions have been documented to improve
30 levels of physical activity.

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