Self-efficacy in Patients with Chronic Obstructive Pulmonary Disease

by

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Abstract

Self-efficacy, defined as behaviour specific confidence, is a consistent correlate of physical activity and other health behaviours. In people with Chronic Obstructive Pulmonary Disease (COPD), self-efficacy has been found to be related to key clinical-health outcomes and is deemed an important contributor to disease self-management. The purpose of this dissertation was to (i) contribute to the understanding of how pulmonary rehabilitation (PR) and vicarious experiences (i.e., observing someone) impact self-efficacy types among patients with COPD, and (ii) examine the relationships of several different types of self-efficacy (i.e., task self-efficacy for exercise, coping self-efficacy for exercise, scheduling self-efficacy for exercise, coping self-efficacy for breathlessness, and walking self-efficacy) to clinical-health and behavioural outcomes: functional exercise capacity, health status, and physical activity. In study 1 (Chapter 2), self-efficacy increased as much or more with PR in COPD patients recently hospitalized for an acute exacerbation of COPD (AECOPD) compared to COPD patients without a recent AECOPD (stable COPD). Among the AECOPD patients, PR delivered within one month or between three and four months after an AECOPD did not impact the amount of improvement in self-efficacy observed. Study 1 also found that among both AECOPD and stable patients self-efficacy for walking was a superior predictor of all clinical-health and behavioural outcomes than self-efficacy for managing breathlessness. Additionally, the association between self-efficacy and physical activity was stronger among stable COPD patients compared to AECOPD patients at both pre- and post-PR. In Chapter 3, a two-part pilot study examined salient exercise-model characteristics to COPD patients and examined patient experiences with cardiopulmonary exercise tests (CPET). The results of this study informed the creation of the intervention evaluated in study 3 (Chapter 4), which examined the effects of coping and mastery model interventions on self-efficacy for walking and exercise (i.e., task self-efficacy for exercise, coping self-efficacy for exercise, scheduling self-efficacy for exercise, coping self-efficacy for breathlessness) in patients with COPD within the context of a CPET. Both the coping and mastery intervention conditions were found to enhance all types of self-efficacy, with the coping condition more strongly enhancing coping self-efficacy for exercise than the mastery condition. Coping self-efficacy for exercise was also the type of self-efficacy that was most strongly related to physical activity in patients with COPD the week following contact. The findings of this dissertation support the delivery of PR in both AECOPD and stable COPD patients and suggest that AECOPD and stable COPD patients may have different salient challenges/needs in PR which should be addressed accordingly. This dissertation highlights the role of self-efficacy within PR environments and provides insight into intervention content that may improve clinical-health and behavioural outcomes among people with COPD.

Preface

This thesis is an original work by Anne-Marie Selzler. The research projects, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board and Covenant Health Research Ethics Board. The following ethics approvals are associated with the research conducted in this thesis: from chapter 2, "Examining Pulmonary and Cardiovascular Outcomes in Inpatients with Chronic Obstructive Pulmonary Disease", Pro00038838, May 7, 2013; from chapter 3, "Exercise Experiences and Comparisons among People with Chronic Lung Diseases", No. Pro00049767, May 11, 1015; and from chapter 4, "The COMMIT Trial in COPD Patients", No. Pro00066645, September 7, 2016.

Some of the research conducted for this thesis forms part of a larger research study led by Dr. M.K. Stickland at the University of Alberta. I was responsible for all data analysis in this thesis, all data collection in chapters 3 and 4, and the literature review in chapter 1. In Chapter 2 I performed data collection with assistance from Dr. M.K. Stickland's research team. The videos used in chapter 4 were created with the assistance of M. Zaplotinsky.

No part of this thesis has been previously published, although part of the data presented in chapter 4 is under review as A.-M. Selzler, W.M. Rodgers, T.R. Berry, and M.K. Stickland, "Coping versus Mastery Modeling Interventions to Enhance Self-efficacy for Exercise in Patients with COPD," at *Behavioral Medicine*. I was responsible for the concept formation, data collection and analysis, as well as manuscript composition. W.M. Rodgers, T.R. Berry, and M.K. Stickland assisted with concept formation and manuscript edits. W.M. Rodgers was the supervisory author.

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Glossary of Self-efficacy Terms

Self-efficacy – belief in one's capability to organize and execute the courses of action to produce a given attainment.

Self-efficacy type – the behavioural target of the self-efficacy. For example, *exercise* self-efficacy is a self-efficacy type.

Self-efficacy sub-type – a skill subset of the self-efficacy type. For example, *task* self-efficacy, *coping* self-efficacy, and *scheduling* self-efficacy are sub-types of exercise self-efficacy.

Chapter 1 – Introduction

Review of the Literature

Overview of Chronic Obstructive Pulmonary Disease

Chronic Obstructive Pulmonary Disease (COPD) is a respiratory disorder predominantly caused by smoking that is characterized by progressive, partially reversible airflow obstruction and lung hyperinflation (O'Donnell et al., 2008). Key symptoms of COPD include dyspnea (i.e., shortness of breath), cough, sputum production, wheezing, and frequent and prolonged respiratory tract infections (O'Donnell et al., 2008). A clinical diagnosis of COPD is made from presenting symptoms, smoking history, and confirmation of airflow obstruction from a post bronchodilator spirometry assessment, with a forced expiratory volume in 1 second (FEV1) to forced vital capacity (FVC) ratio of less than 0.7 (GOLD, 2015). The severity of COPD is often classified by severity of airflow limitation using the following criteria/cut-off values: mild (FEV1 ≥ 80% predicted), moderate (50% predicted ≤ FEV1 < 80% predicted), severe (30% predicted ≤ FEV1 < 50% predicted), and very severe (FEV1 < 30% predicted) (GOLD, 2015). Although COPD primarily affects the lungs, it is also characterized by systemic manifestations and co-morbid conditions, including deconditioning/exercise intolerance, cardiovascular diseases, diabetes, osteoporosis, muscle weakness, depression, and anxiety (Decramer et al., 2008).

Dyspnea, particularly dyspnea upon exertion, is often the symptom that leads people to seek medication intervention (Hareendran et al., 2012). However, the initial symptoms of COPD are mild, and because of this, COPD often goes undiagnosed and untreated until lung function and health status are drastically diminished. Furthermore, inactivity increases as the disease progresses and symptoms worsen, leading to substantial deconditioning (Ries et al., 2007). It has been suggested that the experience of breathlessness among COPD patients may lead to anxiety (Decramer et al., 2008) and the avoidance of activities that result in breathlessness, such as walking, which then leads to deconditioning (Decramer et al., 2008; Watz, Waschki, Meyer, & Magnussen, 2009). However, physical activity has also been shown to be reduced among people newly diagnosed with mild to moderate COPD preceding the onset of breathlessness (Gouzi et al., 2011), suggesting that prior pathophysiological mechanisms in COPD contribute to physical inactivity (Gouzi et al., 2011), and that further research is needed to understand these mechanisms.

In Canada, it is estimated that more than 800,000 people over 35 years are diagnosed with COPD (Statistics-Canada, 2015). However, direct measurements of lung function from the Canadian Health Measures Survey estimate that the number of actual COPD cases is 2.6 million (Evans, Chen, Camp, Bowie, & Mcrae, 2014). In Alberta specifically, the prevalence of COPD in 2015 was 9.1% (Stickland & Sharpe, 2017) as indicated by a COPD diagnosis from acute hospital or physician claims (Gershon, Wang, Wilton, Raut, & To, 2010). Worldwide it is estimated that 65 million people have moderate to severe COPD (WHO, 2018). Currently, COPD is the fifth leading cause of death worldwide (WHO, 2018), although the rates of COPD are increasing in both developed and underdeveloped countries. By 2030, COPD is expected to be the third leading cause of death (WHO, 2018). However, mortality statistics can minimize the overall impact of COPD, as it is estimated that up to 65% of people with COPD die from non-pulmonary causes, including cardiovascular disease and cancer (Calverley et al., 2007). Furthermore, in Canada alone, the annual costs of COPD on the health care system are upwards of $1.7 billion (PHAC, 2007).

Due to the nature and severity of symptoms, along with the prevalence of comorbid conditions, people with COPD have complex medical, physical, and emotional needs. Successful management of COPD requires adherence to a variety of medical and lifestyle behaviours, including smoking cessation, and a medication and exercise regime (O'Donnell et al., 2008). While disease management programs have been developed (i.e., pulmonary rehabilitation), many graduates of such programs are unable to maintain outcome achievement after program end, including maintenance of physical activity and functional exercise capacity (Ries, Kaplan, Myers, & Prewitt, 2003; Spencer, Alison, & McKeough, 2010; Stewart et al., 2014). Poor adherence to disease management behaviours highlights the need to better understand the factors associated with behaviour change in people with COPD and identify strategies that will help promote such change.

Acute Exacerbations of COPD

Acute exacerbations of COPD (AECOPD) are usually triggered by infection (Sethi, 2004) and characterized by increases in breathlessness, cough, sputum volume, and changes in sputum condition that lasts at least two days (Anthonisen et al., 1987). A severe AECOPD requires admission to the hospital and can be life threatening (Rodriguez-Roisin, 2000). An AECOPD is associated with declines in health status (Seemungal et al., 1998; Spencer, Calverley, Burge, & Jones, 2004), and lung function (Donaldson, Seemungal, Bhowmik, & Wedzicha, 2002), along with an increased risk of myocardial infarction one to five days post-hospitalization (Donaldson, Hurst, Smith, Hubbard, & Wedzicha, 2010). Exercise capacity and physical activity levels have also been shown to be dramatically reduced during and after an AECOPD and may persist for weeks to years after hospital discharge (Donaldson, Wilkinson, Hurst, Perera, & Wedzicha, 2005; Pitta et al., 2006a). Physical inactivity following an AECOPD is thought to contribute to muscle weakness and dysfunction (Pitta et al., 2006a). Importantly, data indicate that physical inactivity is associated with an increased risk of mortality (Waschki et al., 2011) and subsequent hospital readmission with AECOPD (Garcia-Aymerich et al., 2003; Garcia-Aymerich, Lange, Benet, Schnohr, & Anto, 2006).

The one and five-year mortality rates after an AECOPD are 21% and 55%, respectively (McGhan et al., 2007). Risk factors associated with increased mortality following an AECOPD include increased age, male gender, greater amount of hospitalizations that are COPD and non-COPD related, and several comorbidities, including heart failure, cancer, pulmonary hypertension, and weight-loss (McGhan et al., 2007). The one and five-year re-hospitalization rates after an AECOPD are 25% and 44%, respectively (McGhan et al., 2007). Risk factors for re-hospitalization include increased age, prior COPD and non-COPD related hospitalizations, male gender, asthma, and pulmonary hypertension (McGhan et al., 2007).

Disease Management for COPD

There are seven goals of COPD management: (1) prevent disease progression (e.g., through smoking cessation), (2) reduce the frequency and severity of exacerbations, (3) alleviate breathlessness and other respiratory symptoms, (4) improve exercise tolerance and amount of daily physical activity, (5) treat exacerbations and complications of the disease, (6) improve health status, and (7) reduce mortality (O'Donnell et al., 2008). Pulmonary rehabilitation (PR) is considered the standard of care for the management of symptomatic COPD patients (O'Donnell et al., 2008). It is an interdisciplinary and comprehensive program designed to produce enduring improvements in the physical and psychosocial well-being of people with chronic lung diseases, and help patients make the behavioural changes required for successful disease management (Spruit et al., 2013). PR offers medical assessment, disease specific education, exercise training, and support of behavioural management strategies. It takes place in a structured clinical environment, where the curriculum is presented according to a pre-determined schedule by clinicians specializing in the care and management of chronic respiratory disease.

The structure and composition of the G.F. MacDonald Centre for Lung Health is consistent with the American Thoracic Society (ATS) guidelines for PR (Spruit et al., 2013). Prior to PR, patients complete lung function and cardiopulmonary exercise testing. PR is either three days per week for six weeks, or two days per week for eight weeks. Each session is composed of two hours of exercise instruction and training and one hour of education. Respiratory therapists or other qualified clinicians supervise exercise training. Exercise activities include stretching and breathing training, hallway and treadmill walking, arm ergometer training, stationary cycling, and muscle-strengthening with handheld weights and resistance bands. Individual exercise prescriptions are tailored to patients' symptoms and exercise capacity. Education sessions are designed to support patient self-management by enhancing knowledge about the disease and teaching adaptive behavioural strategies. Topics of the education sessions include smoking cessation, stress-management and coping with lung diseases, developing an exacerbation action plan, respiratory medication (including proper use and techniques), nutrition, oxygen therapy, and travel/home care.

Patients are not typically enrolled in PR immediately following a hospitalization for an AECOPD. Exercise is a cardiovascular stress and there is some concern that attending PR too soon may be unsafe. An updated Cochrane Systematic Review on PR following an AECOPD compared PR to conventional care (i.e. no PR) on different key clinical health outcomes (Puhan, Gimeno-Santos, Cates, & Troosters, 2016). In the section of the review examining the effects of PR on hospitalizations, 8 studies totalling 810 participants found that there was a greater reduction in hospital readmissions with PR compared to conventional care. In the section of the review examining the effect of PR on health status, 13 studies totalling 1,105 participants found that there was a greater improvement in health status with PR compared to conventional care. Similarly, in the section of the review examining the effects of PR on functional exercise capacity, 13 studies totalling 819 participants found that there was a greater improvement in functional capabilities with PR compared to conventional care. No statistically significant effects of PR on mortality were found across 6 studies including 670 participants.

Importantly, few adverse events were reported across the studies in the review (Puhan et al., 2016), and recent guidelines recommend PR within four weeks of an AECOPD to prevent future exacerbations (Criner et al., 2015). While these studies show promising results for the benefits and safety of PR following a hospitalization for AECOPD, it is unknown if PR affects psychosocial outcomes, such as self-efficacy, and if PR delivered immediately after an AECOPD has superior effects to PR delivered a few months after an AECOPD on important PR outcomes, such as functional exercise capacity, health status, and physical activity.

Outcome Assessment in Pulmonary Rehabilitation

Outcome assessment in PR plays an important role in determining the success of a PR program. To determine success, these assessments should be sensitive enough to detect change. The minimum clinically important difference (MCID), defined as the smallest difference in outcome score that the patient or clinician deems important (Schunemann & Guyatt, 2005), can be used to assess the meaningfulness of change in outcomes. Research establishing MCIDs is becoming more common; currently MCIDs are available for the most prominent outcome assessments in PR, including health status and functional exercise capacity. Less commonly assessed outcomes in PR include physical activity, self-efficacy, anxiety and depression, strength, and nutritional status (Singh, 2014).

In this dissertation, self-efficacy is the main outcome of interest, and functional exercise capacity and health status are the secondary outcomes of interest. Physical activity is also assessed as an outcome of a self-efficacy enhancing intervention. An overview of the more common to the less common outcomes of PR that are relevant to this study are presented next, with the most thorough overview of the main outcome, self-efficacy.

Functional Exercise Capacity. Functional exercise capacity and health status are the two most commonly reported outcome assessments in PR. Walking tests are used to assess functional exercise capacity, where the participant walks along a closed course (usually a corridor) for a specified length of time. Since walking is a highly prescribed behaviour for people with COPD (Sewell, Singh, Williams, Collier, & Morgan, 2005), walking tests are considered to be a clinically and practically relevant outcome of PR. Walking tests are also desirable because they require minimal equipment and resources, and are relatively simple for the participant and supervisor to perform. The 6-minute walk test (6MWT) is a commonly reported walking test in PR (e.g., Garrod, Marshall, Barley, & Jones, 2006; Pitta et al., 2008; Spencer et al., 2010; Troosters, Gosselink, & Decramer, 2000), where individuals are instructed to cover as much ground in 6 minutes, stopping and resting as necessary (Karsunky et al., 2002). Instructions and encouragement should be standardized, and the course should be 30 meters long, with obstacles removed. It is also recommended that a practice walk occur before a testing walk to overcome any learning effect (Karsunky et al., 2002). The MCID for the 6MWT is estimated to be 54 meters (Redelmeier, Bayoumi, Goldstein, & Guyatt, 1997), although more recent reports suggest lower values (i.e., 25 meters) may be appropriate (Holland et al., 2010). In the recently updated section of a Cochrane Database Systematic Review, 38 randomized-control trials including 1879 participants found that typical improvement on the 6MWT with PR is approximately 44 meters (McCarthy et al., 2015), which is greater than the MCID of 25 (Holland et al., 2010). Greater walking distances on the 6MWT have been associated with decreased hospitalizations and mortality (Pinto-Plata, Cote, Cabral, Taylor, & Celli, 2004). Other assessments of functional exercise capacity include the cycle endurance test, the endurance shuttle walking test, and the incremental shuttle walking test.

Health Status. Health status assessment is common in PR. Health status measures (also referred to as health-related quality of life), assess the overall impact that a disease has on one's physical and emotional well-being, along with the amount of disturbance the disease has on one's daily life (Jones, 2001). In COPD patients, disease-specific health status is commonly assessed, although generic health status is also sometimes assessed. Generic health status assesses a broader overall satisfaction with health, whereas the disease-specific health status assesses aspects of the disease that are salient to the disease group. The St. George's Respiratory Questionnaire (SGRQ) is one of the most commonly used disease-specific measures of health status in patients with COPD (Jones, Quirk, Baveystock, & Littlejohns, 1992). On the SGRQ, health status is self-assessed by three sub-domains: activities, impacts, and symptoms that also make up a total score that summarizes the overall effects of the disease. The activities sub-domain assesses the degree that patient activities are affected by breathlessness; the impacts sub-domain assesses how the diseases influences patients' important life factors such as employment, medication and its side-effects, anxiety, and disturbances in daily life; and the symptom sub-domain assesses the amount and severity of patient symptoms, including breathlessness, cough, sputum production, and wheezing. In the recently updated section of a Cochrane Database Systematic Review, 19 randomized-control trials including 1146 participants found that typical improvement on the SGRQ total score with PR is approximately 7 units (McCarthy et al., 2015), which is greater than the MCID of 4 units (Jones, 2005). The SGRQ has been found to be related to physical activity (Gimeno-Santos et al., 2014), self-efficacy (Andenaes, Bentsen, Hvinden, Fagermoen, & Lerdal, 2014), and functional exercise capacity (Garrod et al., 2006). Another common measure of disease-specific health status is the Chronic Respiratory Disease Questionnaire.

Physical activity. Physical activity is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure beyond resting energy expenditure" (Thompson et al., 2003, p. 1). It can be assessed with self-report questionnaires (Godin & Shephard, 1985; Pitta et al., 2006b), motion sensors, such as pedometers and accelerometers (Pitta et al., 2006b; Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005), and with methods assessing free-living energy expenditure, such as the doubly labeled water technique (Manini et al., 2006). It can also be assessed with a multisensory armband (SenseWear Pro armband, BodyMedia, Inc., Pittsburgh, PA, USA) and consumer-based activity trackers, such as the Fitbit Flex and Fitbit Flex2. Self-reported physical activity is commonly subject to recall bias (Ward et al., 2005), and does not provide an accurate estimate of free-living energy expenditure (Manini et al., 2006), although it may be more accurate at estimating energy expenditure in discrete bouts of exercise. Pedometer and accelerometers provide objective quantification of physical activity performed over a period of time. There is some evidence to suggest, however, that estimating daily energy expenditure from bodily movement counts can be inaccurate (Leenders, Sherman, & Nagaraja, 2006; Leenders, Sherman, Nagaraja, & Kien, 2001).

The SenseWear Pro armband combines a biaxial accelerometer that records steps per day and physiological indicators of energy expenditure. In patients with COPD, the SenseWear Pro armband has been found to be a reliable and valid measure of energy expenditure during light, moderate, and intense activity (Langer et al., 2009), although one report suggests that it is less accurate at recording step count (Langer et al., 2009). One study aimed at standardizing the analysis of physical activity in patients with COPD following PR found that steps per day and time spent in light intensity physical activity were the most sensitive outcome measurements of physical activity in COPD patients as measured by the armband (Demeyer et al., 2014). Some COPD patients may not be able to reach a moderate intensity threshold of 3 METS (Demeyer et al., 2014) suggesting that the use of this threshold as an outcome measurement may not be appropriate for all patients. It may be most appropriate to assess moderate intensity activity, defined as ≥ 3METs (Haskell et al., 2007), in tandem with another outcome, such as step count, that provides information about the overall amount of activity irrespective of intensity. The study by Demeyer et al. (2014) also concluded that assessment responsiveness is optimized when assessment periods are at least 4 weekdays long, there is a minimum of 8 hours of monitor wearing time during waking hours, and there is a statistical correction for a difference in daylight time, to control for seasonality.

The Fitbit Flex and Fitbit Flex 2 are popular consumer-based activity trackers. They are user-friendly, inexpensive, and include features that are appealing and motivating to users (Sushames, Edwards, Thompson, McDermott, & Gebel, 2016). Previous studies have found support for the reliability and validity of the Fitbit during treadmill walking (Alinia et al., 2017; Sushames et al., 2016) and walk-tests (Burton et al., 2018). However, studies have consistently reported that the Fitbit Flex underestimates step count during activities of daily living (Alinia et al., 2017; Burton et al., 2018; Sushames et al., 2016; Ummels, Beekman, Theunissen, Beurskens, & Braun, 2018) and slow walking speeds (Alinia et al., 2017; Ummels et al., 2018). To date, no studies have conducted reliability and validity studies using the Fitbit Flex 2. Given that people with COPD often have impaired ambulatory abilities (i.e. shuffling, slow walking speeds) (Lahousse et al., 2015), caution should be taken when interpreting the accuracy of step count in free-living environments in adults with COPD when measured by the Fitbit Flex. Examination of within-subject change over time is appropriate if reliability of the Fitbit is adequate. Further research is needed to test the longitudinal reliability of the Fitbit Flex and Flex 2.

Patients with COPD are less active and exercise at a lower intensity than age-matched controls (Pitta et al., 2005; Troosters et al., 2010; Watz et al., 2009). Further, there is a marked decline in the amount and intensity of physical activity as the disease progresses (Pitta et al., 2005; Troosters et al., 2010; Watz et al., 2009). A reduction in walking time has been reported among patients with moderate COPD, although it is more pronounced in patients with severe and very severe COPD (Watz et al., 2009). Acute exacerbations of COPD have also been shown to be associated with increased physical inactivity (Donaldson et al., 2005; Pitta et al., 2005).

Physical activity in patients with COPD is likely dependent on many factors, including physiologic, behavioural, social, environmental, and social factors (Spruit, Pitta, McAuley, ZuWallack, & Nici, 2015). Recently, a systematic review of the determinants and outcomes of physical activity in patients with COPD was conducted (Gimeno-Santos et al., 2014). As determinants, functional exercise capacity, health status, dyspnea, previous exacerbations, lung hyperinflation, gas exchange, and self-efficacy were found to be consistently related to physical activity levels in patients with COPD. In terms of the outcomes of physical activity, this systematic review found that low levels of physical activity were consistently related to mortality and AECOPD. Dyspnea, health status, functional exercise capacity, and forced expiratory volume in one second (FEV1), were outcomes also related to physical activity (Gimeno-Santos et al., 2014). However, the authors noted the results of this systematic review were often based on few studies that were often cross-sectional and did not control for potential confounding variables; except for the results pertaining to the relationships of physical activity to outcomes of mortality and exacerbations, which were based on a greater number of studies, few had longitudinal designs and controlled for confounding variables. The relationship among physical activity and clinically relevant outcomes, such as mortality and hospitalizations, suggests that physical activity is important to COPD management. More experimental studies examining the determinants of physical activity in people with COPD are needed to inform the design of interventions aimed at improving physical activity and ultimately hospitalization and mortality rates.

Social Cognitive Theory & Self-Efficacy

Social Cognitive Theory (Bandura, 1997, 1986) addresses the complex, dynamic, and reciprocal relationships between behaviour, environmental contexts, and person attributes. Explanation and prediction of human behaviour is derived from the interaction of personal attributes and social processes. Personal attributes include individuals' belief systems and ways of processing and responding to information, such as their self-efficacy. Social processes are the ways that the individual and groups interact, including learning by observing others (i.e., vicarious experience). Importantly, personal and social processes change with the environment. Therefore, behaviour must be understood within the environmental context from which it is derived. Following this perspective, the current research examines the contribution of personal attributes and social processes to self-efficacy in COPD patients, and its relationship to relevant clinical outcomes: functional exercise capacity, health status, and physical activity.

Self-efficacy is defined as "one's beliefs in their capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). A person's beliefs in his or her capabilities can influence the behaviours pursued, the amount of effort put towards a behaviour, level of persistence towards a difficult task, thought patterns, and affect (Bandura, 1997). People with stronger beliefs in their capabilities are more likely to engage in a behaviour, dedicate ample effort to it, and persevere in the face of barriers, whereas people with weaker beliefs in their capabilities are less likely to engage in the behaviour, will dedicate little effort to it, and give up in the face of barriers.

Self-efficacy has been studied extensively in the health behaviour literature. It is found to be an important predictor of many health behaviours, including smoking cessation (Gwaltney, Metrik, Kahler, & Shiffman, 2009), fruit and vegetable consumption (Richert et al., 2010), alcohol consumption (Adamson, Sellman, & Frampton, 2009) and exercise and physical activity behaviour (Blanchard, Arthur, & Gunn, 2015; McAuley et al., 2011; Rodgers, Murray, Courneya, Bell, & Harber, 2009; Rodgers, Murray, Selzler, & Norman, 2013; Scholz, Sniehotta, & Schwarzer, 2005; Sharma, Sargent, & Stacy, 2005). For people with COPD, self-efficacy is considered to be important to the development and continued performance of skills required to self-manage their disease (Andenaes et al., 2014; Bourbeau, Nault, & Dang-Tan, 2004; Singh, 2014; Stewart et al., 2014), and has been found to be related to functional exercise improvement (Garrod et al., 2006; Jackson et al., 2014; Selzler, Rodgers, Berry, & Stickland, 2016), health status (Bentsen, Wentzel-Larsen, Henriksen, Rokne, & Wahl, 2010; Garrod, Marshall, & Jones, 2008; Jackson et al., 2014), physical activity (Hartman, Boezen, de Greef, & ten Hacken, 2013), and survival (Kaplan, Ries, Prewitt, & Eakin, 1994).

Self-efficacy is not a global assessment of one's capabilities, but rather a behaviour-specific set of capability beliefs (Bandura, 1997). Therefore, for successful performance of each self-management behaviour (i.e., medication and exercise adherence, smoking cessation, etc.) a unique set of capability beliefs is required. Bandura (1997) also posits that end-goal behavioural performance is a result of many, smaller, sequential behaviours performed under challenging social circumstances. Therefore, capability beliefs must match the behavioural specificity. Consistent with Bandura (1997), Maddux (1995) contends that there are two sub-types of capability beliefs for any given behaviour: task self-efficacy, which corresponds to the performance of elemental aspects of the task; and coping self-efficacy which corresponds to the performance of the task under challenging circumstances. This categorization emphasizes the importance of the circumstances surrounding behavioural performance. Further, it highlights that in goal achievement it is not so much about the skills that one has, but what people believe they can do with those skills under challenging circumstances (Bandura, 1997).

The types of self-efficacy that have been most commonly assessed in patients with COPD are associated with two salient challenges faced by patients with COPD: managing breathlessness and exercise intolerance. Confidence for managing or avoiding breathlessness in a variety of situations (i.e. COPD Self-Efficacy Scale (CSES) (Wigal, Creer, & Kotses, 1991)) is the most frequent type of self-efficacy that is assessed in COPD patients. Self-efficacy for managing breathlessness has been found to be an important predictor of improvements in health status (Bentsen et al., 2010; Garrod et al., 2008; Jackson et al., 2014; Tu, McDonell, Spertus, Steele, & Fihn, 1997), and functional exercise capacity (Garrod et al., 2008; Jackson et al., 2014). Self-efficacy for walking is also commonly assessed in COPD patients (Davis, Carrieri-Kohlman, Janson, Gold, & Stulbarg, 2006; DePew, Karpman, Novotny, & Benzo, 2013; Kaplan et al., 1994; Lox & Freehill, 1999; Ries, Kaplan, Limberg, & Prewitt, 1995), which is a task specific assessment of walking capability beliefs (e.g., the Self-efficacy for Walking Scale; McAuley, Courneya, & Lettunich, 1991). Walking self-efficacy has been found to be related to functional exercise capacity (Davis et al., 2006; DePew et al., 2013; Lox & Freehill, 1999), and survival (Kaplan et al., 1994) in COPD patients.

Importantly, the assessment of walking self-efficacy alone disregards the role of situational and self-regulatory capabilities required for the enactment of the behaviour. Rodgers, Wilson, Hall, Fraser, and Murray (2008) have developed the Multidimensional Self-efficacy for Exercise Scale (MSES) that accounts for the role of both physical and self-regulatory capabilities in the enactment of exercise behaviour. There are three sub-types of self-efficacy for exercise specified in the MSES that are considered core requirements for exercise behaviour: task self-efficacy, confidence in one's capabilities to perform elemental aspects of exercise; coping self-efficacy, confidence in one's capabilities to exercise under challenging conditions; and scheduling self-efficacy, confidence in one's capabilities to exercise regularly. In COPD patients, task self-efficacy was found to be positively related to attendance at PR, suggesting that confidence for being able to do what is required in an exercise session is important for getting patients to PR classes (Selzler et al., 2016). Coping self-efficacy was found to be positively related to functional exercise improvement with PR, suggesting that confidence for overcoming exercise barriers may facilitate the effort and persistence required to achieve functional outcomes (Selzler et al., 2016). These findings in COPD patients are consistent with the findings in cardiac rehabilitation patients and sedentary adults, which have found task self-efficacy to be most strongly related to exercise initiation (Rodgers et al., 2009; Rodgers et al., 2013; Scholz et al., 2005), and coping and scheduling self-efficacy to be most strongly related to long-term exercise adherence (Rodgers et al., 2009; Rodgers et al., 2013; Scholz et al., 2005). Overall the results suggest that the self-efficacy sub-type most related to exercise behaviour depends on the most pertinent challenges faced by the performer at the time the behaviour is being performed.

While there are numerous reports examining the relationship of self-efficacy to functional exercise capacity and health status, there has been limited research investigating the impact of PR or other interventions on self-efficacy. Two studies found walking self-efficacy to improve with PR (Lox & Freehill, 1999; Ries et al., 1995), and two found self-efficacy for managing breathlessness to improve with PR (Khoshkesht, Zakerimoghadam, Ghiyasvandian, Kazemnejad, & Hashemian, 2015; Scherer & Schmieder, 1997), although only the studies conducted by Ries et al. (1995) and Khoshkesht et al. (2015) compared the change in self-efficacy with PR to no-PR control groups. Given that self-efficacy for COPD management behaviors (i.e., walking, exercise, managing breathlessness) are considered fundamental to the overall outcome of COPD self-management (Bourbeau et al., 2004; Rice, Bourbeau, MacDonald, & Wilt, 2014) and that one of the primary aims of PR is to improve patients` abilities to self-manage their disease, it is important to know how much each self-efficacy type changes with PR (i.e., walking, exercise, managing breathlessness). Further, the change of each self-efficacy type with PR needs to be compared with the behaviours that seem to be most strongly associated with the long-term maintenance of outcomes. If the self-efficacy types (i.e., self-efficacy for different behaviours required to produce the desired outcomes) differentially change with PR it will provide valuable information about how the content and delivery of PR could be manipulated to further enhance self-efficacy for the types of behaviours linked to the desired health outcomes in this population.

Based on the theoretical tenets outlined by Bandura, self-efficacy enhancing interventions have attempted to target one or more of the four sources of self-efficacy: mastery experience, vicarious experience, verbal persuasion, and physiological/affective arousal (described in more detail in the next section). One recent study tested the effects of a self-efficacy enhancing intervention to increase physical activity in COPD patients (Larson, Covey, Kapella, Alex, & McAuley, 2014). Larson et al. (2014) targeted all four sources of self-efficacy in their theoretically designed intervention and found modest effects on light physical activity in the short term only, and no effects on moderate-to-vigorous physical activity in the short or long term. Given that the intervention was designed to impact all four sources of self-efficacy, the individual effects of each self-efficacy source on behaviour in COPD patients are unknown. Further, the authors did not measure self-efficacy, so it is unclear if their intervention changed self-efficacy and if self-efficacy mediated the effect of the intervention on behaviour. A meta-analysis examining intervention techniques associated with enhanced self-efficacy for exercise across a variety of populations, found that of the four sources of self-efficacy, vicarious experience was the source most strongly associated with self-efficacy enhancement (Ashford, Edmunds, & French, 2010), although this has yet to be tested in COPD patients. Overall, little is known about how to practically enhance self-efficacy in patients with COPD from the foundation of the four theorized sources of self-efficacy.

Given that it is not possible to substantially improve lung function, disease-management is the primary focus of clinical care for COPD patients. The advanced age of COPD patients coupled with the nature of the disease and associated comorbidities, contributes to the complexity of managing this disease. Self-efficacy is an important determinant of goal attainment (Bandura, 1997) and is critical to successful disease management in patients with COPD (Bourbeau et al., 2004). Adding assessments of self-efficacy for walking, exercise, and managing breathlessness to the regular assessments of other variables, including clinical targets and health status, for example, over the course of PR will allow for examination of associations among these variables. An evaluation of the impact of PR on self-efficacy types in COPD patients will have implications regarding the content and delivery of PR. In addition, understanding the simultaneous contribution of different self-efficacy types (i.e., walking, exercise, and managing breathlessness) to clinical outcomes (i.e., functional exercise capacity, health status, and physical activity) will provide clarity around the specific behavioural targets of self-efficacy required to improve such outcomes. The identified relationship of self-efficacy for walking, managing breathlessness, and exercise to clinical outcomes in COPD patients, and the fact that self-efficacy is a modifiable variable, suggests that efforts to enhance these types of self-efficacy in COPD patients are merited.

Sources of Self-Efficacy

There are four sources of information that contribute to the development of self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological and/or affective states (Bandura, 1997). Enactive mastery experiences, the strongest sources of self-efficacy, pertain to one's personal history with performing the behaviour. Successful experiences enhance self-efficacy, whereas failures weaken self-efficacy (Bandura, 1997). In vicarious experience, people judge their own abilities based on the achievements of others. In general, successful experiences of others will enhance one's own self-efficacy beliefs, whereas failures will weaken them (Bandura, 1997). Importantly, this effect is hypothesized to be moderated by the characteristics and abilities of the model performing the behaviour. Verbal persuasion is communication to the person about his/her capabilities of performing the behaviour. Communication of belief in a person's abilities will enhance self-efficacy, whereas, communication of doubt will weaken self-efficacy (Bandura, 1997). The physiological and/or affective state of a person will also influence self-efficacy. Agitated, anxious, and negative affective states are often associated with weak self-efficacy, and calm, positive affective states are often associated with strong self-efficacy (Bandura, 1997).

Processing of Self-Efficacy Information. In natural circumstances, information about one's capabilities is provided by a combination of the sources: mastery experiences, vicarious experience, verbal persuasion, and physiological/affective states. Exposure to these information sources is necessary but not sufficient for understanding the development of capability beliefs (Bandura, 1997). For example, observation of a modeled event does not guarantee that the information was attended to or tell us how the information was processed and reflected on by the observer. Therefore, cognitive processing of the information source, including attentional processes, selection of relevant information, reflection, weighting of importance, and integration into current cognitive structures are all key in the development of self-efficacy (Bandura, 1997). Thus, there are numerous environmental, behavioural, and personal characteristics that can complexly impact how direct experience and socially mediated (vicarious) experiences are interpreted.

Vicarious experience/modeling

Both personal mastery and vicarious experiences (observations of models) strongly contribute to the development of self-efficacy beliefs. During observation, others' performances are weighted and integrated into current cognitive structures to make judgments about one's own capabilities (Bandura, 1997). During PR, modeling is frequently used by clinicians to demonstrate proper exercise technique. Modeling has been found to be effective at encouraging exercise performance, enhancing self-efficacy and motivation to continue doing prescribed exercises in younger and healthy older adults (Weeks et al., 2005; Weeks et al., 2002), and heart failure patients (Maddison, Prapavessis, Armstrong, & Hill, 2008). Further, in a meta-analysis examining the association of the sources of self-efficacy as intervention techniques to self-efficacy for exercise, vicarious experience alone was found to have the strongest association to exercise self-efficacy next to interventions composed of vicarious experience with feedback and mastery experiences with feedback, which had similar associations to exercise self-efficacy (Ashford et al., 2010). Feedback may have added benefits to vicarious and mastery experiences alone, as it may help individuals pay attention to and reflect on information that will be most helpful for enhancing their self-efficacy beliefs.

There are several conditions outlined by Bandura (1997) where observation of others contributes strongly to one's own self-efficacy beliefs. When people are new to a behaviour, they rely more heavily on the performances of others to appraise their own capabilities. The less direct experiences initiates have to draw on, the more they will have to look to others' performances to provide information about the behavioural requirements of the task. Similarly, when people are uncertain about their abilities, or when there is no known performance standard, they will appraise their capabilities in relation to others (Bandura, 1997). An older adult may be able to walk for 10 consecutive minutes but will have no idea if his/her performance is 'good' or not without knowing how long or how fast similar others can walk.

Modeling impacts observer self-efficacy by communicating abilities and eliciting social comparison (Bandura, 1997). The strength of the impact on self-efficacy depends on the characteristics and abilities of the model and how the information from the models is processed. The model may be someone else or the individual him- or her-self at another point in time. Older adults develop beliefs about their capabilities by comparing their current performance to their past performance (Suls & Mullen, 1982), and to the performance of others (Bandura, 1997). Positive self-appraisals result from maintaining or improving abilities relative to past-abilities or from surpassing comparative age-mates (Bandura, 1997). Conversely, negative self-appraisals result from declining abilities relative to past abilities or from not measuring up to the abilities of age-mates. In older adults, comparisons of current physical abilities to past physical abilities tend to have de-motivational effects since physical abilities naturally decline with age (Bandura, 1997). Therefore, in theory, comparisons to age-mates are thought to be better than comparisons to one's previous abilities because age-mates are more similar in ability than one's former self (Bandura, 1997). However, age-mates may not be 'good' comparators when the observer has a chronic disease, and the comparator is healthy or healthier than the observer. To date, little is known about who patients with COPD compare themselves to with respect to health behaviours; and how characteristics and performance of models may impact observer self-efficacy and subsequent exercise behaviour. It is expected that unfavourable comparisons will lower self-efficacy and result in poor behavioural persistence whereas favourable comparisons will increase self-efficacy and result in adequate behavioural persistence.

There are several relevant factors that influence how modeled information is processed by the observer: Attribute similarity, performance similarity, multiplicity and diversity of modeling, mastery versus coping models, and model competence (Bandura, 1997). Practically, it may be important for clinicians to consider who is serving as a model for COPD patients during PR and whether this model effectively enhances self-efficacy and exercise behaviour of the observer.

Attribute Similarity. The most influential models are those that have similar personal characteristics, or attributes to the observer (Bandura, 1997). People with more similar characteristics to the observer are considered to be 'more like' the observer and thus a better standard for comparison with his/her own abilities. In addition, people tend to associate personal characteristics, including age, gender, ethnic origin, and socio-economic status with stereotypical or predetermined notions of performance capabilities, even though within any group of people there will be a wide range of performance capabilities. Within a given group of individuals, the attributes deemed most important to behavioural performance carry the most weight when making social comparative appraisals (Bandura, 1997). In non-athletic individuals, self-efficacy was more strongly enhanced from observing non-athletic models than observing athletic models who displayed similar abilities (George, Feltz, & Chase, 1992), suggesting the attribute of 'athlete' or not was more important to non-athletes than the conveyed ability of the model. It is unknown what model characteristics patients with COPD find salient when appraising and comparing models' exercise performance to their own. Determining what model characteristics COPD patients think make a model 'like them' or 'not like them' will indicate the model characteristics that will facilitate or undermine, respectively, the model influence on observer self-efficacy. Previous reports indicate that COPD patients do not want to exercise with younger individuals (Keating, Lee, & Holland, 2011), suggesting that model age and ability may carry some weight when developing their own self-efficacy beliefs.

Bandura (1997) states that age and gender are two model attributes that are particularly important when determining if the model is a suitable comparator. This was partially supported in a sample of healthy older adults in a physiotherapy setting, where model gender, but not age, influenced older women's self-efficacy to perform therapeutic exercises, and neither model gender nor age influenced older men's self-efficacy (Weeks et al., 2005). Qualitative reports from this study revealed that women found it easier to relate to the model of the same gender, and women were intimidated by men whom they perceived to have greater muscular strength. The authors also suggested that age may not have been a relevant model attribute in this study because participants had prior experience with younger exercise leaders and were comfortable with them. It could also be that the observers did not associate the performance of this task with age, in which case a model of any age would be considered a suitable comparator. In another study testing the effects of model sex and ability in female college students, sex of the model was not related to self-efficacy or exercise performance (George et al., 1992). The conflicting results of these studies suggest that there may be different salient model characteristics for different people, behaviours, and settings.

Performance Similarity. Analogous to the importance of attributes, models that are perceived to be of similar or slightly higher ability to the observer provide the observer with the most relevant information about their own abilities (Bandura, 1997). Models that are perceived to be much lesser or much higher in ability provide the observer with little relevant information. In general, observing similar models succeed will increase self-efficacy, whereas observing them fail will lower self-efficacy (Bandura, 1997). Observing models of differing abilities to the observer may not have null effects. If the observer sees a model of supposedly greater ability fail or struggle to complete a task, self-efficacy may decline; however, observing a model of lesser ability fail may increase rather than decrease self-efficacy if the observer believes they are superior in ability (Bandura, 1997). Relatedly, one study found that observing a model of greater ability succeed had detrimental effects on the observer's self-efficacy and performance on a leg endurance task (George et al., 1992). Within PR, there may be motivational and behavioural implications of COPD patients observing others of differing abilities. It is important to understand the effects of observing others of different abilities among COPD patients in PR, as this setting might be inadvertently undermining patients' self-efficacy.

Multiplicity and Diversity of Modeling. In natural settings, people have the opportunity to observe many individuals, and thus, self-efficacy appraisals are formed from a multitude of observed events. Observing many similar others perform alike is more persuasive than observing one individual, because it is possible that the one individual performance was an anomaly (Bandura, 1997). Also, successes of many people with diverse personal characteristics will be more impactful than many people who are very similar. However, it is not diversity alone that leads to strong effects on self-efficacy, it is the successes of others similar in ability within a diverse group that will lead to the strong effects (Bandura, 1997). This is because the successes of similar others within a diverse group indicates to the observer that the phenomenon of interest is robust and likely to generalize to them (Bandura, 1997). Typically, modeling research has used one individual to serve as the model (De Jesus & Prapavessis, 2013; George et al., 1992; Paquette, Egan, & Martini, 2013; Weeks et al., 2005; Weeks et al., 2002). However, one study using multiple models in the same video found strong beneficial effects on self-efficacy and maximal exercise test performance in heart failure patients (Maddison et al., 2008), supporting the importance of having many diverse, positive observations.

Mastery vs Coping Models. Self-efficacy can be modeled through actions and words, and such words can be instructional and motivational (Bandura, 1997). Mastery models perform effortlessly and error-free. Coping models begin uncertainly but incrementally progress at the task and overcome their difficulties through persistent coping efforts. Further, coping models display decreasing distress as they overcome difficulties, demonstrate strategies for overcoming difficulties, and say self-efficacious statements. Theoretically, coping models are considered to be more effective than mastery models at enhancing self-efficacy, particularly among observers who are unsure of their abilities (Bandura, 1997). Observers who are unsure of their abilities regard coping models to be more similar to them. Further, coping models convey that failures or set-backs are expected, but that they can be overcome through persistent effort. Bandura (1997) suggests that apart from model similarity, coping models are particularly effective because they convey instruction and strategies for overcoming challenges through their actions. In addition, accumulating evidence suggests that coping self-efficacy is associated with persistence on exercise tasks (Blanchard et al., 2015; Rodgers, Hall, Blanchard, McAuley, & Munroe, 2002; Rodgers et al., 2009; Rodgers et al., 2013; Scholz et al., 2005), further supporting that models conveying coping strategies may be beneficial to observer self-efficacy and performance of exercise tasks.

So far, empirical research suggests the effects of mastery and coping models on self-efficacy and behavioural performance are similar. Weiss, McCullagh, Smith, and Berlant (1998) found both mastery and coping models to be effective at reducing fear, and improving self-efficacy and swimming performance in children, however coping models produced larger effects than mastery models. Clark and Ste-Marie (2002) and Cumming and Ramsey (2011) also failed to find self-efficacy or behavioural differences from peers observing coping versus mastery models when learning how to dive and learning to enhance balance, respectively. It seems that learners benefit equally from observing mastery and coping models when improving performance of simple skills. When learners observe difficult tasks, or tasks that require a great amount of persistence for success, coping models may be more beneficial than mastery models (Cumming & Ramsey, 2011). Under difficult circumstances, coping models convey that challenges can be overcome with persistent effort, particularly among learners who doubt themselves (Bandura, 1997). Therefore, in addition to controlling for model characteristics, it may also be important to assess or control for task difficulty, and past exercise experience when testing the effectiveness of mastery versus coping models on observer learning. Further, it may be important to consider and control for the behaviour characteristics of the modelled performance. For patients with COPD observing models perform an exercise task, this will include behavioural intricacies and nuances of managing both exercise and breathlessness.

Model Competence. Competence is an important model attribute, particularly when people have a lot to learn. People believe they can learn more from competent people compared to incompetent people and actively seek out skillful models that they aspire to be like (Bandura, 1997). Competent models also command attention from observers and have more instructional influence than do incompetent ones (Bandura, 1997, 1986). Coping models may not be necessary in cases where people are confident in their abilities to learn quickly and manage problems effectively (Bandura, 1997). Therefore, it may be important to consider whether observers' learning self-efficacy influences the effects of observing coping versus mastery models.

Summary of Modeling Literature. The literature on vicarious experience indicates that modeling can be effective at enhancing self-efficacy, and that the influence of model characteristics and performance depends on the person or group of interest. In general, models that are more similar to the observer are more likely to influence self-efficacy than models that are dissimilar. Model characteristics that are considered to be indicative of actual capabilities are particularly influential. Healthy older women consider men's physical stature and abilities much different from theirs, and correspondingly, gender appears to be a salient model characteristic influencing older women's self-efficacy (Weeks et al., 2005). To date, it is unclear what model characteristics are important to older adults with a chronic disease such as COPD, although gender and age seem to be important model characteristics to consider. Model ability and performance may also be important to observer self-efficacy, although it is unclear whether mastery or coping models have superior effects on self-efficacy and what conditions are associated with such effects. It may be important to consider the moderating effects of past exercise experience, perceived task difficulty, and model-observer similarity when testing the effects of modeled events on observer self-efficacy. Similarly, it may be beneficial to determine if learning self-efficacy impacts the effect of observing coping and mastery models.

Chapter 2 – Study 1

The Impact of Pulmonary Rehabilitation on Two Types of Self-efficacy in Stable COPD Patients and Patients Recovering from an Acute Exacerbation of COPD

Abstract

Background: A strong sense of self-efficacy is associated with clinical-health outcomes and disease-management behaviours in patients with COPD. Pulmonary rehabilitation (PR) has been found to be effective at improving clinical-health outcomes among COPD patients recently hospitalized for an acute exacerbation of COPD (AECOPD) and COPD patients without a recent AECOPD (stable COPD); however, it is unclear whether self-efficacy improves with PR in both patient groups and if the timing of PR after an AECOPD impacts this effect. **Method:** A four group (AECOPD no-PR, AECOPD early-PR, AECOPD late-PR, stable PR) quasi-experimental study examined the impact of PR on walking self-efficacy and self-efficacy for managing breathlessness, along with secondary outcomes of functional exercise capacity, health status, and physical activity. The contribution of the self-efficacy types to the secondary outcomes at pre- and post-PR was also examined. **Results:** A total of 105 COPD patients (22 AECOPD no-PR, 22 AECOPD early-PR, 21 AECOPD late-PR, 40 stable COPD PR) completed assessments of the Self-efficacy for Walking Scale, the COPD Self-efficacy Scale, the Six-Minute Walk Test (6MWT), St. George's Respiratory Questionnaire (SGRQ), and wore Fitbits™ to determine steps per day before and at the end of a 6-8-week PR program. Mixed ANOVAs indicated that both types of self-efficacy improved with PR in stable and AECOPD COPD patients, and that stable patients improved more than AECOPD patients on the 6MWT and SGRQ. Even after PR, AECOPD patients were lower on all outcomes than stable patients at the beginning of PR. Neither the AECOPD nor stable patients increased steps per day with PR. The AECOPD no-PR control group did not improve on any outcomes over time. Multiple regressions indicated that walking self-efficacy was a better predictor than self-efficacy for managing breathlessness on all outcomes. At both pre- and post-PR, stronger associations between self-efficacy and physical activity were observed in the stable COPD patients compared to the AECOPD patients. **Conclusions:** The results suggest that self-efficacy improves with PR in AECOPD and stable COPD patients. AECOPD patients may need more time to improve as much as the stable COPD patients on clinical-health outcomes. The results also suggest AECOPD patients may need more time to manage dyspnea and develop functional abilities before dealing with the challenge of becoming more physical active, unlike the stable patients who seem more ready to be challenged to be physical active at the outset of PR.

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disease characterized by shortness of breath, exercise intolerance, and predisposition to exacerbations (O'Donnell et al., 2008). Acute exacerbations of COPD (AECOPD) typically include marked increases in shortness of breath with changes in sputum condition or volume lasting at least two days (Anthonisen et al., 1987), and can result in marked deterioration of patient health status (Seemungal et al., 1998; Spencer et al., 2004), lung function (Donaldson et al., 2002) and increases in mortality (Almagro et al., 2002; Groenewegen, Schols, & Wouters, 2003). Exercise capacity and physical activity levels are also greatly reduced during and after an AECOPD, which may persist for years after hospital discharge (Donaldson et al., 2005; Pitta et al., 2006a) and further contribute to subsequent hospital readmission for an AECOPD (Garcia-Aymerich et al., 2003; Garcia-Aymerich et al., 2006) and an increased risk of mortality (Waschki et al., 2011). In Alberta, AECOPDs were responsible for 9,600 hospitalizations during 2011; more than angina, hypertension, heart failure, or diabetes (Stickland, Mody, Grahan, Daniels, & Jensen-Ross, 2012). The average length of patients' hospitalizations was 12.9 days, costing the health care system $112 million. The prevalence of AECOPD and its impact on patient health and healthcare systems has placed a greater emphasis on facilitating patient access to programs designed to improve disease management.

Since it is not possible to considerably improve lung function, treatment of COPD is focused on restoring patients physical and psychological functioning and facilitating the adoption of skills that will help patients self-manage their disease. Successful disease management requires adherence to many lifestyle behaviours including medication, smoking cessation, and regular exercise. Pulmonary rehabilitation (PR) is comprised of exercise training and disease management education, and is considered the most effective treatment for COPD patients (Spruit et al., 2013). It is uncommon for patients to be enrolled in PR after a recent hospitalization for an AECOPD. However, a Cochrane Systematic Review indicated that PR after a hospitalization for an AECOPD improves functional exercise capacity, health status, and hospital readmission rates (Puhan et al., 2016). Further, few adverse events have been reported (Puhan et al., 2016), and recent guidelines recommend PR within four weeks of an AECOPD to prevent future exacerbations (Criner et al., 2015). While these studies show promising results for the benefits of PR following an AECOPD, it has yet to be determined if PR after a hospitalization for an AECOPD improves psychosocial factors that facilitate adherence to disease management behaviours, and if the timing of PR after a hospitalization plays a role in the development of such factors. One psychosocial factor that is considered integral to disease management is self-efficacy (Bandura, 1997; Bourbeau et al., 2004; Rice et al., 2014).

Self-efficacy, defined as behaviour specific confidence (Bandura, 1997), has been demonstrated to be a robust correlate of lifestyle behaviours, including exercise in nonclinical (McAuley et al., 1991; McAuley et al., 2011; Rodgers et al., 2009) and clinical populations (Blanchard et al., 2015; Millen & Bray, 2008; Rodgers et al., 2013). People with strong self-efficacy are more likely to persist in the face of barriers and sustain commitment to goals than people with low self-efficacy (Bandura, 1997). In patients with COPD, self-efficacy has been found to be an important predictor of survival (Kaplan et al., 1994), health status (Bentsen et al., 2010; Garrod et al., 2008; Jackson et al., 2014; Tu et al., 1997), attendance at PR classes (Selzler et al., 2016), and functional exercise improvement with PR (Garrod et al., 2006; Jackson et al., 2014; Selzler et al., 2016).

Self-efficacy is not a global assessment of one's capabilities, but rather a behaviour-specific set of capability beliefs (Bandura, 1997). Therefore, people have a unique set of capability beliefs (i.e., self-efficacy type) for each disease management behavioural outcome (i.e., exercise, managing breathlessness, medication adherence, smoking cessation, etc.). According to Bandura (1997), self-efficacy is not so much about the skills one has but rather what one can do with those skills under challenging conditions. However, Maddux (1995) has contended that if you do not have the necessary skills, then the circumstances of performing the behaviour are irrelevant. In patients with COPD who have functional limitations, exercise skill acquisition may be a more pertinent objective upon entrance into PR than learning to exercise under challenging conditions. Further, since exercise intensifies breathlessness, COPD patients must also acquire breathing management skills to perform exercise skills. Therefore, the performance of exercise tasks for COPD patients is more complex than among healthy individuals. Addressing circumstantial barriers will likely become more important, and critical for ongoing regular exercise, once exercise skills and breathing management improve.

The types of self-efficacy most often assessed in COPD patients have been related to two salient behavioral challenges associated with COPD, managing breathlessness and exercise intolerance. Self-efficacy for managing and avoiding breathlessness, assessed by the COPD Self-efficacy Scale (Wigal et al., 1991), and self-efficacy for walking are the most common types of self-efficacy assessed. The CSES has been found to be an important predictor of improvements in health status (Bentsen et al., 2010; Garrod et al., 2008; Jackson et al., 2014; Tu et al., 1997), and functional exercise capacity (Garrod et al., 2008; Jackson et al., 2014). Walking self-efficacy has been found to be related to functional exercise capacity (Davis et al., 2006; DePew et al., 2013; Lox & Freehill, 1999), and survival (Kaplan et al., 1994) in people with COPD. The relationships of self-efficacy for walking and self-efficacy for managing breathlessness to physical activity behaviour are unknown. To date, walking self-efficacy and self-efficacy for managing breathlessness have not been assessed simultaneously in COPD patients, and so it is unclear which self-efficacy type is the stronger and more important predictor of clinical health and behavioural outcomes. Given the behavioural specificity of self-efficacy it is postulated that the relationships between each self-efficacy type will vary according to the outcome of interest (e.g., functional exercise capacity, health status, physical activity).

The literature examining the change of self-efficacy with PR is limited. The results of two studies indicated that walking self-efficacy improved with PR (Lox & Freehill, 1999; Ries et al., 1995), with the results of two studies indicating that self-efficacy for managing breathlessness improved with PR (Khoshkesht et al., 2015; Scherer & Schmieder, 1997). However, Ries et al. (1995) and Khoshkesht et al. (2015) were the only groups to compare the change in self-efficacy with PR to a no-PR control group. Given that self-efficacy is considered a key ingredient to the performance of COPD self-management behaviours (Bourbeau et al., 2004; Rice et al., 2014) and that one of the primary aims of PR is to improve patients` abilities to self-manage their disease (Spruit et al., 2013), it is important to know how much self-efficacy levels change with PR and if PR differentially changes the self-efficacy types. In addition, no studies to date have examined the change in self-efficacy types with PR among COPD patients recently hospitalized for an AECOPD, and whether the timing of PR after a hospitalization will impact this effect.

Self-efficacy is also specific to the salient challenges a person faces at the time the behaviour is being performed. Patients recently hospitalized for an AECOPD experience increases in dyspnea and fatigue (Celli, MacNee, & Force, 2004), along with reduction in health status (Seemungal et al., 1998), exercise tolerance and physical activity (Donaldson et al., 2005; Pitta et al., 2006a). When experiencing marked increases in breathlessness, COPD patients may be reluctant to engage in behaviours that beget shortness of breath (Harrison et al., 2015). For patients recently hospitalized for an AECOPD, the salient challenges for disease management behaviours may be managing their current level of dyspnea along with the physical performance of daily tasks, which should be introduced with thoughtful consideration of patients' physical and psychological state. In contrast, stable patients who have not had a recent AECOPD may feel more efficacious in their physical performance and managing breathlessness since they have not experienced a recent flare-up of their disease. Stable COPD patients may have more similar self-efficacy beliefs to sedentary adults or cardiac rehabilitation patients whose exercise management challenges are typically around fitting exercise into schedules regularly and overcoming motivational barriers (Rodgers et al., 2002; Rodgers et al., 2013). A comparison of self-efficacy beliefs over time in stable and AECOPD patients will enhance our understanding of salient challenges COPD patients face over the course of their disease as well as their confidence for overcoming those challenges. Further, the types of self-efficacy may change differently with PR, and it is unknown if PR offered earlier or later will influence the development of self-efficacy types. If the self-efficacy types differentially change, this might in-turn influence the content and delivery of PR in the future.

Primary Research Aims: The primary aims of this study were to (1) examine the change of self-efficacy for walking and self-efficacy for managing breathlessness with PR in patients recently hospitalized for an AECOPD (AECOPD patients) and patients not recently hospitalized for an AECOPD (stable patients), and (2) examine the change of self-efficacy types in early versus late PR in AECOPD patients compared to AECOPD control patients not attending PR. The secondary outcomes for the primary aims were functional exercise capacity, health status, and physical activity.

Hypotheses: It was hypothesized that walking self-efficacy and self-efficacy for managing breathlessness would improve with PR similarly, as both these salient challenges are targeted in PR content. It was also hypothesized that functional exercise capacity and health status would improve more with PR than physical activity, given that functional exercise capacity and health status improvement with PR has been well documented (McCarthy et al., 2015), but the consistent improvement of physical activity with PR has not (Spruit et al., 2015). The self-efficacy types, functional exercise capacity, health status, and physical activity would improve more in the patient groups attending PR compared to the controls who did not attend PR. Improvement of the self-efficacy types, functional exercise capacity, health status, and physical activity with PR would be similar in the early and late PR groups. It was anticipated that stable PR patients would have stronger self-efficacy than AECOPD PR patients.

Secondary Research Aim: The secondary research aim was to conduct an exploratory analysis to determine which self-efficacy type was the strongest predictor of outcomes associated with PR success in stable and AECOPD patients: functional exercise capacity, health status, and objectively measured physical activity behaviour.

Hypotheses: In both stable and AECOPD patients, the self-efficacy type most strongly related to health status at pre- and post-PR would be self-efficacy for managing breathlessness. This finding was anticipated because both health status and self-efficacy for breathlessness assess aspects related to breathlessness, which are relevant to all patients with COPD, stable or AECOPD. It was hypothesized that for AECOPD and stable COPD patients the self-efficacy type most strongly related to functional exercise capacity and physical activity at pre- and post-PR would be walking self-efficacy. This finding was anticipated because of the behavioural congruence between the assessments; that is, physical activity and functional exercise capacity both involve walking, and walking self-efficacy assesses confidence for walking.

The change in self-efficacy as it relates to the change in clinical-health and behavioural outcomes were also assessed. It was hypothesized that for AECOPD and stable COPD patients the relationships between change in the self-efficacy types and change in outcomes (i.e., 6MWT, SGRQ, and physical activity) would be small. The change in self-efficacy over time has been shown to be quadratic (non-linear) (McAuley et al., 2011; Rodgers et al., 2009; Selzler et al., In submission), although using change scores assumes that the change is linear. Therefore, the relationship between the changes in self-efficacy to other variables is likely more complicated than what can be accounted for in a change score analysis.

Method

Recruitment, Participants, & Setting

AECOPD patients were recruited from the University of Alberta Hospital and the Royal Alexandra Hospital following an AECOPD. AECOPD patients were eligible for the study if they have been admitted to the pulmonary or general internal medicine ward of the hospital with an AECOPD as their primary reason for admission and were able to provide written informed consent in English. A diagnosis of COPD was confirmed with a post bronchodilator forced expiratory volume in 1 second/forced vital capacity (FEV1/FVC) ratio of less than 0.7 (GOLD, 2015). Patients were excluded if they were 85 or older, had a terminal diagnosis with a life expectancy less than six months, had evidence of heart failure (B-type Natriuretic Peptide (BNP) >500 pg/ml) or an acute cardiac injury during admission (Troponin >1.0 ug/L), had previously participated in the study, or had signs of dementia or confusion. Nurses or respiratory therapists approached potential participants meeting the inclusion and exclusion criteria and provided them with a brief introduction to the study. From there, nurses introduced interested potential participants to a research assistant, who then described the study in further detail. Informed consent was obtained before initiation of study procedures.

Stable COPD patients were recruited from the Breathe Easy (Pulmonary Rehabilitation) Program at the G. F. MacDonald Centre for Lung Health. Stable patients were eligible for this study if they have a diagnosis of COPD (a post bronchodilator FEV1/FVC ratio of less than 0.7) (GOLD, 2015), were enrolled in PR, had not had an

AECOPD within 6 months, and were able to provide written informed consent in English. Respiratory therapists identified potential participants during usual care pre-PR assessment testing. A researcher approached potential participants at the end of the assessment period and explained the study. Informed consent was obtained from participants.

Participants chose to attend PR in the morning or afternoon three days a week (Monday/Wednesday/Friday) for six weeks, or two days a week for eight weeks (Tuesday/Thursday). Each PR class included two hours of exercise training and one hour of education. The exercise training included aerobic and resistance training that was tailored to the physical capabilities of each participant. The education sessions were delivered with a lecture-style approach on topics that pertain to disease management, including medication, nutrition, travel, oxygen, exercise, breathing techniques, etc. Patients also received three one-on-one sessions about inhaler techniques, maintaining exercise after PR, and stair climbing techniques/pacing.

Participants & Procedures

The measures of this study were being collected as part of a larger study that examined the impact of PR on cardiovascular and pulmonary outcomes in COPD patients following hospital discharge for an AECOPD. Ethical approval was obtained through university and hospital research ethics boards.

This four-group quasi-experimental study compared the impact of PR on self-efficacy in AECOPD patients attending early PR (within one month of hospitalization), AECOPD patients attending late PR (within three to four months of hospitalization), a control group of AECOPD patients not attending PR, and a group of stable patients attending PR. On the day of hospital discharge, AECOPD patients were invited to attend PR. Those who accepted the invitation were referred to the PR-program by study affiliated physicians and randomly assigned with equal allocation to either AECOPD early-PR or AECOPD late-PR groups. Those who declined the invitation (but consented to the research) formed the AECOPD no-PR/control group who did not attend PR. Stable patients who were referred to PR by their own physician were part of the stable PR group. The Breathe Easy Program at the G. F. MacDonald Centre for Lung Health managed PR referrals and provided the PR program. The AECOPD early-PR group were enrolled in PR within one month of hospital discharge. The AECOPD late-PR group were enrolled in PR within three to four months following hospital discharge. The stable PR group were enrolled in PR according to usual care procedures, which is typically two-three months following referral. Once in PR, participants preceded through the program as per usual care. All participants completed assessments of self-efficacy, health status, functional exercise capacity, and step count prior to attending PR (pre-PR), and at the end of the PR program (post-PR). Although not attending PR, the AECOPD control group completed the same assessments at the same scheduled times. The questionnaire-based assessments are provided in Appendix A. Demographic and clinical data were obtained through electronic medical records.

Measures

Demographic and clinical information. Age, sex, BMI, and smoking history in pack years, were obtained through electronic medical records.

Spirometry. Standard spirometry assessments were performed by qualified technicians on all patients prior to attending PR.

Modified Medical Research Council (mMRC) dyspnea scale (Mahler & Wells, 1988). This scale was used to assess patients' pre-PR functional impairment due to breathlessness from 0 (not troubled by breathlessness except with strenuous exercise) to 4 (too breathless to leave the house or breathless when dressing/undressing).

Self-efficacy for walking. A modified version of the Self-efficacy for Walking Scale (SEW; McAuley et al., 1991) assessed participants' beliefs in their ability to walk at a moderate pace for a specified duration, irrespective of distance. Participants responded to 9 items following the prompt, "How confident are you that you can walk every day at a moderate pace for…", on a 100% confidence scale, where 0% indicated no confidence and 100% indicated complete confidence. Each item increased in 5-minute blocks, from 5 to 45 consecutive minutes. A total walking self-efficacy score was calculated by taking a mean of the items. The internal consistency of this scale was .97 at pre- and post-PR.

COPD Self-Efficacy Scale (Wigal et al., 1991). The CSES is a 34-item scale that assesses confidence for managing and avoiding breathing difficulties during activities or situations. One item, pertaining to managing or avoiding breathing difficulties when around pollution was missing from the questionnaire. Therefore, all analyses of this scale are from the remaining 33 items. Participants rated their confidence for each item from 1-5, where 1 = very confident and 5 = not at all confident. A total CSES score is calculated by taking the mean of the item responses. The internal consistency of this scale was .97 at pre-PR and .96 at post-PR.

Six Minute Walk test (6MWT). The 6MWT assesses functional exercise capacity by taking the mean of the best 2 of 3 self-paced 6-minute hallway walks. Participants were given standardized reinforcement and encouraged to walk as fast as they could manage. The 6MWT has been shown to correlate with lung function, health status, and peak oxygen consumption (Brown & Wise, 2007), and be predictive of mortality (Casanova et al., 2008).

St. George's Respiratory Questionnaire (Jones et al., 1992). The SGRQ is an assessment of COPD specific health status made up of 50 items. All items are rated on a Likert type scale of varying points, which yield three content areas; symptoms, activities, and impacts. Amalgamation of the three content areas creates a Total score. The Total score is expressed as a percentage of overall impairment, where 100 indicates the poorest possible health status and 0 the best possible health status. The evidence of validity and reliability of this measure has been well established (Jones, 2005; Jones et al., 1992).

Objective Physical Activity. Participants' wore a Fitbit Flex™ or Fitbit Flex 2™ to measure physical activity. Step count was recorded from the Fitbit™ software which provides data in 15-minute intervals. Participants were instructed to wear the Fitbit™ on the non-dominant hand for seven consecutive days during all waking hours. Most participants wore the Fitbit™ for the first five days only and many did not exceed 10 hours of wear time per day. Therefore, data analysis of step count was based on the first 10 hours of data recorded that was averaged across the first five consecutive days.

Data Analysis

All statistical analyses were performed using IBM SPSS Statistics 24. Unless otherwise stated, the assumptions of statistical analyses were tested and tenable. At pre-PR two step count values > 19,000 per day were identified as outliers and deemed unlikely values. Winsorizing was used and the values were replaced by the next highest value of that group (4440 in AECOPD late-PR group, and 2351 in AECOPD no-PR/control group). At post-PR the step count and SGRQ distributions were mildly kurtotic, 2.337 and 3.899, respectively. No data transformations were conducted due to the few and minor deviations to normality.

A missing value analysis indicated that 31.64% of values across the data set were missing. These data were missing at random, Little's MCAR χ^2 (320) = 334.12, p = .282. The percentage of missing data for each variable across time is presented in Table 2.1. Missing data were handled on an analysis-by-analysis basis given that statistical programs are unable to perform multiple imputation for most ANOVA-related analyses (Graham, 2012). A more detailed discussion of missing data theory, approaches, and decisions are presented in Appendix B.

Primary Analyses

To determine the impact of PR on self-efficacy levels on AECOPD and stable COPD patients, a 4(group: AECOPD no-PR/control, AECOPD early-PR, AECOPD late-PR, stable PR) x 2(self-efficacy type: managing breathlessness, walking) x 2(time: pre-PR, post-PR) mixed MANOVA with repeated measures on the last two factors was conducted. Missing data for participants providing partial data were imputed at the item level, such that missing items were replaced with the participants' mean of available items. Schafer and Graham (2002) support this approach when the items come from a single, well-defined scale. Following guidelines outlined by Graham (2012), it was determined that the scales met the criteria of a well-defined scale. Imputation of partial missing data resulted in complete cases for 95% of pre-PR data (n = 105; AECOPD no-PR = 22, AECOPD early-PR = 22, AECOPD late-PR = 21, stable PR = 40) and 73% of post-PR data (n = 77; AECOPD no-PR/control = 13, AECOPD early-PR = 15, AECOPD late-PR = 11, stable-PR = 38). The mixed MANOVA was conducted three times; first with group-level mean substitution of post-PR values, second on complete cases, and last with the last observation carried forward (intention-to-treat analysis), acknowledging that all three approaches may introduce some level of bias into the results. Forced expiratory volume in 1 second (FEV1) % predicted was tested as a covariate.

To determine the impact of PR on health status, functional exercise capacity, and steps per day in AECOPD and stable COPD patients, 4(group: AECOPD no-PR/control, AECOPD early-PR, AECOPD late-PR, stable PR) x 2(time: pre-PR, post-PR) mixed MANOVAs with repeated measures on the last factor were conducted for the 6MWT, SGRQ, and steps per day. The mixed MANOVAs were conducted three times; first with group-level mean substitution of pre- and post-PR values, second on complete cases, and last with the last observation carried forward (intention-to-treat analysis), acknowledging that all three approaches may introduce some level of bias into the results. Forced expiratory volume in 1 second (FEV1) % predicted was tested as a covariate.

Secondary Analyses.

To determine which types of self-efficacy were strongest predictors of PR outcomes, Hierarchical Multiple Regressions at pre-, post-PR, and on change scores were conducted for the SGRQ total score, 6MWT, and steps per day with demographic/clinical indicators entered in the first block of predictors and self-efficacy for walking and managing breathlessness entered in the second block. A series of preliminary analyses were conducted to determine if separate multiple regression analyses should be conducted on AECOPD and stable COPD patient groups. First, Pearson product-moment correlations were computed between self-efficacy types (walking and managing breathlessness) and PR outcomes (SGRQ total score, 6MWT, and steps per day) stratified by AECOPD/stable COPD patient groups. Next, Fisher's r-to-z transformations were computed, and the values compared to determine if the correlations between the self-efficacy types and outcome variables were statistically different in stable compared to AECOPD patients. The correlations were statistically different; therefore, separate multiple regressions were conducted for the AECOPD and stable groups. Then, to determine the demographic/clinical indicators to be controlled for in the multiple regression analyses, partial correlations were computed between demographic/clinical indicators (age, sex, BMI, pack years smoking, mMRC dyspnea, FEV1 % predicted, FEV1/FVC%) and PR outcomes (SGRQ total score, 6MWT, and steps per day), while controlling for self-efficacy for walking and managing breathlessness. The demographic and clinical indicators that had statistically significant partial correlations to the PR outcomes were controlled for in the multiple regression analyses. Multiple imputations were used to replace missing data for the secondary analyses. As recommended by Graham (2012), the settings for the multiple imputations were 40 imputations and 50 iterations of fully conditional specification (MCMC) between imputed data sets.

Results

The primary analyses were conducted on 105 participants that consented to participate and provided at least partial data on the primary outcomes at baseline: 22 in the AECOPD control group, 22 in the AECOPD early-PR group, 21 in the AECOPD late-PR group, and 40 in the stable PR group. The power for detecting a statistically significant time by group interaction in the primary analysis, with *N* = 105, alpha = .05, and a medium effect was .54 (G*Power; Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). Demographic/clinical indicators and descriptive statistics for study variables are presented in Table 2.2. A MANOVA with Games-Howell post-hoc tests comparing demographic/clinical indicators across groups indicated the following group differences: the stable PR group had greater FEV1/FVC% than all of the AECOPD groups, *p*'s between <.001 – .003; and the stable PR group had greater FEV1% predicted than the AECOPD no-PR group and AECOPD early-PR group, *p*'s = .021 and .001, respectively. The chi-square test examining group differences across gender was not statistically significant, *p* = .30.

Primary Analysis of Primary Outcome – Self-efficacy Types

Table 2.3 reports the results of the mixed MANOVA and follow-up ANOVAs across the three analyses: group-level mean substation of post-PR values, complete case analysis, and last observation carried forward. The interaction terms that contained time and group were notably different across the three analyses, although there was only one instance of discrepancy in statistical significance. In the time by group interaction for the CSES, the group-level mean substitution and complete case analyses yielded a statistically significant effect, whereas the last observation carried forward analysis did not. In general, the interaction terms that contained time and group were approaching statistical significance in the group-level means substitution analysis, but not in the complete case and last observation carried forward analyses. The remaining statistical effects were consistent across the three analyses. The covariate of FEV1% predicted was not statistically significant for any of the time effects, suggesting that improvement in self-efficacy over PR is not conditional on degree of lung function impairment. Below is a more detailed summary of the mixed MANOVA with mean substitution of post-PR values. This analytical approach is reported over the others as it has more power than the complete case analysis and the last observation carried forward analysis was thought to be overly conservative.

The mixed MANOVA conducted on the group-level mean substitution data yielded a statistically significant time by self-efficacy type interaction, $F(1, 101) = 20.31$, $p < .001$, $\eta^2_p = .17$, and self-efficacy type by group interaction, $F(1, 101) = 10.26$, $p < .001$, $\eta^2_p = .23$. There were also main effects of time, $F(1, 101) = 19.07$, $p < .001$, $\eta^2_p = .16$, self-efficacy type, $F(1, 101) = 203.32$, $p = .001$, $\eta^2_p = .67$, and group, $F(3, 101) = 9.69$, $p = .001$, $\eta^2_p = .22$. The time by self-efficacy type by group interaction was approaching statistical significance, $F(3, 101) = 2.60$, $p = .06$, $\eta^2_p = .07$.

Follow-up mixed ANOVAs were conducted for each self-efficacy type. For walking self-efficacy, the time by group interaction was approaching significance, $F(3, 101) = 2.47$, $p = .07$, $\eta^2_p = .07$, with the time effect $F(1, 101) = 19.70$, $p < .001$, $\eta^2_p = .16$, and group effect statistically significant, $F(3, 101) = 9.98$, $p < .001$, $\eta^2_p = .23$. Figures 2.1a-f display the time by group interactions for walking self-efficacy and self-efficacy for managing breathlessness. Graphical and numerical inspection of the data indicated that walking self-efficacy did not change in the AECOPD no-PR control group, and that rate of change for walking self-efficacy was greatest in the AECOPD late PR-group, followed by the stable PR group, and then the AECOPD early-PR group. The follow-up mixed ANOVA on self-efficacy for coping with breathing difficulties, yielded a statistically significant time by group interaction $F(3, 101) = 7.00$, $p = .001$, $\eta^2_p = .17$, main effect of time $F(1, 101) = 11.35$, $p = .001$, $\eta^2_p = .10$, and group $F(3, 101) = 3.90$, $p = .003$, $\eta^2_p = .13$. Graphical and numerical inspection of the data indicated that the AECOPD no-PR group had a reduction in self-efficacy for managing breathlessness, whereas the AECOPD early-PR group, AECOPD late-PR group, and stable PR group had increases, with the AECOPD early-PR and AECOPD late-PR having greater increases than the stable PR group.

Primary Analysis of Secondary Outcomes – Functional Exercise Capacity, Health Status, and Physical Activity

Table 2.4 reports the results of the mixed ANOVAs for the 6MWT, SGRQ, and steps per day across the three analytical approaches: group-level mean substitution, complete case analysis, and last observation carried forward. For the 6MWT mixed ANOVA the results of the three analytical approaches were the same. For the SGRQ mixed ANOVA, the results of the three analytical approaches were variable, and for the steps per day mixed ANOVA the results of the three analytical approaches were mostly similar, except for the time by group interaction, where there was a statistically significant effect for the mean substitution analysis only. The covariate of FEV1% predicted was not statistically significant for any of the time effects, suggesting that improvement in the 6MWT, SGRQ, and steps per day over PR is not conditional on degree of lung function impairment. Below is a more detailed summary of the mixed ANOVA with the last observation carried forward. This analytical approach is reported over the complete case analysis because it is a more powerful approach. While mean substitution was reported in the previous mixed MANOVA and is thought to be a better approach when it reasonable to assume change amongst outcomes, it was not deemed suitable here. In the current analyses mean substitution was used to impute both pre- and post-PR values, whereas in the previous analyses mean substitution was only needed on post-PR values. The mean substitution resulted in more than half of the observations being imputed for the 6MWT (54.9%) and physical activity in steps per day (57.6%), and just under half of the observations imputed for the SGRQ (43.85%). This amount of data imputation was thought to introduce too much bias and make the results unreliable.

For the 6MWT, the mixed ANOVA conducted on the last observation carried forward data yielded a statistically significant time by group interaction, $F(3, 94) = 6.20$, $p = .001$, $\eta^2_p = .17$, time effect $F(1, 94) = 17.21$, $p = .000$, $\eta^2_p = .16$, and group effect, $F(3, 94) = 21.39$, $p = .000$, $\eta^2_p = .41$. The time by group interaction is displayed in Figure 2.2a. Graphical and numerical inspection of the data indicated that distance on the 6MWT increased in the stable PR (+34.17m) and AECOPD early-PR (+45.26m) groups and did not change in the AECOPD late-PR(-0.57m) and AECOPD no-PR (-0.86m) groups. The increases in 6MWT in the stable PR group and AECOPD early-PR groups met the minimum clinically importance difference estimate of 25-35m (Holland et al., 2010; Puhan et al., 2011; Puhan et al., 2008).

For the SGRQ, the mixed ANOVA conducted on the last observation carried forward data yielded a statistically significant time by group interaction, $F(3, 94) = 6.20$, $p = .001$, $\eta^2_p = .17$, and time effect $F(1, 94) = 17.21$, $p = .000$, $\eta^2_p = .16$. The time by group interaction is displayed in Figure 2.2b. Graphical and numerical inspection of the data indicated that health status improved (as indicated by a decrease in impairment) over PR in the stable PR (-6.37%), AECOPD early-PR (-2.37%), AECOPD late-PR (-1.73%) groups, and did not change in the AECOPD no-PR group (-.08%). The improvement in health status in the stable PR group met the minimum clinically important difference of 4% (Jones, 2001).

For steps per day, the mixed ANOVA conducted on the last observation carried forward data yielded a statistically significant effect of group, $F(3, 91) = 5.62$, $p = .001$, $\eta^2_p = .16$. A Games-Howell post-hoc test indicated that the AECOPD no-PR group and stable PR group differed in steps per day, with AECOPD no-PR group taking fewer steps per day than the stable PR group. Although not statistically significant, the time by group interaction is displayed in Figure 2.2c.

Preliminary Secondary Analyses - Determining Multiple Regression Equations for PR Outcomes

The AECOPD no-PR, early-PR, and late-PR were collapsed into one AECOPD group (n = 71). The secondary analyses were conducted on all 111 participants who consented to the study: 71 AECOPD patients, and 40 stable patients. The correlations and z-transformations for self-efficacy types (walking and managing breathlessness) and PR outcomes (6MWT, SGRQ, step count) stratified by AECOPD and stable COPD groups are presented in Table 2.5. All estimates are pooled from 40 multiple imputation samples. The relationships for the self-efficacy types to the PR outcomes were statistically different for stable and AECOPD patients. Further, there were statistical differences in the partial correlations for demographic/clinical indicators to PR outcomes while controlling for the self-efficacy types for the AECOPD and stable patients. As a result of these preliminary analyses, it was decided to conduct separate multiple regressions for the AECOPD and stable COPD groups.

Several demographic and clinical indicators were identified as having statistically significant partial correlations to the PR outcomes (6MWT, SGRQ, steps) after controlling for the self-efficacy types and were controlled for in the respective multiple regression analyses. The contribution of these demographic/clinical indicators, along with the contribution of self-efficacy for walking and self-efficacy for managing breathlessness to functional exercise capacity, health status, and physical activity at pre-and post-PR in both the AECOPD and stable COPD patients are presented in Table 2.6. All estimates are pooled from 40 multiple imputation samples.

Secondary Analyses – Predicting the 6MWT from Self-efficacy Types at Pre- and Post-PR

After controlling for demographic/clinical indicators, the multiple regression model predicting the 6MWT from self-efficacy for walking and managing breathlessness at pre-PR was statistically significant in the AECOPD, $F(4, 66) = 17.08$, $p = .000$, $R^2_{adj} = .47$; and stable COPD patients, $F(3, 36) = 13.30$, $p = .000$, $R^2_{adj} = .44$. In the AECOPD patients, self-efficacy for walking and managing breathlessness accounted for an additional 13% of unique variance in the 6MWT at pre-PR, whereas in the stable patients, self-efficacy for walking and managing breathlessness accounted for 20% of unique variance. In both the AECOPD and stable COPD patients, self-efficacy for walking was the only self-efficacy type that was a statistically significant predictor, p's < .01, with stronger walking self-efficacy associated with greater distance on the 6MWT.

The same pattern of results was observed when predicting the 6MWT from self-efficacy for walking and managing breathlessness at post-PR. After controlling for demographic/clinical indicators, the multiple regression model predicting the 6MWT from self-efficacy for walking and managing breathlessness at post-PR was statistically significant in the AECOPD, $F(2, 68) = 19.16$, $p = .000$, $R^2_{adj} = .33$; and stable COPD patients, $F(4,35) = 14.33$, $p = .000$, $R^2_{adj} = .57$. In the AECOPD patients, self-efficacy for walking and managing breathlessness accounted for 33% of unique variance in the 6MWT at post-PR, whereas in the stable COPD patients, self-efficacy for walking and managing breathlessness accounted for 24% of unique variance. In both the AECOPD and stable COPD patients, self-efficacy for walking was the only self-efficacy type that was a statistically significant predictor of the 6MWT at post-PR, p's < .001, with stronger walking self-efficacy associated with greater distance on the 6MWT.

Secondary Analyses – Predicting the SGRQ from Self-efficacy Types at Pre- and Post-PR

After controlling for demographic/clinical indicators, the multiple regression model predicting the SGRQ total score from self-efficacy for walking and managing breathlessness at pre-PR was statistically significant in the AECOPD patients, $F(4,66) = 12.23$, $p = .000$, $R^2_{adj} = .39$; and stable COPD patients, $F(4,35) = 6.85$, $p = .000$, $R^2_{adj} = .37$. In the AECOPD patients, self-efficacy for walking and managing breathlessness accounted for 8% of unique variance in the SGRQ, whereas in the stable patients, self-efficacy for walking and managing breathlessness accounted for 20% of unique variance. In both the AECOPD and stable COPD patients, self-efficacy for walking was the only self-efficacy type that was a statistically significant predictor, *p*'s .016 and <.001, respectively, with stronger walking self-efficacy associated with lower impairment of health status.

A similar pattern of results was observed when predicting the SGRQ from self-efficacy for walking and managing breathlessness at post-PR. After controlling for demographic/clinical indicators, the multiple regression model predicting the SGRQ from self-efficacy for walking and managing breathlessness at post-PR was statistically significant in the AECOPD, $F(2, 68) = 22.67$, $p = .000$, $R^2_{adj} = .37$; and stable COPD patients, $F(4,35) = 4.79$, $p = .005$, $R^2_{adj} = .28$. In the AECOPD patients, self-efficacy for walking and managing breathlessness accounted for 33% of unique variance in the SGRQ at post-PR, whereas in the stable patients, self-efficacy for walking and managing breathlessness accounted for 20% of unique variance. In both the AECOPD and stable COPD patients, self-efficacy for walking was a statistically significant predictor, *p*'s = .005 and .004, respectively, with greater walking self-efficacy associated with lower impairment of health status. In the AECOPD patients, self-efficacy for managing breathlessness was also a statistically significant predictor of the SGRQ at post-PR, *p* =

.019, with greater self-efficacy for managing breathlessness associated with lower impairment of health status.

Secondary Analyses – Predicting Steps per Day from Self-efficacy Types at Pre- and Post-PR

After controlling for demographic/clinical indicators, the multiple regression model predicting steps per day from self-efficacy for walking and managing breathlessness at pre-PR was statistically significant in the AECOPD, $F(3, 67) = 6.25$, $p = .003$, $R^2_{adj} = .18$; and stable COPD patients, $F(2, 37) = 12.58$, $p = .000$, $R^2_{adj} = .37$. In the AECOPD patients, self-efficacy for walking and managing breathlessness accounted for an additional 14% of unique variance in steps per day, whereas in the stable patients, self-efficacy for walking and managing breathlessness accounted for 37% of unique variance. In both the AECOPD and stable COPD patients, self-efficacy for walking was a statistically significant predictor of steps per day, *p*'s = .001 and <.001, respectively, with stronger walking self-efficacy associated with greater steps per day. In the stable COPD patients, self-efficacy for managing breathlessness was also a statistically significant predictor of steps per day at pre-PR, $p = .021$, with stronger self-efficacy for managing breathlessness associated with fewer steps per day. However, the beta weight of self-efficacy for managing breathlessness to steps per day was substantially larger than the zero order correlation suggesting that suppression was present (Tabachnick & Fidell, 2013). Walking self-efficacy was the only other DV in the equation suggesting that it enhanced the importance of self-efficacy for managing breathlessness to physical activity by suppressing irrelevant variance in the relationship.

A similar pattern of results was observed when predicting steps per day from self-efficacy for walking and managing breathlessness at post-PR. After controlling for demographic/clinical indicators, the multiple regression model predicting the steps per day from self-efficacy for walking and managing breathlessness at post-PR was statistically significant in the AECOPD, $F(2, 68) = 13.70$, $p = .002$, $R^2_{adj} = .26$; and stable COPD patients, $F(2,37) = 28.26$, $p = .000$, $R^2_{adj} = .57$. In the AECOPD patients, self-efficacy for walking and managing breathlessness accounted for 26% of unique variance in steps per day at post-PR, whereas in the stable group, self-efficacy for walking and managing breathlessness accounted for 57% of unique variance. In both the AECOPD and stable COPD patients, self-efficacy for walking was a statistically significant predictor of steps at post-PR, *p*'s = .002 and < .001, respectively, with stronger walking self-efficacy associated with greater steps per day. In the AECOPD patients, the relationship between self-efficacy for managing breathlessness and steps per day at post-PR was approaching statistical significance, $p = .054$, with stronger self-efficacy for managing breathlessness associated with fewer steps per day. Similar to the analysis of the pre-PR data, walking self-efficacy was a suppressor in the relationship between physical activity and self-efficacy for managing breathlessness. No demographic/clinical indicators had a statistically significant unique relationship to steps per day in either the AECOPD or stable COPD patients at pre- or post-PR.

Secondary Analyses – Predicting Change in the 6MWT, SGRQ, and Steps per Day from Self-efficacy Types

None of the multiple regression models predicting change in the 6MWT, SGRQ, or steps per day, from change in self-efficacy for walking, change in self-efficacy for managing breathlessness, and demographic characteristics were statistically significant, *p*'s between = .130 and .234. The amount of variance accounted for by the self-efficacy types in the outcomes was less than 5% across all models. The change in self-efficacy for walking and the change in self-efficacy for managing breathlessness did not predict change in the 6MWT, SGRQ, or steps per day in either the AECOPD or stable COPD patients, all *p*'s > .20.

Discussion

This study examined the change of two self-efficacy types (walking and managing breathlessness), functional exercise capacity, health status, and physical activity with PR in AECOPD and stable COPD patients; and compared these changes in early-PR, late-PR, and no-PR in patients who had recently been hospitalized for an AECOPD. An additional purpose of this study was to determine the self-efficacy types with the strongest predictive relationships to outcomes associated with PR success (i.e., functional exercise capacity, health status, physical activity) in stable and AECOPD patients. This is the first study to compare the change of self-efficacy with PR in AECOPD and stable COPD patients and provides insight into whether the timing of PR after an AECOPD impacts this effect.

The results of this study indicate that self-efficacy improved as much or more with PR in AECOPD patients compared to stable COPD patients. Self-efficacy for walking and managing breathless improved with PR in both AECOPD and stable COPD patients, although there was greater improvement of self-efficacy for managing breathlessness observed in the AECOPD patients. These results are consistent with previous research that has found self-efficacy for walking (Lox & Freehill, 1999; Ries et al., 1995) and self-efficacy for managing breathlessness (Khoshkesht et al., 2015; Scherer & Schmieder, 1997) to improve with PR in stable patients with COPD. In the present study, AECOPD patients, on average, were ‘somewhat confident’ for managing or avoiding breathing difficulties before PR, and were ‘pretty confident’ by the end of PR. In contrast, stable COPD patients were, on average, ‘pretty confident’ before and at the end of PR. Thus, these results may indicate that AECOPD patients have more to gain from PR than stable COPD patients, in terms of confidence for managing breathlessness. In terms of walking self-efficacy, both AECOPD and stable COPD patients had ample room for improvement with PR, which may indicate that confidence for walking at a moderate pace warrants early attention from healthcare professionals for both AECOPD and stable COPD patients.

Functional exercise capacity and health status improvement with PR was observed in stable COPD and AECOPD patients, although only the improvement in the stable PR group met the minimum clinically important difference (MCID) for both the 6MWT (Holland et al., 2010; Puhan et al., 2011; Puhan et al., 2008) and SGRQ (Jones, 2005). However, the MCIDs for the 6MWT and SGRQ may be different values for stable compared to AECOPD patients, or AECOPD patients may just need more time to reach those values. The patients who had experienced a recent AECOPD began PR more functionally limited, perceived themselves to have lower health status, were less active, and had weaker self-efficacy than the patients who did not experience an AECOPD within at least six months (i.e., the stable group). Even after completion of PR, the AECOPD patients were at similar and no greater levels of functional exercise capacity, health status, physical activity, and self-efficacy as the stable patients at the beginning of PR. Thus, the trajectory of outcome improvement when recovering from an exacerbation may be different from the trajectory of those who are not recovering. Also, for patients with significant limitations, small improvements may have a meaningful impact on daily functioning.

Still, improvement of health status was observed among AECOPD patients who attended PR, early or late, but was not observed in AECOPD patients who did not attend PR. Interestingly, improvement of functional exercise capacity was not observed in the late PR group, although it was observed in the early PR group. The late PR group only had 9 of 21 complete cases of pre- and post-PR 6MWT data; therefore, 57% of the post-PR observations were carried forward from the pre-PR observations. Thus, the conservative analytical approach may have contributed to the lack of statistically significant improvement in functional exercise capacity among the late-PR group, as well as the limited improvement in the SGRQ among the AECOPD early- and late-PR groups. It has been consistently documented that functional exercise capacity and health status improve with PR in stable COPD patients (McCarthy et al., 2015). The results of this study corroborate previous findings that functional exercise capacity, and health status improve with PR in patients who have recently had an AECOPD (Puhan et al., 2016), and support the delivery of PR services in patients with and without a recent AECOPD (Criner et al., 2015).

Previous literature on the change of physical activity levels with PR among COPD patients has been inconclusive (Spruit et al., 2015). The type and timing of physical activity measurement, duration of PR, and content of PR – specifically the focus on knowledge-based education rather than implementation of strategies to support behaviour change in PR, have been implicated as potential explanations for the lack of physical activity change with PR (Spruit et al., 2015). In this study, physical activity was measured objectively before participants started PR and after they completed PR. Therefore, the assessment was not subject to recall error and did not encompass the physical activity that patients performed while in PR. However, our results are based on 10 hours of wear time as many participants did not wear the Fitbits™ the entire day. Previous research in stable COPD patients has indicated that 10 hours of wear time is enough to detect improvements in step count, provided that the sample size is ≥ 53 (Demeyer et al., 2014). In this study only 61 of 105 participants (54 of whom attended PR) provided step count data at both time points, many of whom were patients with a recent AECOPD. It is possible that a greater sample size is needed to detect improvements in physical activity among AECOPD patients, as the amount of change expected may be less among patients recovering from an AECOPD. However, as noted above, the content and structure of PR may have also contributed to the lack of improvement in physical activity over PR. During PR, patients were encouraged to be physically active and discussed plans to engage in physical activity after PR with a health care practitioner. They engaged in exercise-based training 2-3 days a week during PR and may not have engaged in much more physical activity outside of PR due to fatigue and knowing that they will be active while in PR. Thus, patients may not gain practical experience integrating physical activity into their typical routines while attending PR, and as a result may not know how to get started on their own, or how to deal with physical activity barriers in non-PR environments.

Overall, the results of this study indicate that the timing of PR after an AECOPD, either within one month (early) or between three and four months (late), does not greatly impact the benefits patients obtain from PR. Both early and late PR resulted in improved self-efficacy and clinical health outcomes, whereas not attending PR after an AECOPD resulted in limited to no improvement. Given that PR after an AECOPD is associated with few adverse events (Criner et al., 2015; Puhan et al., 2016), and positively impacts health outcomes (Puhan et al., 2016), it is recommended that PR be the standard of care following an AECOPD (Criner et al., 2015). Interestingly, the AECOPD no-PR group started off with lower confidence, greater impairment in functional exercise capacity and health status, and lower physical activity levels than all the other groups, even the AECOPD early and late PR groups, suggesting that those who self-selected no-PR after an AECOPD may be the most in need of PR. While originally it was planned to randomize the AECOPD patients to the no-PR, early-PR, or late-PR groups, potential participants indicated a strong preference for either attending or not attending PR. Therefore, it was decided to let participants self-select PR or not to maximize study enrollment and randomize those who wanted to attend PR to early or late programs. Given that clinical health outcomes and self-efficacy have been shown to improve with PR among people who have recently experienced an AECOPD, more research is needed to better understand how to facilitate patient uptake of this valuable service.

When predicting clinical health outcomes and physical activity before and after PR, self-efficacy for walking seems to be the superior predictor to self-efficacy for managing breathlessness in both AECOPD and stable COPD patients. While it was hypothesized that self-efficacy for walking would be a superior predictor of functional exercise capacity and physical activity than self-efficacy for managing breathlessness, it was not expected to be a superior predictor of health status, given that both the SGRQ and the CSES assess aspects related to breathlessness. However, breathlessness and functional exercise impairment are strongly correlated (Waatevik et al., 2012), and while breathlessness in COPD undoubtedly contributes to health status, the link between breathlessness and health status may manifest in the ability functionally move around one's environment, thus creating the association between self-efficacy for walking and health status.

The pattern of relationships between the self-efficacy types and PR outcomes was similar in the AECOPD and stable COPD patients, although the strength of the relationships of self-efficacy to outcome variables appears to be different across the groups. There was more unique variance accounted by the self-efficacy types for physical activity in the stable compared to the AECOPD patients at both pre- and post-PR. It may be that stable and AECOPD patients have different salient challenges. AECOPD patients had more impairment in functional exercise capacity and health status than stable patients, and while they are also less physically active, this may not become a pertinent concern until after a certain level of functional exercise capacity and health status has been built up. On the other hand, stable patients may have a greater handle on improving functional exercise capacity and health status and may be ready to engage in physical activity. Further, while the relationships of self-efficacy to clinical-health and behavioural outcomes were weaker among the AECOPD compared to the stable COPD patients before PR, the relationships between self-efficacy and all outcomes strengthened over the course of PR among AECOPD patients. The link between self-efficacy and behaviour is only observed if the necessary incentives (i.e., outcome expectations) are in place (Bandura, 1997). In AECOPD patients who are more limited than stable patients, the formation of outcome expectations and the link between self-efficacy and clinical-health and behavioural outcomes may not be realized until patients perceive a connection between the behaviours learned in PR and the improvement in functional abilities and symptoms (i.e., dyspnea). Thus, it seems stable patients are ready to be challenged to become more physically active at the outset of PR, whereas AECOPD patients may need more time to manage dyspnea and develop functional abilities before dealing with the challenge of becoming more physical active.

Consistent with the hypothesis, the change in self-efficacy types with PR were not found to be related to the change in the 6MWT, SGRQ, or steps per day with PR. The change in self-efficacy over time has been documented to be quadratic (i.e., non-linear) (McAuley et al., 2011; Rodgers et al., 2013; Selzler et al., In submission) and quite variable over time (Selzler et al., In submission). Thus, the relationship among the change in self-efficacy to clinical-health and behavioural outcomes is likely to be more complicated than what can be accounted for in a change score analysis, which assumes that the change over time is linear. Self-efficacy is strongly influenced by environmental circumstances, which can explain why self-efficacy is mostly likely to have the strongest relationship to cross-sectional outcomes (Bandura, 1997).

An important finding of this research was that self-efficacy, specifically walking self-efficacy, was a stronger predictor of clinical-health outcomes and physical activity than demographic/clinical indicators. In fact, no demographic or clinical indicators had statistically significant relationships to physical activity when controlling for self-efficacy. This finding is promising as it suggests that physical activity is being influenced by a psychosocial construct that can be enhanced. Specifically, self-efficacy can be enhanced by individuals having their own successful behavioural experiences (mastery experiences), observing others have successful behavioural experiences (vicarious experiences), communicating to individuals that they are capable of performing the behaviour (verbal persuasion), and facilitating positive affective and physiological states associated with the behaviour while reducing negative affective and physiological states (Bandura, 1997). One study by Larson et al. (2014) found that a self-efficacy intervention designed to enhance all sources of self-efficacy was successful at increasing light physical activity among a group of COPD patients. Although few interventions designed to enhance self-efficacy have been tested in COPD patients, the results of this study along with the study by Larson et al. (2014) suggests future pursuits to develop and test such interventions are warranted.

While this was the first study to examine the change of two types of self-efficacy with PR in stable and AECOPD patients and provide insight into the most beneficial timing of PR after an AECOPD there are some limitations to be acknowledged. Most importantly, there was a notable amount of missing data across the measures, including individual items on the self-efficacy scales in addition to the complete absence of certain assessments even though participants remained in the study. While the missing data analysis indicated that the data was missing completely at random (MCAR) and thus a random process, the amount of missing data could make imputation unreliable. For multiple imputation analyses, 40 data sets were requested to help mitigate this concern (Graham, 2012). Further, at present there is no formal process for pooling sums of squares and *F*-tests for mixed ANOVAs in statistical software, and so less desirable methods for handling missing data such as mean substitution, last observation carried forward, and listwise deletion were implemented for these analyses. Mean substitution and last observation carried forward are conservative analyses that reduce variability and can provide biased parameter estimates. Listwise deletion reduces the number of cases substantially and therefore reduces the power in the analyses.

It is important to note that most of the missing data came from the AECOPD participants. These participants were recently hospitalized for and recovering from an AECOPD, which can be life threatening (Rodriguez-Roisin, 2000). During an AECOPD patients experience a marked increase in symptoms, including breathlessness, cough, and phlegm volume (Anthonisen et al., 1987), in addition to an increase in fatigue and anxiety (Rodriguez-Roisin, 2000). Thus, the missing data may reflect the condition of the patients along with a disinterest or lack of incentive among the patients to participate in testing. Future research investigating how to facilitate interest and incentives for participating in research among this patient group is needed.

An additional limitation of this study was the omission of the assessment of self-efficacy for exercise. Self-efficacy for exercise has been found to be a predictor of functional exercise capacity (Garrod et al., 2006; Selzler et al., 2016) and attendance at PR (Selzler et al., 2016) in stable COPD patients. It would be beneficial to determine which type of self-efficacy is most strongly related to clinical health outcomes and physical activity so that interventions can be tailored appropriately. Despite these limitations this study provides important preliminary evidence regarding the impact of PR on self-efficacy for walking and self-efficacy for managing breathlessness in AECOPD and stable patients and provides insight into the importance of the timing of PR after an AECOPD.

In conclusion, self-efficacy and clinical health outcomes improved with PR in both stable and AECOPD patients. The results of this study suggest that PR is beneficial when delivered within one month or within three to four months after an AECOPD, and that there is not much difference in outcome improvement when delivered at these two time points. However, PR may need to be longer in AECOPD patients than stable COPD patients, as even after PR, AECOPD patients were still below the pre-PR levels of stable patients on outcomes (i.e., walking self-efficacy, self-efficacy for managing breathlessness, functional exercise capacity, health status, and physical activity). Self-efficacy for walking was a better predictor of all clinical health and behavioural outcomes than self-efficacy for managing breathlessness, suggesting that targeting confidence for walking is important for optimal outcome development. Additionally, the results indicate a larger contribution of self-efficacy for walking to physical activity in stable patients compared to AECOPD patients; and a stronger association of self-efficacy to all outcomes at the end of PR compared to the beginning of PR among AECOPD patients. These findings may indicate AECOPD and stable COPD patients have different salient challenges and/or needs within PR. Immediately after an AECOPD the focus may need to be on managing dyspnea and functional limitations, while also linking improvement among these clinical symptoms to the behaviours learned in PR. Physical activity may become a more salient challenge once patients have more fully recovered. Care should be taken to focus on the challenges that are most relevant to each patient group.

Table 2.1

Percent of Missing Values Across Time-points

Variable	Pre-PR	Post-PR
Self-efficacy for Walking	9.61	30.63
Self-efficacy for Managing Breathlessness	8.19	36.25
Six-Minute Walk Test	13.50	41.40
St. George's Respiratory Questionnaire	7.51	36.34
Steps per day	15.30	42.30

Note. PR = pulmonary rehabilitation

Table 2.2

Descriptive Statistics by Group

	AECOPD No-PR		AECOPD Early-PR		AECOPD Late-PR		Stable PR	
	Pre-PR M±SD	Post-PR M±SD	Pre-PR M±SD	Post-PR M±SD	Pre-PR M±SD	Post-PR M±SD	Pre-PR M±SD	Post-PR M±SD
Age, years	69±9		65±10		67±6		67±8	
Gender, % female	61		42		58		43	
BMI	28±8		29±9		29±9		30±7	
Pack years smoking, years	41±17		48±26		48±22		39±22	
mMRC Dyspnea, 0-4	2.2±1		2.3±.9		2.4±1		2.0±.9	
Hospitalization, days	5.5±3		6.6±4		6.7±4			
FEV1 % predicted	48±13		42±13		51±12		60±22	
FEV1/FVC	46±14		44±14		52±12		67±18	
Self-efficacy for Walking, 0-100	21±19	22±19	27±21	37±26	26±29	46±28	46±31	59±32
Self-efficacy for Managing Breathlessness, 1-5	2.8±.7	3.1±.9	2.9±.7	2.4±.92	2.9±.7	2.5±.62	2.4±.7	2.3±.7
6MWT, m	226±67	216±66	240±91	295±65	270±87	282±78	379±91	413±96
SGRQ Total Score, %	61±13	64±13	62±12	57±11	54±14	55±8	55±17	51±15
Steps per day	1276±868	1815±1448	2763±1886	2097±1306	2530±1369	2891±2170	3468±2195	3668±2342

Note. The data presented were calculated from complete cases on a variable-by-variable basis. PR = pulmonary rehabilitation, BMI = body mass index, FEV1 = forced expiratory volume in 1 second, FVC = forced vital capacity, 6MWT = six-minute walk test, SGRQ = St. George's Respiratory Questionnaire.

Table 2.3

Results of the Mixed MANOVA for and Follow-up ANOVAs for Self-efficacy across Three Analyses

	1.Group-Level Mean Substitution[a]		2. Complete Case Analysis[b]		3.Last Observation Carried Forward[c]		Discrepancy in statistical significance
Effect	*p*	η^2_p	*p*	η^2_p	*p*	η^2_p	
4Group X 2Time x2 SE Type MANOVA							
Time*SE Type*Group	.056	.07	.756	.02	.360	.03	
Time*SE Type	.000	.17	.000	.17	.000	.11	
Time*Group	.077	.07	.802	.01	.356	.03	
SE Type*Group	.000	.23	.000	.22	.000	.18	
Time	.000	.16	.001	.15	.001	.11	
SE Type	.000	.67	.000	.58	.000	.59	
Group	.000	.22	.001	.21	.000	.17	
4Group X2Time ANOVA for SEW							
Time*Group	.066	.07	.763	.02	.358	.03	
Time	.000	.16	.000	.16	.000	.11	
Group	.000	.23	.000	.22	.000	.17	
4Group X 2Time ANOVA for CSES							
Time*Group	.000	.17	.042	.11	.188	.04	1&2 v 3
Time	.001	.10	.000	.18	.001	.10	
Group	.003	.13	.012	.14	.020	.09	

Note. SE = self-efficacy; SEW = self-efficacy for walking scale; CSES = COPD self-efficacy scale.

Forced expiratory volume in one second % predicted was not a statistically significant covariate and was not included in these analyses.

[a] = In group-level mean substitution analysis N = 105 (AECOPD no-PR = 22, AECOPD early-PR = 22, AECOPD late-PR = 21, stable PR = 40).

[b] = In complete case analyses N = 77 (AECOPD no-PR = 13, AECOPD early-PR = 15, AECOPD late-PR = 11, stable PR = 38).

[c] = In last observation carried forward analyses N = 105 (AECOPD no-PR = 22, AECOPD early-PR = 22, AECOPD late-PR = 21, stable PR = 40).

Table 2.4

Results of the Mixed ANOVA for Functional Exercise Capacity, Health Status, and Physical Activity across Three Analyses

	1.Group-Level Mean Substitution		2. Complete Case Analysis		3.Last Observation Carried Forward		Discrepancy in statistical significance
Effect	*p*	η^2_p	*p*	η^2_p	*p*	η^2_p	
2Group X 2Time ANOVA for 6MWT[a]							
Time*Group	.005	.12	.000	.26	.001	.17	
Time	.001	.11	.000	.23	.000	.16	
Group	.000	.52	.000	.46	.000	.41	
2Group X 2Time ANOVA for SGRQ[b]							
Time*Group	.076	.07	.152	.10	.006	.13	1 & 2 vs 3
Time	.281	.01	.001	.22	.000	.14	1 vs 2 & 3
Group	.005	.12	.110	.12	.120	.06	1 vs 2 & 3
2Group X 2Time ANOVA for Steps per day[c]							
Time*Group	.032	.08	.481	.04	.523	.02	1 vs 2 & 3
Time	.457	.01	.899	.00	.848	.00	
Group	.000	.21	.030	.14	.001	.16	

*Note.*6MWT = six-minute walk test, SGRQ = St. George's Respiratory Questionnaire, PR = pulmonary rehabilitation.

Forced expiratory volume in 1 second % predicted was not a statistically significant covariate and was not included in these analyses.

[a] = In group-level mean substitution analysis N = 105 for all analyses of dependent variables (AECOPD no-PR = 22, AECOPD early-PR = 22, AECOPD late-PR = 21, stable PR = 40).

[b] = In complete case analyses N = 65 for the 6MWT (AECOPD no-PR = 11, AECOPD early-PR = 12, AECOPD late-PR = 9, stable PR = 33); N = 52 for SGRQ (AECOPD no-PR = 9, AECOPD early-PR = 6, AECOPD late-PR = 6, stable PR = 31); N = 61 for steps per day (AECOPD no-PR = 7, AECOPD early-PR = 11, AECOPD late-PR = 9, stable PR = 34).

[c] = In last observation carried forward analyses N = 98 for 6MWT (AECOPD no-PR = 17, AECOPD early-PR = 21, AECOPD late-PR = 21, AECOPD PR = 39); N = 92 for SGRQ (AECOPD no-PR = 18, AECOPD early-PR = 20, AECOPD late-PR = 19, stable PR = 35); N = 95 for steps per day (AECOPD no-PR = 16, AECOPD early-PR = 19, AECOPD late-PR = 20; stable PR = 40).

Table 2.5

Comparing Correlation Coefficients for Self-efficacy Types to Secondary Outcomes between AECOPD (n = 71) and Stable COPD Patients (n=40) over Time

	6MWT				SGRQ				Step count			
Pre-PR	r^{AECOPD}	r^{Stable}	*z*-statistic	*P*	r^{AECOPD}	r^{Stable}	*z*-statistic	*p*	r^{AECOPD}	r^{Stable}	*z*-statistic	*P*
SEW	.604	.659	-.449	.327	-.518	-.365	-.0935	.175	.365	.565	-1.261	.104
CSES	-.286	.082	-1.84	.033	.396	.204	1.038	.150	-.015	.283	-1.498	.067
End-PR												
SEW	.577	.599	-.165	.435	-.510	-.229	-1.613	.053	.511	.730	-1.785	.037
CSES	-.118	.118	-1.512	.065	.437	.233	1.132	.129	-.073	.296	-1.852	.032

Note. PR = pulmonary rehabilitation; SEW = Self-efficacy for Walking Scale; CSES = COPD Self-efficacy Scale.

Table 2.6

Multiple Regression Analyses Predicting Secondary Outcomes from Self-efficacy Types and Demographic/Clinical Indicators

		Pre-PR					Post-PR				
6MWT		B [95% CI]	SE	*t*	*p*	$r^{Partial}$	B	SE	*t*	*p*	$r^{Partial}$
AECOPD [a]	Constant	367.68 [207.03 – 528.32]	81.34	4.52	.000		234.80 [138.09 – 331.51]	48.88	4.80	.000	
	SEW	1.46 [0.42 – 2.49]	0.52	2.78	.006	.41	1.82 [0.88 – 2.75]	0.47	3.85	.000	.56
	CSES	-12.24 [-42.17 – 17.69]	15.27	-0.80	.423	-.10	-8.49 [-38.98 – 22.01]	15.42	-0.55	.583	-.10
Stable[b, c]	Constant	193.28 [98.81 – 287.74]	48.20	4.01	.000		365.55 [224.08 – 507.02]	72.14	5.07	.000	
	SEW	1.62 [0.89 – 2.35]	0.37	4.33	.000	.59	1.54 [0.88 – 2.21]	0.34	4.53	.000	.62
	CSES	14.74 [-14.68 – 44.15]	15.01	0.98	.326	.17	3.52 [-28.21 – 35.26]	16.17	0.22	.828	.04
Step count											
AECOPD [d]	Constant	1041.28 [-1411.07 – 3493.63]	1249.87	0.83	.405		758.83 [-1548.24 – 3065.90]	1164.39	0.65	.516	
	SEW	32.51 [13.11 – 51.90]	9.88	3.29	.001	.41	35.89 [13.59 – 58.18]	11.26	3.19	.002	.51
	CSES	546.79 [-118.20 – 1211.78]	338.96	1.61	.107	.21	51.77 [-660.92 – 764.45]	360.16	0.14	.886	.03
Stable	Constant	-490.15 [-2524.32 – 1544.02]	1037.86	-0.47	6.37		-1421.58 [-3748.50 – 905.33]	1181.39	-1.20	.230	
	SEW	40.77 [22.98 – 58.55]	9.07	4.49	.000	.59	53.29 [35.70 – 70.88]	8.96	5.95	.000	.75
	CSES	876.81 [131.18 – 1622.43]	380.43	2.31	.021	.35	810.89 [-15.73 – 1637.50]	420.45	1.93	.054	.36
SGRQ											
AECOPD [e]	Constant	80.61 [57.15 – 104.07]	11.97	6.74	.000		47.51 [30.65 – 64.37]	8.51	5.59	.000	
	SEW	-0.16 [-0.30 – (-0.03)]	0.07	-2.41	.016	-.33	-0.24 [-0.41 – (-0.08)]	0.09	-2.89	.005	-.49
	CSES	1.75 [-2.67 – 6.17]	2.24	0.78	.436	.13	6.22 [1.05 – 11.40]	2.61	2.38	.019	.40
Stable[f,g]	Constant	99.64 [54.50 – 144.78]	23.03	4.33	.000		93.82 [30.48 – 157.17]	32.31	2.90	.004	
	SEW	-0.25 [-0.38 – (-0.11)]	0.07	-3.49	.000	-.51	-0.24 [-0.40 – (-.08)]	0.08	-2.87	.004	-.45
	CSES	3.56 [-2.15 – 9.27]	2.92	1.22	.222	.20	6.35 [-0.69 – 13.38]	3.59	1.77	.077	.31

Note. a,b,c,d,e,f,g denote demographic/clinical indicators that were controlled for in the analyses.
a = BMI in Pre-PR equation, B = -2.92 [-5.28 – (-0.57)], SE = 1.20, *t* = -2.44, *p* = .015, $r^{Partial}$ = -.34; mMRC in Pre-PR equation, B = -23.49 [-45.82 – (-1.170], SE = 11.34, *t* = -2.07, *p* = .04, $r^{Partial}$ = -.31.
b = FEV1 % predicted in Pre-PR equation, B = 1.28 [0.27 – 2.28], SE = 0.51, *t* = 2.50, *p* = .013, $r^{Partial}$ = .39
c = BMI in post-PR equation, B = -5.12 [-8.22 – (2.03)], SE = 1.58, *t* = -3.25, *p* = .001, $r^{Partial}$ = -.50; FEV1% predicted in post-PR equation, B = 1.72 [0.73 – 2.70], SE = 0.50, *t* = 3.42, *p* = .001, $r^{Partial}$ = .52
d = gender in Pre-PR equation, B = -800.79 [-1646.07 – 44.49], SE = 430.85, *t* = -1.86, *p* = .063, $r^{Partial}$ = -.24
e = age in pre-PR equation, B = -0.44 [-0.74 – (-0.14)], SE = 0.15, *t* = -2.92, *p* = .004, $r^{Partial}$ = -.36, mMRC in Pre-PR equation, B = 3.28 [0.30 – 6.27] , SE = 1.52, *t* = 2.16, *p* = .03, , $r^{Partial}$ = .30.
f = age in pre-PR equation, B = -0.78 [-1.34 – (-0.21)], SE = 0.29, *t* = -2.71, *p* = .007, $r^{Partial}$ = -.42; pack years smoking in pre-PR equation, B = 0.25 [0.06 – 0.44], SE = 0.10, *t* = 2.53, *p* = .012, $r^{Partial}$ = .40
g = age in post-PR equation, B = -0.97 [-1.67 – (-0.27)], SE = 0.36, *t* = -2.71, *p* = .007, $r^{Partial}$ = -.44; BMI in post-PR equation B = 0.62 [-0.10 – 1.33], SE = 0.36, *t* = 1.70, *p* = .09, $r^{Partial}$ = .28
6MWT = six minute walk test; SEW = self-efficacy for walking; CSES = self-efficacy for managing breathing; PR = pulmonary rehabilitation; BMI = body mass index; mMRC = modified Medical Research Council Dyspnea Scale; FEV1% predicted = forced expiratory volume in 1 second percent predicted.

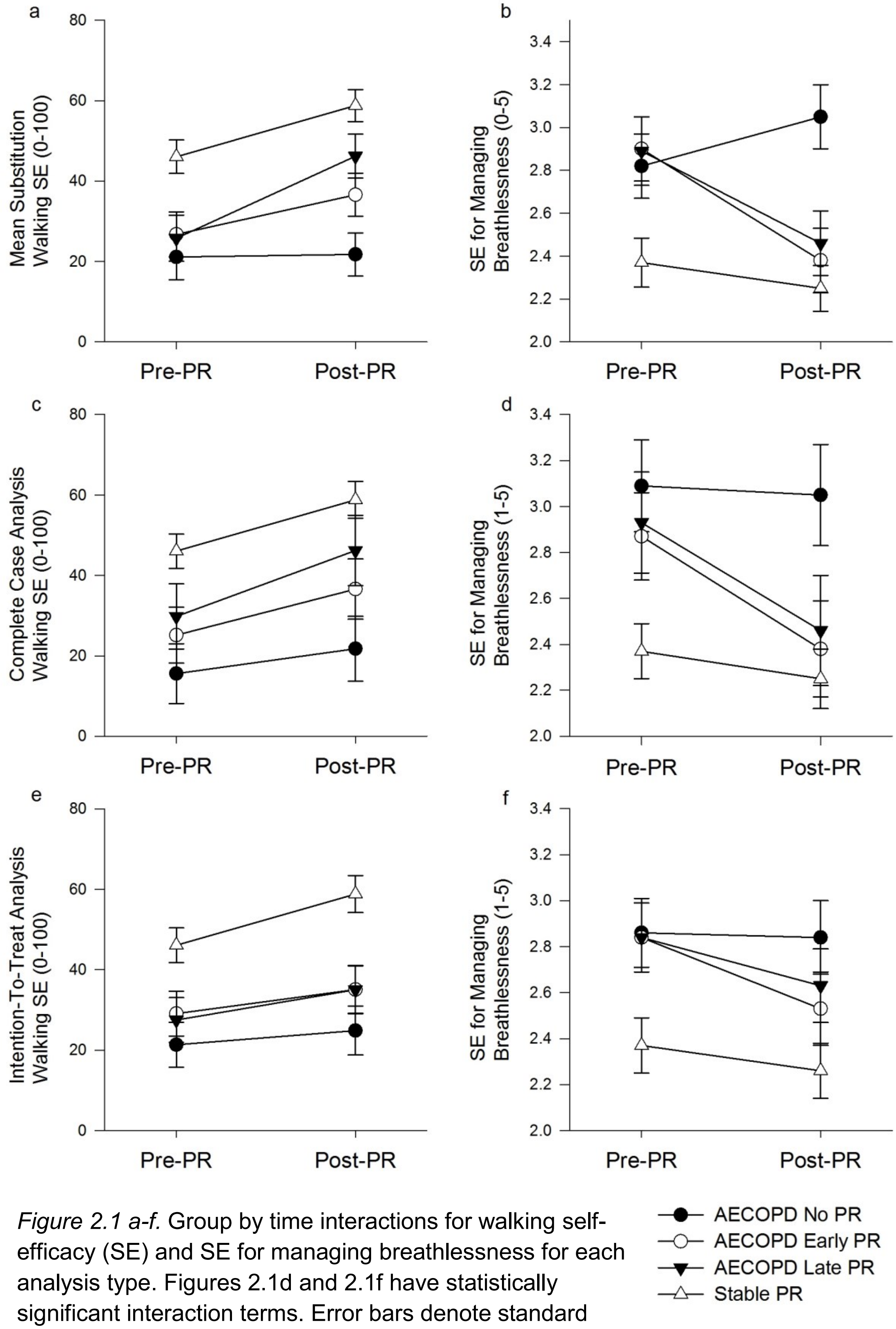


Figure 2.1 a-f. Group by time interactions for walking self-efficacy (SE) and SE for managing breathlessness for each analysis type. Figures 2.1d and 2.1f have statistically significant interaction terms. Error bars denote standard error. PR = pulmonary rehabilitation.

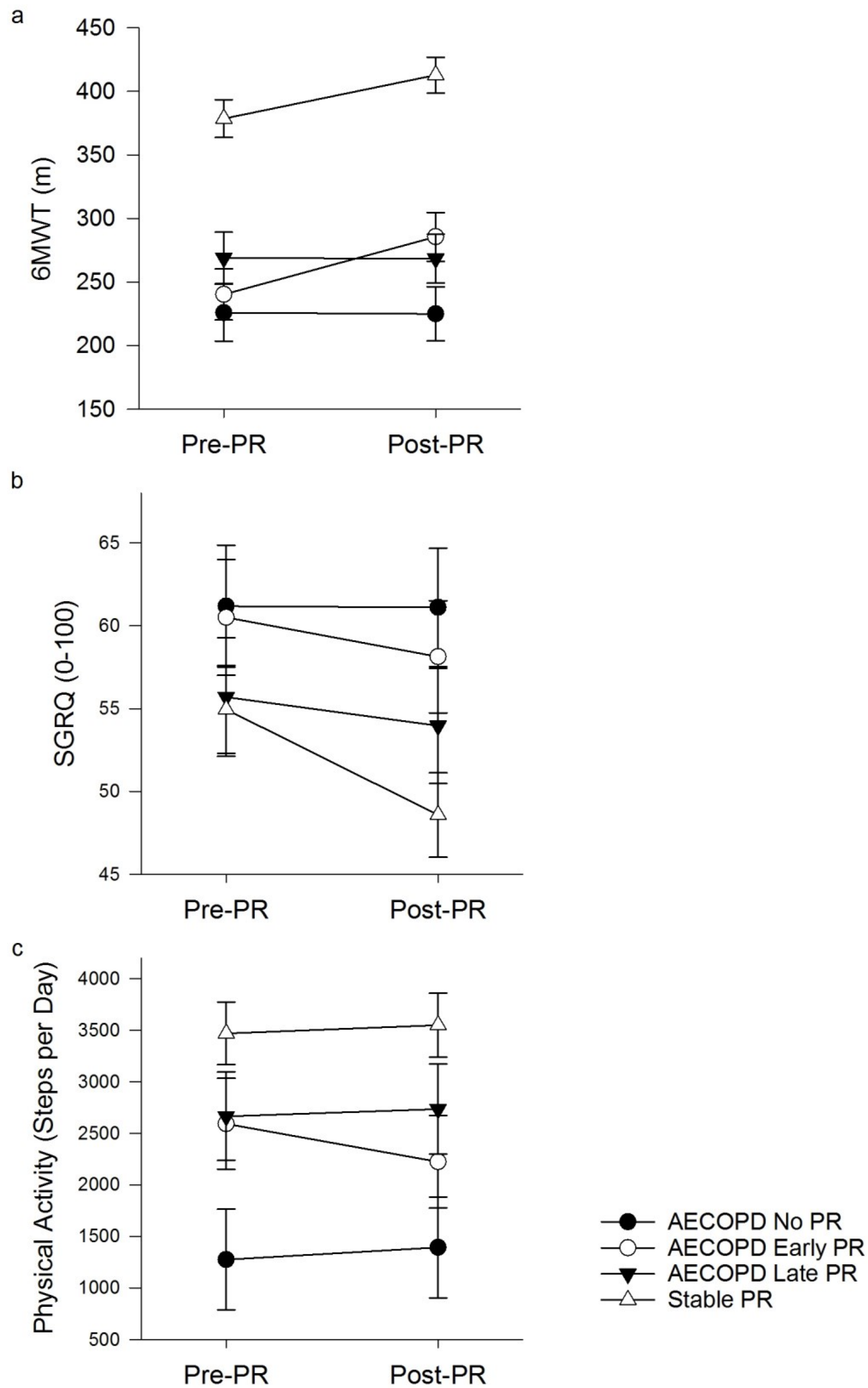


Figure 2.2a-c. Group by time interactions for the six-minute walk test (6MWT), St. George's Respiratory Questionnaire (SGRQ), and steps per day for last observation carried forward analysis. Figure 2.2c has a statistically significant interaction term. Error Bars denote one standard deviation. PR = pulmonary rehabilitation.

Chapter 3 – Study 2 (Pilot)

Exercise Experiences and Comparisons in Chronic Lung Disease Patients

Abstract

Background: The purpose of this study was to inform the creation of video-based vicarious experience (i.e., modeling) interventions to enhance exercise self-efficacy in patients with COPD within the context of a cardiopulmonary exercise test (CPET). Vicarious experience involves making judgements about one's capabilities based on the observation of others (i.e., a model). Part 1 of this pilot study examined the model attributes most important to patients with COPD when deciding if they are good at exercise. Part 2 of this pilot study examined patient experiences of CPETs. **Method:** In part 1, 30 (15 male, 15 female) COPD patients listed all the people they compare themselves to when deciding if they are good at exercise. A new sample of 30 (15 male, 15 female) COPD patients indicated with an oral questionnaire (i) how well they compared to those on the list, and (ii) how frequently they made those comparisons. In part 2, oral questionnaires were conducted with 20 (10 male, 10 female) COPD patients and 3 health care practitioners (HCPs) to understand patient experiences of CPETs. **Results:** Regarding exercise, COPD patients compared themselves unfavourably to younger people and favourably to older people. COPD patients were more likely to compare themselves to people of the same gender than people of the opposite gender, and females were unlikely to perceive themselves as better than males, although the reverse was not observed for male participants. COPD patients and HCPs identified common challenges associated with patient performance on CPETs. HCPs identified techniques to support optimal patient performance. **Conclusions:** Based on the results of part 1, a female and male close in age to typical COPD patients will be recruited to be models in the video-interventions, and participants will observe a model of the same gender. The results of part 2 will be used to create the storyline for the video interventions and ensure that the series of actions portrayed by the models in the videos accurately represent patient experiences.

Introduction

Studies show that in patients with Chronic Obstructive Pulmonary Disease (COPD), functional outcomes (Berry et al., 2010; Ries et al., 1995; Ringbaek, Brondum, Martinez, Thogersen, & Lange, 2010), as well as physical activity and exercise participation (Berry et al., 2010; Rodgers et al., 2014; Steele et al., 2008) decline after contact with clinicians or researchers is removed. Given the robust association of low physical activity to subsequent exacerbations and increased mortality (Gimeno-Santos et al., 2014), identifying and understanding the factors associated with long term physical activity are essential for informing the design of behaviour change strategies aimed at increasing physical activity in this population. One factor that has been demonstrated to be robustly associated with physical activity behaviours in a variety of populations is self-efficacy (Blanchard et al., 2015; McAuley et al., 1991; McAuley et al., 2011; Millen & Bray, 2008; Rodgers et al., 2009; Rodgers et al., 2013; Sharma et al., 2005).

Self-efficacy, defined as behaviour specific confidence (Bandura, 1997), is recognized as an important outcome of COPD-management programs (Bourbeau et al., 2004; Singh, 2014). Despite the prominence of self-efficacy in the clinical COPD literature, few interventions specifically targeting self-efficacy have been evaluated. This pilot study was conducted to inform the design of a theory-based intervention to enhance self-efficacy for exercise among patients with COPD participating in a usual care pre-PR maximal cardiopulmonary exercise test (CPET). The intervention study aims to determine if exercise self-efficacy can be modified in a highly controlled situation. While the CPET test may not be the most practically relevant day-to-day exercise experience, it was chosen because it fits the parameters of a highly controlled situation and therefore ideal for initial experimental testing. If the intervention positively influences self-efficacy for exercise, future studies could be conducted to examine the intervention in less controlled exercise situations.

Vicarious experience, defined as judging one's own abilities based on the achievements of others (i.e., behavioural models), is one of four sources of self-efficacy (Bandura, 1997). In general, observing similar models succeed will increase self-efficacy, whereas observing them fail will lower self-efficacy (Bandura, 1997). Observing failure of models of supposedly greater ability may weaken self-efficacy, but observing failure of a model of lesser ability may strengthen self-efficacy if the observer believes they are superior in ability (Bandura, 1997). While Bandura (1997) considers personal mastery experiences to be the strongest source of self-efficacy, there are several conditions where vicarious experiences might also contribute strongly to self-efficacy beliefs. For example, behavioural initiates rely more heavily on vicarious experiences than mastery experiences because they have fewer experiences to draw on (Bandura, 1997). Therefore, they look to others' performances to appraise their own capabilities. In addition, when people are uncertain about their abilities or when there is no identifiable performance standard, they will rely more heavily on vicarious experiences to judge their own abilities. Interestingly, a meta-analysis examining the sources most associated with exercise self-efficacy found that vicarious experience was the source most strongly associated with exercise self-efficacy enhancement in healthy adults (Ashford et al., 2010). Moderators of this relationship, including past exercise experience, age, and gender were not tested.

Vicarious experience may be a particularly relevant source of self-efficacy for exercise in patients with COPD participating in PR. During PR, health care practitioners (HCP) demonstrate prescribed exercises to help patients learn the correct form and technique. Also, PR is typically conducted with groups of patients, which lends many opportunities for social comparisons between patients. It is important to understand how patient self-efficacy is impacted by the individuals who demonstrate and perform exercise in PR so that efforts can be taken to ensure patient self-efficacy is positively impacted. Further, low activity levels (Pitta et al., 2008; Watz et al., 2009) and functional exercise capacity upon entrance into PR (McCarthy et al., 2015), suggest patients' recent exercise experiences are limited, one of the key situations where people look to others' performances as benchmarks against which to judge their own capabilities (Bandura, 1997). For the proposed study, the context of the intervention is a usual care, pre-PR maximal CPET. There is limited literature examining COPD patients' experiences of CPET; however, anecdotal evidence from the clinical setting supports that the CPET is the first experience on a treadmill for many patients. Given that COPD patients` previous mastery experiences of CPETs are limited; patients may draw on models as a source of information about their own abilities during pre-PR CPETs.

Importantly, mere observation of a model does not guarantee that the observer's self-efficacy will be impacted. The performance outcomes and attributes of the model are two key moderators of the influence of vicarious experience on observer self-efficacy (Bandura, 1997). In general, models more similar to the observer in terms of appearance and apparent performance capability tend to have a stronger impact on observer self-efficacy than models that are dissimilar (Bandura, 1997). People who are deemed more similar to the observer are considered to be a good standard of comparison of their own abilities.

Bandura (1997) posits that there are several model attributes that can be important to the observer, including age, gender, ethnic origin, or any stereotypical notions of performance capabilities. Notably, it is the attributes the observer believes are most important to behavioural performance that will carry the most weight when observer makes comparative appraisals (Bandura, 1997). In a sample of older heathy adults, model gender but not age influenced observer self-efficacy in women only

(Weeks et al., 2005). Qualitative reports from this study revealed that women found it easier to relate to the model of the same gender, and that men's greater perceived muscular strength was intimidating to women. In a sample of non-athletes, self-efficacy was more strongly enhanced when observing non-athletic models compared to athletic models, even though models were of the same ability (George et al., 1992). This finding suggests that to non-athletes, the attribute of being an 'athlete' was more important than the actual abilities of the model. To date it is unknown what model attributes are relevant for people with COPD when making exercise-related comparative appraisals.

The characteristics of a models' performance is also known to impact observer self-efficacy. For example, there is a distinction between coping and mastery model performances. Coping models begin unsure of their abilities and make mistakes, but through persistent effort they improve over time, whereas mastery models perform effortlessly and error free (Bandura, 1997). Theoretically, coping models are thought to have a more positive impact on observer self-efficacy than mastery models, particularly among observers who are unsure of their capabilities (Bandura, 1997). Observers unsure of their abilities regard coping models to be more similar to themselves and find coping models useful for developing strategies to overcome challenging situations. Empirical research has found both coping and mastery models effective for enhancing observer self-efficacy for exercise-specific tasks (Clark & Ste-Marie, 2002; Cumming & Ramsey, 2011; Weiss et al., 1998). However, coping models may have stronger effects on self-efficacy when the behaviour is more complex and requires great persistence for success (Cumming & Ramsey, 2011; Weiss et al., 1998). To date, no empirical research has examined the effects of mastery and coping models on COPD patients' exercise self-efficacy.

The purpose of this pilot study was to inform the creation of coping and mastery model video interventions designed to enhance exercise self-efficacy in patients with

COPD. While not as naturalistic as in-person modeling, video modelling provides an opportunity for researchers to manipulate the key variables of interest, and has found to be effective for encouraging exercise performance and self-efficacy (Maddison et al., 2008; Weeks et al., 2005; Weeks et al., 2002). The intervention study utilized video-modeling because it made it possible to control for and test the specific effects of mastery and coping models' performances on observer self-efficacy while also controlling for model attributes. Part 1 of this pilot study aims to determine the model attributes salient to COPD patients when they are trying to decide if they are 'good' at exercise so that they can be controlled for when recruiting people to act as the models in the experimental videos. Part 2 of this pilot study aims to understand patient experiences of performing CPETs so that the models' actions in the videos accurately portray typical patient experiences.

Part 1

Method

Participants, Procedures & Materials

This study received ethical approval from University of Alberta Health Research Ethics Board (HREB: Pro00049767), and the Covenant Health Research Ethics Board, and was conducted at The Breathe Easy Program, G. F. MacDonald Centre for Lung Health, Edmonton General Continuing Care Centre. All patients with COPD attending the PR program were eligible for this study. Staff members identified potential participants who were then contacted in person by the primary researcher during downtime at the PR program to explain the study (i.e., before or after class, or between the exercise and educational components of the program). The study involved participants orally listing all of the different people they compare themselves to when deciding if they are good at exercise. Implied consent procedures were used and explained to participants. Participants were offered private rooms to provide their responses; however, all participants declined this option.

First, participants were given examples of situations where comparisons to others were made. Then participants were asked, “Who do you compare yourself to when trying to decide if you are ‘good’ at exercise?” Examples of exercise behaviours were given to participants so that they responded to exercise behaviours and not activities of daily living (e.g., household chores, personal hygiene behaviours). Participants were encouraged to orally list all people they compare themselves to in exercise situations. Participant responses were recorded by the primary researcher on an individual designated form. No identifying personal information was collected.

A total of 30 (15 men, 15 women) patients with COPD participated in the study. The following sources of exercise comparisons were identified by participants: males in PR-class, females in PR-class, older people in PR-class, younger people in PR-class, spouse/partner, male children, female children, male friends, female friends, males in other exercise classes, females in other exercise classes. Many participants were particular about pointing out the gender, age, and ability level of the people that they compare themselves to when deciding if they are ‘good’ at exercise, indicating that these are particularly salient characteristics to this group of people.

Next, using the same recruitment procedures described above, 30 new patients with COPD (15 men, 15 women) were asked to rate on a brief oral questionnaire, (1) how well (i.e., better, the same, worse), and (2) how often they compared themselves (i.e. never, rarely, sometimes, often, frequently) to the sources of exercise comparisons identified by participants in the previous section of the study (i.e., males in PR-class, spouse/partner, female children, etc.). All participant responses were recorded by the primary researcher on an individual designated form. No identifying personal information was collected.

Analysis & Results

All statistical analyses were conducted using IBM SPSS Statistics 24. Descriptive statistics were calculated to determine how well and how often participants compared themselves to each of the sources of exercise comparisons. Table 3.1 displays the ratings of exercise comparisons by gender and Table 3.2 displays the frequency of exercise comparisons by gender. A summary of key information from the tables is provided below.

Of the participants, 60% of males and 73% of females indicated they were 'better' than older patients in PR at performing exercise tasks, indicating that most participants tended to compare themselves favourably to those they perceived to be older than them. A total of 60% of the male and female participants indicated that they were 'worse' than younger patients in PR at performing exercise tasks and 40% of both genders indicated that they were 'the same', suggesting that most participants tended to compare themselves unfavourable to those they perceived to be younger than them. Notably, no female participants indicated that they perceived themselves to be 'better' than any of the male sources of exercise comparisons, including males in their PR class, their spouse, male children, male friends, or males in other physical activity classes; although this was not observed for male participants when making exercise comparisons to females. Female participants were more likely to report comparing 'often' and 'frequently' across the sources of exercise comparisons than the male participants. Both male and female participants made more frequent comparisons to people of the same gender than the opposite gender. Disease status was not a factor in making comparisons, as most COPD patients thought they compared similarly to males and females that were part of their PR class, as well as male and female friends who were not part of their PR class.

Part 2

Method

Participants, Procedures, & Materials

This study received ethical approval from the University of Alberta Health Research Ethics board and the Covenant Health Research Ethics board (HREB: Pro00049767). Participant recruitment and study procedures occurred at the G. F. MacDonald Centre for Lung Health, Edmonton General Hospital. All patients with COPD performing a usual care pre-PR CPET were eligible for this study; along with health care practitioners (HCPs) at the Centre for Lung health with experience conducting CPETs. Potential patient participants were recruited from the waiting area prior to their pre-PR assessment. Potential HCP participants were recruited during informal conversations by the primary researcher and were based on consultation with the Lung Centre's staff supervisor. The study was explained to potential participants by the primary researcher. Potential participants were given an opportunity to ask questions and provided with an information letter. Similar to part 1 of this pilot study, implied consent procedures were used, and it was made clear to participants that responding to the researchers' questions indicated they consented to the study. Names and identifying information were not recorded.

Procedures for COPD patient participants. Oral questionnaires were conducted with 10 male and 10 female COPD patients before and after a usual care CPET. Prior to the CPET, participants were asked to indicate (1) the types of exercises they were currently performing (if any), (2) whether they have performed an exercise test before, and (3) what they expect from performing their CPET. After the CPET, participants were asked to indicate (1) how they thought the CPET went for them, (2) how their CPET experience was the same or different from their expectations, (3) the challenges they experienced during the CPET, (4) how they overcome those challenges,

(5) whether their CPET experience was anxiety provoking, and (6) anything they wish they would have known before performing the CPET. The primary researcher recorded participants' responses on individual designated forms.

Procedures for cardiopulmonary exercise test. Prior to the treadmill-based CPET, a HCP gave standardized information about the equipment, measures, and procedures to the patient. Participants were encouraged to walk on the treadmill for as long as possible but assured that they could stop the test if they could not continue any longer. When prompted before, during, and after the exercise test, participants rated their degree of breathing and leg discomfort by pointing to the appropriate value on an exertion scale. Once the exercise test began, the work load increased by adjustments of speed and grade every minute or two up until a maximum duration of 8-12 minutes (Wasserman, 2005). The supervising physician determined the specific exercise protocol on an individual basis. Gripping tightly or leaning onto the handrails of the treadmill was discouraged, although participants could rest hands on the railings when balance was sought. Standardized encouragements were given to all participants during the test. Physicians monitored ECG throughout the test to ensure there were no exercise-induced ECG changes

Procedures for HCP participants. Oral questionnaires were also conducted with 1 respiratory therapist and 2 respiratory assistants to understand HCP experiences with patient CPETs. HCP participants were asked to indicate (1) what the tests are like for patients lowest in ability, highest in ability, and for the average patient, (2) the skills and strategies used by patients who perform well, (3) aspects of the test patients find difficult, (4) common form errors during CPETs, (5) how they instruct patients who make errors on the treadmill, (5) aspects of the test patients find anxiety provoking, and (6) how they support patients whom are showing signs of anxiety. The primary researcher recorded participants' responses on individual designated forms.

Analysis & Results

Patient Participants

Half of the sample (n = 10) reported participating in exercise at the time of the study. It was common for both male and female participants to report participating in walking groups. Male participants also reported participating in unsupervised aerobic and strength training exercises, whereas female participants reported participating in supervised exercise classes (i.e., yoga, tai chi, water aerobics, Zumba, supervised circuit training). Approximately half of the sample reported performing a supervised treadmill test before.

When asked about expectations of the CPET prior to the test, common statements from both male and female participants included negative expectations of having difficulty during the test, the test being unpleasant, and experiencing anxiety before or during the test. A few male and female participants indicated they did not have any expectations and they were keeping an open mind. Only one participant (female) indicated they were confident they could do well. In general, women were concerned but hopeful of doing well, whereas men either had an ambivalent or negative outlook.

One male and one female were not given physician consent to perform the CPET due to high blood pressure the morning of the test. Therefore, the remaining responses are from nine male and nine females who completed a CPET. When asked about how the CPET went for them, most participants reported being satisfied with their performance despite the difficulty of the test. All participants reported performing as well or better than expected, except for one male participant who indicated he performed worse than expected. Common challenges identified by participants during the CPET included: the mouth piece and equipment were uncomfortable (e.g., dry mouth), difficulty keeping up with the pace and/or incline of the treadmill and managing shortness of breath. Common strategies identified by participants to overcome these challenges included self-encouragement, trusting, and listening to the directions provided by staff members, distraction (i.e., think of other things), controlling breathing, and normalizing the experience. One male and three female participants reported feeling anxious at some point during the testing procedures. Most participants reported feeling prepared for the CPET although one third of participants indicated they wish they would have known more about the CPET procedures in advance.

Health Care Practitioner Participants

When asked about patient experiences during the CPET, HCPs indicated patients highest in abilities are comfortable, confident, have good form during exercise tests, and want to be challenged, whereas patients lowest in abilities tend to walk awkwardly on the treadmill, lack confidence, often seek assurance, and make many errors on the treadmill (e.g., taking short unnatural strides; all listed in detail below). The HCPs indicated that the average patient will make a few mistakes on the treadmill, experience discomfort from the equipment, and find the CPET challenging. The HCPs noted that the skills and strategies used by patients who perform well include staying calm, relaxed, and trusting equipment and staff.

When asked to identify aspects of the CPET patients find difficult, HCPs reported the following: getting used to the mouth piece and nose plug, adjusting to different speeds – including fast and slow, the feeling of walking on a treadmill, the feeling of being ‘tested’, and the number of people in the room (i.e., two staff members, one doctor – perhaps two if training a resident). The most common errors patients make on the treadmill as identified by the HCPs, were taking short unnatural strides, shoulders raised and close to their ears, gripping onto the railings, and legs and hips behind body and not underneath shoulders. HCPs reported using verbal cues and encouragement to help patients correct for errors, such as “relax your grip on the railings” or “try taking longer, more natural steps”. Some HCPs reported using behavioural cues, such as placing hand close to the front of the treadmill and encourage patients to walk towards it and lifting patients' hands off the railings to improve walking posture, if appropriate.

When asked about aspects of the CPET patients find anxiety provoking, the HCPs identified the mouth piece and nose clip, and the feeling of not being in control of the speed and/or incline. To help patients manage anxiety, HCPs explain what the equipment does and why it is needed, reassure patients that they can stop the test whenever they want to, and take their time with the procedures. One HCP indicated she puts her hand on patients back for support, and that patients have indicated that they like this gesture.

Discussion

The purpose of this pilot study was to inform the creation of video modeling interventions to enhance exercise self-efficacy. Part 1 of this pilot study determined the model attributes salient to COPD patients when they try to decide if they are 'good' at exercise. The results of this pilot study were used to select models to be in the video interventions that aim to positively impact participants exercise self-efficacy levels. Part 2 of this pilot study explored patient experiences of performing CPETs. The results of this study will be used to create the storyline for the video interventions and ensure that the series of actions portrayed by the models in the videos accurately represent patient experiences.

Consistent with theoretical expectations (Bandura, 1997), the results of part 1 indicated that when COPD patients made decisions about how well they compare themselves to others, the age and gender of the model were important. COPD patients tended to compare themselves favourably to those they perceived to be older than them, and unfavourably to those who they perceive to be younger than them. This finding was consistent across both male and female participants. It may be that those perceived to be younger are indeed greater in ability than those perceived to be older, or it is possible that these perceptions are due to stereotypical notions of exercise and physical capabilities. When selecting a model for the video interventions, it will be important to recruit someone with whom participants perceive to be of similar age.

The results also suggest that it would be best to have participants watch videos where the model is of the same gender. Participants were more likely to make comparisons to people of the same gender which suggests that COPD patients may be more competitive with people of the same gender or are simply more inclined to make comparisons with people of the same gender. Additionally, it seems that female COPD patients are unlikely to perceive themselves as better than males in terms of physical capabilities. This finding is consistent with previous research that found older females more easily relate to models of the same gender and are intimidated by the perceived muscular strength of males (Weeks et al., 2005). Similar to the importance of age, it is unclear if males are indeed greater in ability than females, or if the perception is due to stereotypical notions of exercise and physical capabilities.

Whether the models had COPD did not seem to be as important as age and gender when COPD patients made decisions about how well they compare to others. Most COPD patients thought they compared similarly to males and females that were part of their PR class, as well as male and female friends who were not part of their PR class. However, the disease status of male and female friends was not determined. The non-PR friends of COPD patients may have had other chronic conditions that limit their physical abilities in some way, which could contribute to perceptions of similarity. In 2009-2010, almost 50% of Canadian adults between the ages of 51-60 were living with at least one chronic condition (Statistics-Canada, 2009). The number of Canadian adults living with at least one chronic condition rises to almost 70% in adults aged 61-70, and greater than 80% in adults aged 71 and over (Statistics-Canada, 2009). Whether the model has a chronic disease that limits their physical capabilities may be more important for determining comparisons than the type of chronic disease that the comparator has. Given that many older adults have at least one chronic condition, age and severity of the limitations stemming from the chronic condition may account for the importance of models having COPD or other chronic conditions.

The results of part 1 of this study have implications for the types of models that PR programs should consider using when demonstrating exercise behaviours. Given the importance of age and gender to COPD patients when deciding if they are good at exercise, PR programs should consider bringing in both male and female adults close in age to COPD patients to demonstrate exercise techniques. For example, former graduates of the PR program who can comfortably and accurately demonstrate the exercise movements would be desirable model candidates. This way, COPD patients would receive critical exercise instruction while having a better opportunity to increase their confidence for performing exercise behaviours than they would if watching a younger HCP of greater ability who may also be of the opposite gender.

The results of this study suggest that developing videos of the CPET procedures will be beneficial. All participants reported experiencing challenges during the CPET, such as difficulty with mouth piece and equipment (e.g., dry mouth), difficulty keeping up with the length and pace of the test, and difficulty managing shortness of breath. In addition, many patient participants wish they would have known more about the CPET before they performed their own, and some reported feeling a noticeable amount of anxiety prior to and/or during the CPET. While the HCPs were diligent with explaining the CPET procedures prior to patients performing their own, a video may be more informative and detailed, and provide a starting point for patients to ask questions and address their concerns prior to getting on the treadmill.

Many of the participants in part 2 of the pilot study, particularly the female participants, reported being active, and the majority had performed an exercise test before. Typically, the activity levels of COPD patients are often low (Watz et al., 2009), whereas the self-reported activity levels of the COPD patients in this study were quite high. Due to inherent problems with self-reported behavioural assessments, such as recall and social desirability, it is unclear how active COPD participants were in this study. It is possible that they were more active and have more experience with exercise tests than a typical patient. It will be important for the models in both the mastery and coping videos to not appear too capable for a typical COPD patient.

In summary, two models will be recruited to be in the videos: one male and one female. The model of each gender will play the role of both the coping and the mastery model to control for physical characteristics. The models recruited for the videos will be graduates from The Breathe Easy Program who consistently exercise at the G. F. MacDonald Centre for Lung Health. Therefore, we can be sure that the models chosen are high in abilities and able to act out different scenarios, have adequate stamina for taking multiple shots, and appear to be similar in age to many COPD patients (i.e., 65-70 years old). The mastery models will appear comfortable and confident on the treadmill, and not make any errors. The coping models will make several errors on the treadmill as identified in this study – short unnatural strides, shoulders raised and close to their ears, gripping onto the railings, and legs and hips behind body and not underneath shoulders. The HCPs will support correction of form errors by orally encouraging and directing the models, which will result in the correction of the form errors by the models. At the end of the CPET, the coping models will perform as comfortable and confident as the mastery models and without error.

Table 3.1

Ratings of Exercise Comparisons by Gender

	Comparison Rating					
	Males (n = 15)			Females (n = 15)		
Source of Exercise Comparison	Worse	The Same	Better	Worse	The Same	Better
Men in class	20%	66.7%	13.3%	13.3%	86.7%	0%
Women in class	26.7%	53.3%	20%	13.3%	46.7%	40%
Older people in class	20%	20%	60%	13.3%	13.3%	73.3%
Younger people in class	60%	40%	0%	60%	40%	0%
Spouse[a]	16.7%	75%	8.3%	23%	77%	0%
Male children[b]	100%	0%	0%	100%	0%	0%
Female children[c]	100%	0%	0%	92.3%	7.6%	0%
Female friends	20%	53.3%	26.7%	13.3%	66.7%	20%
Male Friends	26.7%	66.7%	6.7%	33.3%	66.7%	0%
Females in other physical activity classes[d]	0%	0%	100%	33.3%	66.7%	0%
Males in other physical activity classes[e]	0%	100%	0%	0%	100%	0%

Note.
[a,b,c,d,e] = responded to if applicable.
[a] = n_{male} = 12, n_{female} = 13;
[b] = n_{male} = 13, n_{female} = 13;
[c] = n_{male} = 10, n_{female} = 13;
[d] = n_{male} = 1, n_{female} = 3;
[e] = n_{male} = 1, n_{female} = 2;

Table 3.2

Frequency of Exercise Comparisons by Gender (M/F)

		Frequency of Comparisons (M/F)				
Sources of Exercise Comparison	Participant Gender	Never	Rarely	Sometimes	Often	Frequently
Men in PR class	Male	6.7%	13.3%	60%	20%	0%
	Female	6.7%	13.3%	46.7%	33.3%	0%
Women in PR class	Male	20%	40%	33.3%	6.7%	0%
	Female	6.7%	6.7%	33.3%	40%	13.3%
Older people in PR class	Male	6.7%	46.7%	40%	6.7%	0%
	Female	6.7%	6.7%	40%	33.3%	13.3%
Younger people in PR class	Male	26.7%	46.7%	26.7%	0%	0%
	Female	20%	20%	53.3%	6.7%	0%
Spouse[a]	Male	8.3%	16.7%	75%	0%	0%
	Female	0%	23%	46.2%	30.8%	0%
Male children[b]	Male	23%	46.2%	30.7%	0%	0%/
	Female	30.8%	46.2%	23%	0%	0%
Female children[c]	Male	20%	70%	10%	0%	0%/
	Female	23%	38.5%	30.8%	7.7%	0%
Female friends	Male	33.3%	60%	6.7%	0%	0%/
	Female	20%	33.3%	33.3%	13.3%	0%
Male Friends	Male	26.7%	46.6%	26.7%	0%	0%
	Female	33.3%	33.3%	33.3%	0%	0%
Females in other activity classes[d]	Male	0%	100%	0%	0%	0%
	Female	0%	0%	100%	0%	0%
Males in other activity classes[e]	Male	0%	0%	100%	0%	0%
	Female	0%	50%	50%	0%	0%

Note. M = Males, F = Females, PR = pulmonary rehabilitation.
[a,b,c,d,e] = responded to if applicable.
[a] = n_{male} = 12, n_{female} = 13;
[b] = n_{male} = 13, n_{female} = 13;
[c] = n_{male} = 10, n_{female} = 13;
[d] = n_{male} = 1, n_{female} = 3;
[e] = n_{male} = 1, n_{female} = 2;

Chapter 4 – Study 3

Coping versus Mastery Modeling Intervention to Enhance Self-efficacy for Exercise in Patients with COPD

Abstract

Background: The literature suggests strong self-efficacy beliefs can facilitate long-term physical activity and management of Chronic Obstructive Pulmonary Disease (COPD). The purpose of this study was to (i) test the effects of two vicarious experience interventions, coping versus mastery modeling, on self-efficacy in COPD patients performing a cardiopulmonary exercise test (CPET), and (ii) determine the type of self-efficacy most strongly related to physical activity in patients with COPD. **Method:** After a baseline assessment of self-efficacy (task, coping for exercise, coping for breathing, scheduling, and walking) and potential moderators, 120 COPD patients watched a mastery model or coping model CPET video, or received usual care verbal instructions. Then, self-efficacy was assessed, followed by a CPET, and another assessment of self-efficacy. Fitbits™ tracked participants' step count the week following contact. Repeated measures MANOVAs assessed the intervention effects and multiple regression models assessed the contribution of the self-efficacy sub-types to step count. **Results:** All self-efficacy sub-types improved in the mastery and coping conditions, although greater improvement of self-efficacy for coping with exercise barriers was observed in the coping condition. Self-efficacy did not improve in the control condition and no moderators were identified. There were no differences between the groups on exercise test tolerance. Self-efficacy for coping with exercise barriers was the self-efficacy sub-type most strongly related to step count the week following contact. **Conclusions:** This research suggests modeling is a useful intervention technique to enhance self-efficacy in COPD patients, although coping models may be more beneficial than mastery models for enhancing capability beliefs during complex tasks. Future interventions in COPD patients should target self-efficacy for coping with exercise barriers.

Introduction

Chronic obstructive pulmonary disease (COPD) is a leading cause of death (WHO, 2018), and is predominantly caused by a substantial smoking history (Lacasse, Goldstein, Lasserson, & Martin, 2006). Physical inactivity has been found to be the strongest predictor of mortality in patients with COPD (Waschki et al., 2011), although many patients with COPD are inactive (Pitta et al., 2008; Watz et al., 2009), with activity decreasing and sedentary time increasing as dyspnea and disease severity progress (Watz et al., 2009). Pulmonary rehabilitation (PR) is a comprehensive intervention including patient assessment, exercise training, and self-management education designed to improve the physical and psychological condition of people with COPD and promote long-term adherence to health behaviours, such as physical activity (Spruit et al., 2013). Physical activity comprises all types of body movement, including exercise, sport, play, and activities of daily living (Tremblay et al., 2011). In PR, structured exercise is recommended to improve exercise capacity in addition to physical activity (Spruit et al., 2013). While PR has been shown to improve exercise capacity, it is less effective for improving and sustaining daily physical activity (Spruit et al., 2015). To improve the long-term effectiveness of PR and health outcomes among people with COPD, more research examining predictors of physical activity behaviour change is needed. Self-efficacy has been found to be a determinant of physical activity in patients with COPD (Gimeno-Santos et al., 2014), yet few interventions have been developed to enhance self-efficacy in this population. This study contributes to the literature by testing the effects of mastery versus coping model interventions on self-efficacy during an exercise experience in a PR setting and examines the relationship of exercise specific self-efficacy to objectively measured physical activity.

Self-efficacy is defined as “one’s beliefs in their capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p.

3). People with stronger beliefs in their capabilities are more likely to strive towards goals and have stronger behavioural persistence than people with weaker beliefs in their capabilities (Bandura, 1997). Capability beliefs are contingent on the behavioural and social contexts in which they occur. According to Maddux (1995), there are two capability beliefs for any given behaviour: task and coping. Task self-efficacy is confidence for performing elemental aspects of behaviour, whereas coping self-efficacy is confidence for performing the behaviour under challenging circumstances. For exercise self-efficacy, Rodgers et al. (2008) further specify scheduling self-efficacy, a sub-type of coping self-efficacy that is specific to coping with time-related barriers to exercise.

Evidence supports the notion that the importance of each self-efficacy sub-type varies according to behavioural outcomes. In COPD patients, task self-efficacy has been found to predict PR attendance, and coping for exercise self-efficacy has been found to predict improvement in functional exercise capacity (Selzler et al., 2016). It seems confidence for performing a task supports COPD patients' attendance at PR, but confidence for persisting in the face of challenges supports improvement of functional abilities. It might also be important to assess self-efficacy for disease-specific factors that might influence physical activity. In COPD, managing breathlessness during exertion is a salient challenge. The COPD Self-efficacy Scale (CSES; Wigal et al., 1991) assesses confidence for managing breathlessness, but it is composed of a composite score that conflates the circumstances and behaviours for which breathing difficulties occur. For example, confidence is rated for managing or avoiding breathing difficulties in many situations, such as when it is humid, when feeling frustrated, and when going up stairs. It may be useful to simultaneously assess items from the CSES (Wigal et al., 1991) that pertain to managing breathlessness during physical exertion, along with coping self-efficacy items of the MSES (Rodgers et al., 2008) to further understand the distinct relationships between different targets of self-efficacy and behaviour.

Walking self-efficacy is commonly assessed in COPD patients and has been shown to predict functional exercise capacity (Davis et al., 2006; Lox & Freehill, 1999), and survival (Kaplan et al., 1994) in COPD patients. If each self-efficacy type has a unique relationship to behavioural outcomes, and the relationship between self-efficacy and behaviour are reciprocal as outlined in Social Cognitive Theory (Bandura, 1997), behavioural experiences may impact each self-efficacy type differently. Therefore, this study addressed multiple types of self-efficacy outcomes outlined in Table 4.1, including exercise self-efficacy sub-types from the MSES (Rodgers et al., 2008) (task, coping for exercise, coping for breathing, scheduling) and walking self-efficacy. Since it is unknown which type of exercise-specific self-efficacy is most strongly related to physical activity in patients with COPD, the independent effects of each self-efficacy sub-type on physical activity behaviour after researcher contact will also be examined.

Mastery experiences – one's own successful behavioural experiences, are the strongest source of self-efficacy followed by vicarious experiences – estimates of one's own capabilities based on observations of others (Bandura, 1997). When individuals have limited behavioural experience, they tend to draw on observation of others' performances to judge their own capabilities (Bandura, 1997). Model performance and attributes can influence observer self-efficacy. The greater the model-observer similarity, the more strongly self-efficacy is impacted (Bandura, 1997). For behaviour initiates, Bandura (1997) postulates that observing a coping model (one who begins unsure of themselves but through persistent effort improves performance) is thought to have more positive effects on self-efficacy than observing a mastery model (one who performs the behaviour competently without error). Behavioural initiates may find coping models more like themselves than mastery models. Coping models may also display strategies for performance improvement that are useful to behavioural initiates, and by demonstrating success through persistence, coping models can reduce the negative effects of setbacks and better sustain motivation (Bandura, 1997).

The limited empirical research suggests that mastery and coping models have similar impacts on observer self-efficacy (Clark & Ste-Marie, 2002; Cumming & Ramsey, 2011; Weiss et al., 1998). The studies to date have examined coping versus mastery models in the context of swimming performance (Weiss et al., 1998), diving (Clark & Ste-Marie, 2002) and balance on a stability task (Cumming & Ramsey, 2011) in young healthy participants. However, there may be circumstances that moderate the effects of coping and mastery models on observer self-efficacy. When learners observe difficult tasks or tasks that require a great amount of persistence for success, coping models may be more beneficial than mastery models (Cumming & Ramsey, 2011; Weiss et al., 1998). Alternatively, coping models may not be necessary when people are confident in their abilities to learn quickly and manage problems effectively (Bandura, 1997). To date, no studies have examined potential moderator effects of coping and mastery models on observer self-efficacy, such as previous experience (Bandura, 1997), gender (Bandura, 1997), perceived difficulty of task (Cumming & Ramsey, 2011), and learning self-efficacy (Bandura, 1997). Further, the effect of coping and mastery models on exercise self-efficacy has not yet been studied in COPD patients.

The primary purpose of this study was to test the effects of two vicarious experience interventions, coping versus mastery video-modeling, on COPD patients' self-efficacy levels within the context of a usual-care, pre-PR cardiopulmonary exercise test (CPET). The CPET was chosen because it is a highly controlled situation and therefore ideal for preliminary experimental testing before proceeding to more complex environments. It was hypothesized that coping models would enhance observer self-efficacy more than mastery models. Potential moderators of this effect were explored, including gender, perceived difficulty, response efficacy, and learning self-efficacy. Not all self-efficacy types were expected to be impacted similarly. Given that the video interventions portrayed patients' physical experiences of CPET tests and did not include actions related to scheduling exercise, it was hypothesized that task, walking, and coping self-efficacy for exercise and breathing would be impacted more than scheduling self-efficacy.

The secondary purpose of this study was to determine the self-efficacy sub-type that has the strongest predictive relationship to physical activity the week following the CPET. It was hypothesized that coping self-efficacy (breathing-related and exercise related) would have the strongest relationships to physical activity, followed by task and walking self-efficacy. It was thought that elemental aspects of exercise tasks and overcoming challenging circumstances would be the most important to COPD patient persistence with physical activity behaviours.

Method

Participants and Procedures

Ethical approval was obtained from the university and hospital research ethics boards (HREB Panel B: Pro00066645). Eligibility requirements for the study were a physician diagnosis of COPD, and airflow obstruction (post bronchodilator forced expiratory volume in 1 second/ forced vital capacity (FEV1/FVC) ratio of less than 0.7 (GOLD, 2015)), and capability to provide written informed consent in English. Potential participants were excluded if they had a respiratory exacerbation within the previous month, unstable cardiac disease, talc granulomatosis, interstitial lung disease, or cognitive impairments. Patients requiring supplemental oxygen or with other comorbidities were allowed to participate in the study.

Participants were recruited from the waiting area prior to a usual care pre-PR assessment at an outpatient PR clinic. A total of 120 participants, 40 per group (50%

female), provided informed consent. Specifying a medium effect, and an α of .05, the power calculation for the primary hypothesis in G*Power was .88 (Faul et al., 2009; Faul et al., 2007).

Participants were randomized with equal allocation to one of three conditions (coping, mastery, control) using a random numbers table. First, participants completed assessments of exercise self-efficacy, walking self-efficacy, learning self-efficacy, perceived difficulty, response efficacy, and past exercise experience. Next participants watched the video associated with their intervention condition (or received verbal instructions if in the control condition), followed by assessments of exercise self-efficacy, walking self-efficacy, perceived difficulty, and perception of model-observer similarity for those in the mastery and coping conditions. Participants then completed a usual-care physician supervised CPET, followed by another assessment of exercise self-efficacy, walking self-efficacy, and perceived difficulty. The questionnaires at each timepoint are provided in Appendix C. Lastly, participants were given Fitbits™ to measure physical activity in steps per day during the subsequent week.

The following comorbidities and systemic manifestations were present in this sample: 53% musculoskeletal impairment, 48% hypertension, 42% dyslipidemia, 32% mental illness, 21% diabetes, 16% coronary artery disease, 19% cancer, 16% asthma, 7% valvular heart disease, 7% renal disease, 4% obstructive sleep apnea, 4% cerebrovascular, and 4% liver disease. The comorbidities and systemic manifestations of this sample are in line with the extant literature on COPD (Evans & Morgan, 2014). Additional participant characteristics are displayed in Table 4.2.

Development of Video Interventions

Two pilot studies were conducted to support the development of the interventions. In the first pilot study, 30 people with COPD attending PR (15 males, 15 females) orally listed all the people they compared themselves to when deciding if they were good at exercise. A cumulative list of possible comparators and characteristics was constructed from participant responses (e.g., males/females in PR-class, spouse, male/female children). Next, 30 new participants with COPD attending PR (15 male, 15 female) rated on a brief oral questionnaire (i) how well (better, the same, worse), and (ii) how often (never, rarely, sometimes, often, frequently) they compared themselves to the people on the list generated by the previous sample. Participants reported comparing similarly and most frequently to people the same age and gender. As a result, separate videos of male and female models close in age to the average COPD patient were created.

In the second pilot study, oral questionnaires were conducted with 20 COPD patients (10 males, 10 females) before and after performing a CPET, and three health care practitioners (HCPs) who conduct CPETs, to gather information about patient experiences of the CPET. The findings indicated that patients expect the CPET to be difficult, although many perform either the same or better than they thought they would. Aspects of the CPET patients found difficult were getting used to the mouth piece and nose plug, adjusting to different speeds (both fast and slow), the feeling of walking on a treadmill, the feeling of being ‘tested’, and the number of people in the room (i.e., two staff members, one physician – sometimes two if a resident was training). HCPs identified the most common errors made by patients on the treadmill: taking short unnatural strides, shoulders raised and close to their ears, gripping onto railings, and legs and hips behind body and not underneath shoulders. These results informed patient experiences to be portrayed by the models in the videos, including the types of errors the coping models would act out.

Video Modeling Interventions

One female and one male graduate of the PR program who regularly exercised were recruited as models for the intervention videos. They were recruited because they had adequate stamina for taking multiple video shots, were able to act out different scenarios, and appeared similar in age to many COPD patients. The videos were recorded in the designated exercise testing room at the PR centre and were developed with assistance from a videographer. Four videos were created that were between 5-7 minutes in length: female coping, female mastery, male coping, and male mastery. The same female and male models were in each video.

Both coping and mastery videos began with the same footage of a HCP explaining the CPET procedures, equipment, and measures, followed by the attachment of equipment to the models' body, and usual care spirometry assessments and breathing maneuvers. Next, models acted out a CPET but did not achieve their maximum exercise capacity as they were higher in ability and fitness than typical COPD patients. The models' performances during the CPET differed in the coping and mastery videos. In the coping model video, the models began the CPET acting out common errors identified in the pilot studies: (i) taking short strides, (ii) walking with legs and hips behind body instead of underneath shoulders, and (iii) tensing shoulders and gripping the support railings. HCPs provided the models with instruction to overcome these errors. As the CPET continued, the models' performance improved as a result of the instruction, and by the end of the video, the models performed competently and without error. In the mastery model video, the models appeared competent and did not make any errors throughout. The models demonstrated ideal form, with hips directly underneath shoulders, long and natural strides, and a stable but loose grip on the support bars. The HCPs did not give mastery models instructions as it was not required. In both coping and mastery videos, the models appeared to terminate the CPET as a result of maximal effort. Commentary was provided by the models after the CPET. The coping models stated that the CPET was difficult at first, but with the instruction from the staff and through their persistent effort, they were able to grasp the task. The mastery models stated that it was a relatively easy and straightforward task for them to do.

Participants in the intervention conditions watched the video associated with their assigned study condition and their gender: coping (male/female) or mastery (male/female). Participants in the control condition received standard care procedures that included verbal instruction from a HCP about the CPET test only. The verbal instructions were standardized across all patients and conditions.

Cardiopulmonary Exercise Testing

All participants were given standardized information about CPET procedures, equipment, and measures before beginning. Participants were encouraged to walk for as long as possible but informed they could end the test when they felt they could not continue. Participants pointed to the appropriate value on the modified Borg exertion scale (Hareendran et al., 2012) when prompted at baseline, every two minutes, immediately post-exercise, and 2 minutes post-exercise to rate their breathing and leg discomfort. Once the exercise test began, the work load increased by adjustments of speed and/or grade every minute or two up until a maximum duration of 8-12 minutes (Wasserman, 2005). The specific exercise protocol was determined on an individual basis by the supervising physician. Gripping or leaning onto treadmill handrails was discouraged. Participants could rest hands on handrails when balance was sought. Standardized general encouragements were given to all participants during the test, such as “good job”, and “you are doing well”. Baseline spirometry, as well as inspiratory capacity, minute ventilation, oxygen update, and carbon dioxide production were collected throughout the test by a metabolic cart (Vmax Spectra V29 System; SensorMedics, Yorba Linda, CA). Physicians monitored a 12-lead electrocardiogram (ECG, Cardiosoft; SensorMedics, Yorba Linda, CA) during the test to ensure there were no exercise-induced ECG changes. Cardiopulmonary exercise test data are summarized in Table 4.3.

Materials

Demographics. Age, gender, BMI, and smoking history in pack years were obtained from program records.

Modified Medical Research Council (mMRC) dyspnea scale (Mahler & Wells, 1988). This routine measure collected by the PR program was obtained through program records and assessed patients' degree of functional impairment due to breathlessness from 1 (not troubled by breathlessness except with strenuous exercise) to 5 (too breathless to leave the house or breathless when dressing/undressing).

Modified Borg Scale (Hareendran et al., 2012). This scale is routinely used by the PR program to assess patients' perceived exertion, from 0 (not breathless at all) to 10 (maximal breathlessness), during CPETs.

Spirometry. Standard spirometry assessments were performed on all patients prior to the pre-program assessment. Patients were stratified according to Global initiative for chronic Obstructive Lung Disease (GOLD) forced expiratory volume in 1 second (FEV1) criteria (GOLD, 2015).

Leisure Score Index (LSI) from the Godin-Leisure-Time Exercise Questionnaire (GLTEQ; Godin & Shephard, 1985). Participants recalled average weekly frequency and duration of light (minimal effort, no perspiration), moderate (not exhausting, light perspiration), and vigorous (heart beats rapidly, sweating) exercise that lasted at least 10 minutes during the past month. Total energy expenditure expressed as metabolic equivalents was calculated using a standard algorithm. This instrument has been found to be reliable and valid in previous reports (Amireault & Godin, 2015; Godin & Shephard, 1985).

Multidimensional Self-efficacy for Exercise Scale (MSES; Rodgers et al., 2008). A modified version of the MSES was used to assess exercise self-efficacy. This version assesses task, coping for exercise, and scheduling with three items each from the original version; and a new fourth sub-type, coping for breathing, using three additional items from the COPD Self-efficacy Scale (Wigal et al., 1991) that pertain to managing breathlessness during exercise or exertion. Confidence for each question is rated from 0 (no confidence) to 100 (complete confidence). The mean of each self-efficacy sub-type was calculated and used for analysis. The MSES has been found to be reliable and valid (Rodgers et al., 2008), and has been used in many populations, including patients with COPD (Selzler et al., 2016). The internal consistency values across all time points for the sub-types ranged from .83 to .91.

Modified Self-efficacy for Walking Scale (McAuley et al., 1991). Participants responded to 9 items following the prompt, “How confident are you that you can walk every day at a moderate pace for…”, on a 100% confident scale, from 0 (no confidence) to 100 (complete confidence). Each item increases in consecutive 5-minute increments, from 5 to 45 minutes. The mean of the nine items was calculated used for analysis. The internal consistency values for this scale across all time points were between .96-.97.

Self-efficacy for Learning. Four items assessed self-efficacy for learning exercise tasks from 0 (no confidence) to 100 (complete confidence). The items correspond with Rodgers et al.’s (2008) MSES task self-efficacy items. For example, one task self-efficacy item from Rodgers et al.’s (2008) scale is “how confident are you that you can perform all of the movements required for your exercises”, and a corresponding learning self-efficacy item is “how confident are you that you can learn new movements required for your exercises.” The mean of the items was calculated and used for analysis. The internal consistency value for this scale was .99.

Perceived Difficulty. Perceived difficulty of treadmill walking was assessed with three items on a 1-7 Likert-type scale, from 1 (extremely easy) to 7 (extremely difficult). Each item assessed a different exercise intensity (i.e., light, moderate, strenuous). Participants responded to items following the prompt, "How difficult would it be for you to walk on a treadmill at a ______intensity (intensity description) for at least 10 minutes?" The mean of the items was calculated and used for analysis. The internal consistency value for this scale was .82.

Model-Observer Similarity. Participants rated their similarity to the model in the video with a single item, from 1 (completely dissimilar) to 7 (exactly like me).

Response efficacy. Participants indicated the extent to which they agree from 1 (strongly disagree) to 7 (strongly agree), with the following two statements, "Increasing my exercise will improve my physical capabilities" and "Increasing my exercise will improve my well-being". The mean of the items was used for analysis. The internal consistency value was .94.

Objective Physical Activity. Participants' physical activity was assessed by recording step count in 15-minute intervals using the Fitbit Flex™ or Fitbit Flex 2™. Patients were instructed to wear the device on their non-dominant wrist during all waking hours for one week following their CPET. Data were downloaded onto a secured laboratory computer in order to evaluate patients' average step count. Data analysis was based on the first 10 hours of data recorded averaged across 5 consecutive days.

Analysis & Results

Data screening

All statistical analyses were performed using IBM SPSS Statistics 24. Assumptions of statistical tests were tested and tenable unless otherwise stated. Minor deviations from normality were found for learning self-efficacy and response efficacy at baseline (kurtosis = 2.92 and 4.55, respectively), and task self-efficacy post-exercise test (skewness = -2.13, kurtosis = 5.72). Given the few and minor deviations from normality no data transformations were performed.

Preliminary analyses

MANOVAs were conducted with continuous variables and chi square statistics with categorical variables to determine if coping model, mastery model, and control groups differed on baseline levels of (i) demographic and clinical data (age, gender, BMI, FEV1 % predicted, FEV1/FVC % predicted, and smoking history in pack years), and (ii) psychosocial and behavioural data (modified MSES, SEW, learning self-efficacy, perceived difficulty, GLTEQ). None of these tests were statistically significant.

Manipulation check

A one-way ANOVA compared participants' ratings of the number of model errors in the video across intervention groups. The test was statistically significant, $F(1, 78) = 316.38$, $p < .001$, $\eta^2_p = .80$, $M_{mastery} = 0$, $M_{coping} = 3$, indicating that the manipulation was successful.

Primary analysis

To test the effects of coping versus mastery model interventions on COPD patients' self-efficacy a 3(condition: coping, mastery, control) by 5(self-efficacy: task, coping for exercise, coping for breathing, scheduling, walking) by 3(time: pre-video, post-video, post-exercise test) mixed MANOVA with repeated measures on the last two factors was conducted. Mauchly's test indicated the assumption of sphericity was violated for the main effect of time, $\chi^2 = 28.88$, $p < .001$, self-efficacy, $\chi^2 = 89.03$, $p < .001$, and the interaction between time and self-efficacy, $\chi^2 = 199.23$, $p < .001$. Therefore, multivariate tests are reported. There was a statistically significant interaction between time, self-efficacy type, and group, $F(16, 222) = 1.70$, $p = .049$, $\eta^2_p = .11$; as well as between time and group, $F(4, 234) = 6.93$, $p < .001$, $\eta^2_p = .10$, and between time and self-efficacy type, $F(8, 110) = 6.30$, $p < .001$, $\eta^2_p = .31$. There were main effects of time,

$F(2, 116) = 46.38$, $p < .001$, $\eta^2_p = .44$, and self-efficacy, $F(4, 114) = 94.79$, $p < .001$, $\eta^2_p = .77$. Consistent with the significant interactions, the planned simple contrasts for group were not statistically significant. Follow-up time by group repeated measures ANOVAs were conducted for each self-efficacy type. The task and group interaction was statistically significant, $F(4, 234) = 5.00$, $p = .001$, $\eta^2_p = .08$; along with coping for exercise and group, $F(4, 234) = 7.83$, $p < .001$, $\eta^2_p = .12$; and coping for breathing and group, $F(4, 234) = 2.79$, $p = .027$, $\eta^2_p = .05$.

Figures 4.1a-e display the interaction between time and group for each self-efficacy sub-type. The figures indicate positive effects of the intervention conditions, such that all the self-efficacy sub-types were strengthened from baseline to post-video in the coping and mastery conditions. The figures also indicate that there was no change in any of the self-efficacy sub-types from baseline to post-verbal instructions in the control condition. For the coping and mastery conditions, the rate of increase across task, scheduling, coping for breathing, and walking self-efficacy was similar. However, the rate of increase for coping for exercise self-efficacy was greater in the coping condition compared to the mastery condition. Across all three of the groups, the self-efficacy sub-types were strengthened from post-intervention to post-exercise test, with one exception. In the coping group, walking self-efficacy did not improve from post-intervention to post-exercise test. In the control group, there was a greater increase in the self-efficacy types from post-intervention to post-exercise test compared to the coping and mastery groups, such that all groups had similar levels of self-efficacy post-exercise test.

Exploratory Moderator Analyses

Learning self-efficacy, response efficacy, perceived difficulty, and GLTEQ were recoded into dummy variables to test the moderating effects of these variables on the relationship between the interventions and self-efficacy. Learning self-efficacy, response efficacy, and perceived difficulty were split into quantiles at the median of each scale, and the GLTEQ was split into quantiles at the mean, which was 10. The means of the high and low categories for perceived difficulty were 5.00 and 1.33, respectively, and the point-biserial correlation coefficients to the self-efficacy sub-types across all time points ranged from -.07 to -.36. The means of the high and low categories for GLTEQ were 35.61 and 1.39, respectively, and the point-biserial correlation coefficients to the self-efficacy sub-types across all time points ranged from -.02 to .32. Learning self-efficacy and response efficacy were not tested as moderators as less than 10% of the sample fell into the 'low' categories. The mean and median scores for learning self-efficacy were 85 and 100 (out of 100), respectively, and for response efficacy were 6.10 and 6.50 (out of 7), respectively. Perceived difficulty and the GLTEQ were also split into tertiles with the middle group removed for a second moderator analysis.

To determine whether gender, perceived difficulty, and GLTEQ moderated the effects of the intervention, these variables were added one at a time to the main ANOVA analysis. None of the interaction terms containing group with perceived difficulty, GLTEQ, or gender (quantiles or tertiles) were statistically significant, *p*'s between .07 and .98, respectively, Therefore, perceived difficulty, GLTEQ, and gender were not retained as moderators in the primary analysis.

Model observer similarity

To determine whether model-observer similarity impacted the intervention effects, a time by self-efficacy type by intervention group (coping, mastery) repeated measures ANOVA with model-observer similarity included as a covariate was conducted. The covariate was not statistically significant and did not change the pattern of the intervention effects.

Impact of the self-efficacy intervention on physical activity

An ANOVA was conducted to determine if the intervention conditions had an impact on physical activity behaviour the week following intervention contact. There were no differences between groups in physical activity behaviour, $F(2, 99) = 1.06$, $p = .350$, $\eta^2_p = .02$, indicating that intervention conditions did not impact physical activity behaviour.

Impact of the self-efficacy intervention on CPET performance

ANCOVAs were conducted to determine if the intervention conditions had an impact on peak VO_2 (ml/kg/min) and peak heart rate while controlling for FEV1 % predicted. There were no statistically significant differences between groups on peak VO_2, $F(2, 90) = 0.04$, $p = .959$, $\eta^2_p < .01$ and peak heart rate, $F(2, 106) = 0.23$, $p = .796$, $\eta^2_p < .01$ indicating that intervention conditions did not impact exercise tolerance or effort. More detailed results of the CPET are presented in Table 4.3.

Secondary Analyses

Remaining analyses were conducted on 102 participants that returned Fitbits™ and provided 10 hours of data for 5 consecutive days. To determine if any demographic/clinical variables influenced the self-efficacy – physical activity relationship, partial correlations were computed between demographic/clinical indicators (age, gender, BMI, smoking history, mMRC dyspnea, season, FEV1% predicted, and FEV1/FVC %) and steps per day while controlling for self-efficacy sub-types. None of the relationships were statistically significant; therefore, no demographic/clinical indicators were controlled for in the subsequent analysis.

A multiple regression was used to determine if post-intervention self-efficacy predicted average steps per day in the subsequent week. Bias in the regression model was examined by plots and diagnostic statistics to test assumptions and identify unusual cases. The assumptions of multiple regression were tenable. Several cases had Mahalanobis distances (Field, 2013) and leverage values (Stevens, 2002) greater than the recommended cut-offs. However, all cases were well below the cut-off of 1 for

Cook's distance, indicating that there was no need to delete these cases since they did not have a large effect on the regression analysis (Stevens, 2002).

The multiple regression model predicting average steps per day from the self-efficacy variables was statistically significant, $F(5, 97) = 3.26$, $p = .009$, $M = 4{,}231$, $SD = 2{,}637$, range = 473 – 11,417. The predictors accounted for 10% (adjusted) of the variance in steps per day. Table 4.4 displays the coefficients for the regression model. Coping for exercise and breathing were statistically significant predictors of steps per day, such that greater coping for exercise self-efficacy and lower coping for breathing self-efficacy were significantly associated with greater steps per day. The beta weights of scheduling self-efficacy and coping for breathing related self-efficacy to steps per day were substantially larger than the zero-order correlations to steps per day, suggesting suppression was present (Tabachnick & Fidell, 2013). To identify the variable responsible, the variables with congruent beta weights and correlations were systematically left out of the regression equation (i.e., task, coping for exercise, and walking self-efficacy) and then the changes in the beta weights for the independent variables with incongruent beta weight and correlations were examined (Tabachnick & Fidell, 2013). Results of this procedure indicated that coping for exercise self-efficacy enhanced the relationship of scheduling self-efficacy to physical activity, and walking self-efficacy enhanced the importance of coping for breathing self-efficacy to physical activity by suppressing irrelevant variance.

Discussion

This is the first study to test the effects of mastery and coping model interventions on observer self-efficacy in COPD patients. Both mastery and coping model interventions positively impacted self-efficacy, whereas verbal instructions alone did not change self-efficacy. Compared to the coping models, the mastery models had a similar impact on the self-efficacy sub-types, except for coping for exercise self-efficacy, which was the type of self-efficacy most strongly associated with post-exposure physical activity. For this type of self-efficacy, the coping models had a greater impact on observer self-efficacy than the mastery models. The models in the coping video portrayed common errors that COPD patients make on CPETs and how to correct them. Therefore, the coping models may have provided participants with more information specific to overcoming exercise challenges than the mastery models, which could explain the greater increase of coping for exercise self-efficacy in the coping group compared to the mastery group. The similar changes across the other self-efficacy sub-types suggest that vicarious experience can have a generalized effect on self-efficacy. However, the greater increase in coping for exercise self-efficacy in the coping condition points to the specificity needed in the design of behavioural interventions to get the strongest possible impact on the desired outcome (Rodgers et al., 2009).

Given the context of the intervention was a physical exercise task, it was hypothesized that task, coping (both types), and walking self-efficacy would be more strongly impacted than scheduling self-efficacy. This hypothesis was partially supported. Task and coping self-efficacy (both types) were most strongly impacted by the interventions, followed by scheduling self-efficacy. The increase in scheduling self-efficacy may have occurred by virtue of its relationship to task self-efficacy. Confidence for elemental aspects of tasks is a prerequisite for confidence for performing the task under challenging situations (Maddux, 1995). COPD patients may not be confident that they can schedule exercise tasks if they are not sure if they can perform the task itself. Through gaining confidence to perform a physical exercise task, patients with COPD may also gain confidence to arrange their schedule to do the task itself, particularly if time demands are not a pressing issue, which may be the case in a predominantly retired population group.

Contrary to our hypothesis, there was limited change in walking self-efficacy across the conditions. This lack of change may be explained by the intensity of the activity specified in the scale. The modified SEW (McAuley et al., 1991) assesses perceptions of walking endurance at a moderate pace. However, the CPET is a maximal test where the intensity steadily increases until the patient or supervising physician terminates the test. Observing a model perform a CPET may not provide the observer with much relevant information about walking endurance at a moderate pace.

Cumulating empirical research suggests that mastery and coping models have similar effects on observer self-efficacy (Clark & Ste-Marie, 2002; Cumming & Ramsey, 2011), although several moderators of this relationship have been suggested. For example, some researchers have suggested that coping models may be more beneficial than mastery models when learners observe difficult tasks, or tasks that require great persistence for success (Cumming & Ramsey, 2011). In this study, perceived difficulty and past exercise experience did not moderate the intervention (coping or mastery) and self-efficacy relationship. However, the greater impact on coping self-efficacy in the coping intervention compared to the mastery intervention, coupled with similar impact on task self-efficacy across the mastery and coping conditions suggests that coping models may be more beneficial than mastery models when the complexity of the task is great. During elemental and basic tasks, both mastery and coping models are able to improve observer capability beliefs. However, when the task is a composite of multiple smaller behaviours and more information is required by the observer, coping models seem to be better than mastery models for improving capability beliefs.

While the primary purpose of this paper was to examine the effects of two vicarious experience interventions on observer self-efficacy, the effects of mastery experience can also be determined. In the coping and mastery conditions, there was an increase in self-efficacy with the vicarious experience interventions and then a further small increase in self-efficacy after participants performed their own CPET (i.e., mastery experience). In the control condition, there was no change in self-efficacy with verbal instructions only, but an increase in self-efficacy with the CPET that brought self-efficacy levels up to those of the coping and mastery model intervention conditions. This finding is in line with theoretical expectations that mastery experiences are the strongest source of self-efficacy (Bandura, 1997), although it does not negate the importance of vicarious experiences. Vicarious experiences are useful for instructional purposes and may be important for supporting the initiation of new behaviours when individuals are unsure of how to begin, the task is complex, or when support from an expert is absent. Further, observation of others is inevitable in social environments. Additionally, the cumulative value of vicarious and mastery experiences across time and under differing circumstances might encourage better adherence and achievement and warrants further study. Understanding the impact people's behaviour has on others is necessary for creating situations that will support development of confidence and behaviour.

Although the primary purpose of this study was to examine the effects of two vicarious experience interventions on observer self-efficacy, the impact of the intervention conditions on exercise tolerance, effort on the exercise test, and subsequent physical activity were also examined. The intervention conditions were not found to have statistically significant impact on any of these variables. The protocol of a CPET is designed to facilitate patient achievement of maximal exercise tolerance and effort, so it is not surprising that the intervention conditions did not translate into better performance on the CPET. However, in those who have greater baseline anxiety, it is possible that a CPET intervention that reduced anxiety could have facilitated greater exercise tolerance by reducing hyper-inflation. This hypothesis could not be tested in this study but may be worth further perusal. The intervention conditions were also not found to have a statistically significant impact on physical activity the week following contact. This finding was not expected given that the intervention was only delivered one time and in the context of a very specific exercise experience and was prior to the formal PR program. Also, the CPET is not, strictly speaking, an intervention – but is a capability assessment. It is likely that a more intensive and explicit intervention would be required to impact physical activity levels. However, the results of this study are promising, given that the type of self-efficacy most strongly impacted by the coping model intervention was the type of self-efficacy most strongly related to physical activity the week following contact.

This study was the first to examine which type of exercise-self-efficacy is most strongly related to objective physical activity in patients with COPD. Physical activity is a key component of optimal disease-management in COPD patients (Spruit et al., 2013), and physical activity has been shown to be related to acute exacerbations (flare-up of disease symptoms) and mortality in patients with COPD (Gimeno-Santos et al., 2014). While the development of self-efficacy is considered fundamental to long-term physical activity and is a key component to COPD management protocols (Bourbeau et al., 2004; Rice et al., 2014), no previous research has examined the relationship of exercise-specific self-efficacy to physical activity in COPD patients and few studies have empirically tested how to enhance self-efficacy in this population. This study demonstrated that self-efficacy for coping with exercise barriers was the type of self-efficacy most strongly related to objectively measured physical activity. This was also the type of self-efficacy most strongly impacted by the coping model intervention. Previous research has found that coping for exercise self-efficacy predicts improvement in functional exercise capacity in COPD patients over and above demographic and clinical indicators (Selzler et al., 2016). Cumulatively, these studies suggest targeting coping exercise self-efficacy in future interventions to improve functional capabilities and physical activity levels in COPD patients may be a fruitful avenue to explore, and that vicarious experiences using coping models may be a useful intervention technique to achieve these behavioural goals.

An important contribution of this research is the inclusion of self-efficacy for coping with breathing barriers and exercise barriers. Given that dyspnea (i.e., breathlessness) is a primary symptom of COPD and that physical activity will naturally induce dyspnea, it is reasonable to assume that self-efficacy for coping with breathing barriers would be important to physical activity participation in this group. However, this research tentatively suggests that self-efficacy for coping with exercise barriers may be more important to physical activity than coping with breathing barriers. Future research statistically distinguishing the two constructs in COPD patients is needed. The results of that research will have implications for the design of future interventions to improve physical activity adherence in COPD patients.

There are several applications of this research for PR settings. First, PR could utilize peers for demonstrating exercise tasks and solutions for overcoming common pitfalls. Demonstration could occur in vivo or through pre-recorded videos, as in this study. Previous research has shown that low task self-efficacy was associated with poor attendance at PR (Selzler et al., 2016). Videos illustrating exercise training components by a peer may facilitate the enhancement of self-efficacy prior to attending PR, which may then make it more likely for COPD patients to initiate attendance at PR. The second application of this research to PR settings is that while demonstration of an ideal situation is helpful, demonstration of a situation in which one has to cope, may be better. This point applies to the performance of physical exercise tasks, such as form while walking on a treadmill, but it may also apply more broadly to other exercise tasks, such as overcoming motivational, environmental, and social challenges. While the former challenges have implications for performance of exercise in the PR setting, the latter challenges have implications for the performance of long-term physical activity after PR has concluded.

Limitations

This study demonstrated that observation of similar others perform exercise tasks can enhance self-efficacy in COPD patients. The patient CPET experience was an ideal environment to preliminarily test vicarious experience effects as the setting was highly controlled. However, it is unknown if vicarious experiences in less controlled environments, such as a PR exercise training class, would have similar impacts on self-efficacy. In less controlled environments there is much more information available for individuals to interpret and it is unclear what information will ultimately impact confidence. Facilitating opportunities for beneficial mastery and vicarious experiences may help to ensure that patients' confidence is being impacted in a positive way in environments that are more difficult to control. Additionally, the results of the multiple regression should be interpreted with caution. Although Coping for exercise self-efficacy was a statistically significant predictor of steps per day, the confidence intervals were large. Further, the coping for breathing sub-scale was preliminary and requires psychometric testing.

Conclusions

This research tested the effects of vicarious mastery and coping experiences on multiple types of observer self-efficacy within the context of usual care CPET in COPD patients. While both mastery and coping models had beneficial effects on observer self-efficacy, coping models had a stronger effect on self-efficacy for coping with exercise barriers, which was the type of self-efficacy most strongly related to physical activity. This research suggests that vicarious experience is a useful intervention technique to enhance self-efficacy, and that future interventions with COPD patients should target coping for exercise self-efficacy. Further, this research highlights the importance of detailed, population-specific interventions to have the greatest possible impact on outcomes. Future research examining the generalizability of coping self-efficacy will be useful for understanding the theoretical and applied limits of this variable.

Table 4.1

Types and Definitions of Self-efficacy Assessed

Self-efficacy type	Definition
Task	Confidence for performing elemental aspects of exercise.
Coping with exercise	Confidence for exercising under challenging circumstances.
Coping with breathing	Confidence for managing breathing during physical exertion.
Scheduling	Confidence for exercising regularly.
Walking	Confidence for walking at a moderate pace at incremental intervals.

Table 4.2

Descriptive Statistics

	Control	Mastery	Coping
Variables	M±SD	M±SD	M±SD
Age, years	63.67 ±10.65	68.00 ±7.67	67.16 ±7.08
BMI, kg/m^2	30.87 ±6.98	28.18 ±6.79	31.26 ±6.64
mMRC, 1-5	3.00 ±1.08	2.92 ±1.15	3.00 ±1.00
Smoking history, pack years	39.07 ±20.41	40.03 ±21.67	36.36 ±24.97
FEV1, % predicted	68.43 ±23.89	64.31 ±20.02	58.00 ±20.14
FVC/FVC, %	65.81 ±19.20	63.25 ±19.83	63.71±20.13
Gold Stage, %			
I/Mild	32.5	17.5	12.5
II/Moderate	27.5	55.0	45.0
III/Severe	35.0	15.0	35.0
IV/Very Severe	5.0	12.5	7.5

Note. BMI = body mass index, mMRC = modified Medical Research Council Dyspnea Scale, FEV1 = forced expiratory volume in one second, FVC = forced vital capacity. Gold Stage = classification of disease severity by lung function impairment: I/mild = FEV1 ≥ 80% predicted; II/moderate = 50% ≤ FEV1 < 80% predicted; III/severe = 30% ≤ FEV1 < 50% predicted; III/very severe = FEV1 < 30% predicted.

Table 4.3

Cardiopulmonary Exercise Test Data

Variable	Total Sample	Control	Mastery	Coping	Group differences, $p < .05$
Peak VO_2, ml/min	1408 ±440	1448 ±385	1353 ±475	1431 ±460	
Peak VO_2/kg, ml/kg/min	16.96 ±4.13	17.29 ±3.65	16.92 ±3.68	16.62 ±5.16	
Peak VO_2, % predicted	74.39 ±19.09	72.63 ±16.42	77.50 ±19.24	72.48 ±21.63	
Peak VCO_2, ml/min	1464 ±530	1548 ±464	1420 ±604	1426 ±508	
Peak, RQ	1.03 ±.11	1.06 ±.11	1.03 ±.12	.99 ±.08	Coping vs control[a]
Peak METs	4.53 ±1.36	4.55 ±1.38	4.70 ±1.12	4.33 ±1.58	
Peak HR, BPM	124 ±22	126 ±20	122 ±19	124 ±26	
Peak HR, %max	81 ±14	81 ±13	80 ±12	81 ±17	
Peak V_E, L/min	52.23 ±15.16	55.64 ±14.30	51.30 ±15.58	49.62 ±15.39	
Breathing Reserve, %	4.02 ±27.51	3.13 ±27.90	6.00 ±24.77	2.52 ±30.95	
Inspiratory Capacity Rest, L	2.45 ±.72	2.42 ±.77	2.53 ±.75	2.38 ±.63	
Inspiratory Capacity Exercise, L	2.01 ±.75	2.08 ±.65	1.82 ±.96	2.15 ±.59	

Note. VO_2 = oxygen uptake, VCO_2 = carbon dioxide production, RQ = respiratory quotient, METs = metabolic equivalents, HR = heart rate, V_E = minute ventilation.

ANOVAs with Tukey's post-hoc tests were conducted to determine if the interventions had an impact on exercise test performance. Group differences are noted above.

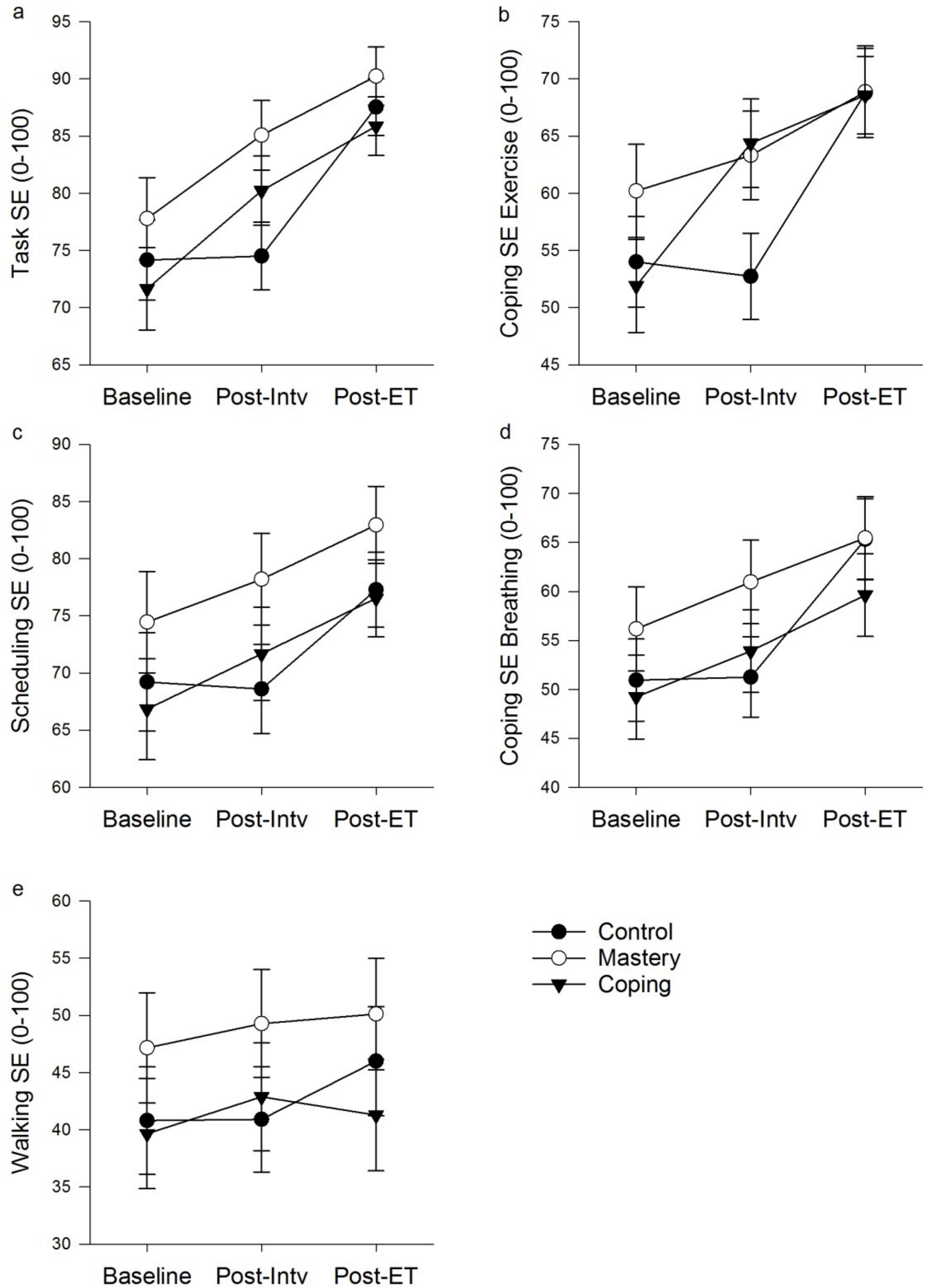
[a] = After controlling for forced expiratory volume in 1 second (FEV1) there were no statistically significant differences between groups indicating that interventions did not impact exercise test performance.

Table 4.4

Multiple Regression Analysis Predicting 10 Hour Step Count Average One Week Post Contact

	(Adj)R^2	Unst. *B* (95% CI)	SE	St. B	*p*-value	*r*
Model	.10					
SE Predictor						
Task		23.15 (-21.22 – 67.52)	22.36	.12	.303	.21
Coping with exercise		37.87 (7.845 – 67.90)	15.13	.35	.014	.29
Scheduling		-27.34 (-57.92 – 3.23)	15.41	-.22	.079	.00
Coping with breathing		-25.16 (-49.24 – -1.08)	12.13	-.25	.041	-.02
Walking		15.15 (-4.20 – 34.49)	9.75	.18	.123	.19

Note. SE = self-efficacy; Unst = unstandardized; St. = standardized.



Figures 4.1a-e. Self-efficacy sub-types over time by intervention condition.
Note. Intv = intervention, ET = exercise test. Figures 1a, 1b, and 1d have statistically significant interaction effects.

Chapter 5 – General Discussion

This dissertation contributes to accumulating research that suggests self-efficacy improves with PR in patients with COPD (Khoshkesht et al., 2015; Lox & Freehill, 1999; Ries et al., 1995; Scherer & Schmieder, 1997) and supports the purposeful inclusion of self-management education curriculum in PR that aims to enhance self-efficacy (Bourbeau et al., 2004; Rice et al., 2014; Stewart et al., 2014; Troosters, Demeyer, Hornikx, Camillo, & Janssens, 2014). Study 1 (Chapter 2) of this dissertation extends previous research by showing that self-efficacy was strengthened with PR in patients with and without a recent AECOPD. Examination of PR indicates that the components are delivered in a way that supports the development of self-efficacy through the four sources: mastery experiences, vicarious experiences, verbal persuasion, and affective/physiological arousal (Bandura, 1997). For example, exercise training in PR creates repeated opportunities for patients to have mastery experiences that are specific to the performance of exercise tasks. PR content also focuses on teaching patients how to manage breathlessness during exertion and encourages patients to persist through exertion-related fatigue and discomfort. In these ways, PR creates repeated opportunities for patients to have mastery experiences that are specific to coping with in vivo physical barriers of exercise. The other sources of self-efficacy are also activated in PR. Patients are exposed to others' behavioural performances, an example of vicarious experience. Patients receive encouragement from healthcare practitioners and potentially other patients, examples of verbal persuasion. Finally, patients are coached to reduce anxiety around the feeling of breathlessness during exertion and taught to understand appropriate levels of breathlessness – examples of physiological/affective arousal.

Thus, PR provides many opportunities for COPD patients to develop self-efficacy for fundamental skills related to physical activity participation. However, the development of fundamental skills is only the first required component to long-term behavioural adherence. Bandura (1997) emphasizes that it is not so much about the skills people have, but what believe they can do under challenging circumstances that matters for real-world behavioural enactment. In Study 1 (Chapter 2) of this dissertation, functional exercise capacity increased with PR among AECOPD and stable COPD patients, but steps per day did not, suggesting that although PR content improves fundamental exercise abilities it does not facilitate the integration of physical activity into usual routines outside of the PR centre. While self-efficacy for walking predicted physical activity in study 1 of this dissertation, the assessment of self-efficacy for exercise was absent, making it unable to determine in this study which type of self-efficacy was the superior predictor. In study 3 (Chapter 4) of this dissertation, the ability of five self-efficacy types (i.e., walking, task, coping for exercise, coping for breathing, scheduling) to predict physical activity was tested, and it was found that self-efficacy for coping with exercise barriers was the best predictor. In study 1, AECOPD patients were found to take fewer steps per day than stable COPD patients and self-efficacy accounted for less variance in physical activity in AECOPD patients compared to stable patients. Thus, collectively these studies indicate the importance of enhancing fundamental aspects of exercise and enhancing confidence for performing those fundamental behaviours before focusing on challenges related to physical activity performance; but also, that confidence and skills for fundamental aspects of exercise are insufficient for physical activity participation among patients with COPD.

The belief that the content and structure of PR programs is insufficient for supporting long-term physical activity among most COPD patients is becoming more widespread amongst researchers (Spruit et al., 2015; Stewart et al., 2014; Troosters et al., 2014). Exercise training and improvements in functional exercise capacity do not necessarily translate into sustained increased physical activity (Spruit et al., 2013). Given the associations found between self-efficacy for coping with exercise barriers and physical activity, while controlling for demographic/clinical characteristics and other self-efficacy types in study 3 (Chapter 4), coupled with the premise that self-efficacy is a modifiable construct, it is recommended that more efforts to enhance coping with exercise barriers be integrated within PR content or extensions of PR content. PR may be a valuable opportunity to strengthen self-efficacy for coping with exercise barriers among people with COPD because it is a service that connects patients to healthcare practitioners with the intent to improve disease self-management (Spruit et al., 2013). However, research has shown that there is an extreme shortfall in the capacity of PR programs to serve the amount of people diagnosed with COPD (Camp et al., 2015; Desveaux, Janaudis-Ferreira, Goldstein, & Brooks, 2015). In Canada, it has been estimated that the capacity of PR programs to provide services to COPD patients is only 0.4% of the diagnosed population (Camp et al., 2015). So, while PR may be a good opportunity to connect with COPD patients, the total proportion of people with COPD that PR programs reach is quite low. Thus, future research in this area may explore opportunities to offer extensions of PR programs through public or private partnerships that focus on coping with exercise barriers in real-world settings.

Indeed, interventions to support the integration of physical activity into individuals' typical routines may be more beneficial in environments that are less structured than PR environments. In the triadic reciprocal determinism principle of Social Cognitive Theory (Bandura, 1997), the person, behaviour, and environment dynamically and reciprocally interact (Bandura, 1997). If one aspect changes than so do the parameters of the other aspects. Thus, in rehabilitation contexts, individuals enhance self-efficacy for the behaviours learned in that context, which is a very structured environment (Rodgers et al., 2013). For example, patients are given a time and location of PR; there are healthcare practitioners and materials that indicate the types of exercises to perform, how to perform them, and for how long; if patients do not attend a session a healthcare practitioner will follow-up about the absence, and help patients troubleshoot should any difficulties with attendance or exercise participation arise. Thus, the rehabilitation experience is very different from being physically active on one's own. When the environment changes (i.e., PR is over), so does the behaviour and the circumstances surrounding the behaviour (Rodgers et al., 2013). Consequently, new social cognitive processes that are specific to the new environment and behaviour need to be developed (Rodgers et al., 2013). Exercising on one's own requires individuals to become problem-solvers and perhaps more importantly, become confident in their abilities to problem-solve when barriers to exercise participation arise.

It is important not to underestimate the difficulty of developing a resilient sense of confidence for overcoming exercise barriers. It takes a great deal of time to encounter all possible barriers, and many barriers will change over time. For example, older adults often downsize their housing requiring them to relocate. This relocation may change their exercise routine if they typically exercised outside of the home, or if the safety or walkability of the new neighborhood is different from the previous neighborhood. Another example that is more variable on a day-to-day basis is modifying exercise plans when one experiences a flare-up of COPD symptoms, and then returning to the regular exercise plan when feeling better. These are just a few examples. And, while barriers may be faced by individuals during PR, it is more likely that barriers will occur or re-occur outside of PR, when there is less environmental support. Therefore, interventions to support self-efficacy for overcoming barriers of exercise may be most beneficial when people are in their own natural environments, or environments of their choosing. Such environments will allow more relevant experiences to individuals than a structured PR exercise environment.

Study 3 (Chapter 4) of this dissertation provides some insight into the intervention content that could be developed and tested to enhance self-efficacy for coping with exercise barriers. In Study 3, a vicarious experience intervention was successful at enhancing self-efficacy in patients with COPD before participating in a maximal exercise test. It was also found that coping models were better at enhancing coping self-efficacy than mastery models. While the intervention conditions were not found to influence subsequent physical activity, coping self-efficacy, which was most strongly influenced by the coping model intervention, was the type of self-efficacy most strongly related to physical activity in the subsequent week. It was not expected that the one-time intervention would be strong enough to influence subsequent physical activity, or that there would be sufficient environmental transfer from the maximal exercise test to general physical activity performance. What the results of the intervention suggest however, is that vicarious experiences with a coping model may be a useful intervention technique to support coping self-efficacy and the development of other physical activity behaviours. Therefore, developing and testing vicarious experience interventions designed to enhance self-efficacy in COPD patients are warranted. PCI Media Impact creates entertainment-education videos to increase knowledge, change social cognitions, and facilitate behaviour change through story-telling (www.mediaimpact.org). They have created health-focused videos about family planning and sexual health, public sanitation and hygiene, among many others. It may be worthwhile to create, and test similar entertainment-education videos aimed at enhancing coping-specific self-efficacy for physical activity behaviours in patients with COPD.

Perhaps the design of an in vivo peer modeling intervention to support coping self-efficacy and physical activity may be beneficial to explore. A previous intervention using peer support delivered over the telephone was not more effective than no support at maintaining health outcomes after PR in COPD patients (Wong et al., 2013). Telephone support is more similar to verbal persuasion than vicarious experience, which is considered to be a weaker source of self-efficacy than vicarious experience (Bandura, 1997). The study by Wong et al. (2013) in conjunction with the theoretical tenets of SCT suggests that the experience of observing a similar other, rather than just listening to a similar other may be a crucial component to the intervention. The results of this study also suggest that observing a similar other displaying coping rather than mastery behaviours may be important component to a vicarious experience intervention. Careful consideration of the content and delivery of a peer modeling intervention to enhance coping self-efficacy and physical activity would be crucial to the success of the intervention.

The results of study 3 (Chapter 4) also indicated that mastery experiences are a beneficial way to enhance self-efficacy in COPD patients. In fact, regardless of whether participants received a vicarious experience intervention or not, all participants ended up with a similar level of self-efficacy after having a mastery exercise test experience. This finding is consistent with theoretical claims that mastery experiences are the strongest source of self-efficacy (Bandura, 1997). Further, this finding suggests that supporting COPD patients through their own mastery experiences of overcoming barriers to exercise, may be a beneficial way to enhance coping self-efficacy and subsequent physical activity behaviour. The level of specificity that will be required for such coping interventions is unknown. That is, will an intervention designed to overcome common barriers be just as effective as an intervention designed to overcome barriers that are specific to an individual? Further exploration of the level of specificity may be important to the success of an intervention.

Strengths/Contributions

A strength of this research is the theoretical approach for understanding behaviour and health outcome achievement. To date, limited research has tested theoretical behavioural interventions in COPD patients. A theoretical approach provided a starting point for the intervention developed in study 2 (Chapter 3) and allowed for specific hypotheses to be formulated and tested throughout the dissertation. The research of this dissertation was based on the theoretical tenets of Social Cognitive Theory (Bandura, 1997). In Social Cognitive Theory, human behaviour is the result of psychosocial processes that occur within social environments (Bandura, 1997). This theory was chosen because it emphasizes the impact of the social environment on people and behaviour, and because it provides principles for how to go about changing social cognitions and behaviour (i.e., the four sources of self-efficacy). This research grows the empirical literature of Social Cognitive Theory (Bandura, 1997), and provides support for the usefulness of vicarious and mastery experience for enhancing self-efficacy in real-world clinical settings. Furthermore, the results of this study provide a starting point for the development of future interventions to enhance self-efficacy and physical activity behaviours based on vicarious and mastery experiences.

An additional strength of this research was assessing many different types of self-efficacy simultaneously. This research demonstrated that the specificity of self-efficacy is important for understanding different health and behavioural outcomes among patients with COPD. A similar degree of self-efficacy specificity has been noted in cardiac rehabilitation patients (Luszczynska & Sutton, 2006; Rodgers et al., 2013; Scholz et al., 2005) and sedentary adults (Rodgers et al., 2002; Rodgers et al., 2009). In cardiac and sedentary adults, task self-efficacy for exercise seems to be most important for initiating exercise programs (Rodgers et al., 2013; Scholz et al., 2005), whereas scheduling self-efficacy for exercise seems to be most important to maintaining exercise programs long-term (Rodgers et al., 2013; Scholz et al., 2005). Interestingly, this research found that self-efficacy for coping with exercise barriers and self-efficacy for walking were the types of self-efficacy most strongly related to physical activity behaviour in COPD patients. Thus, there seems to be different salient challenges to COPD patients than to other populations. Many COPD patients are retired and may have more flexible schedules than adults in the work-force, which may explain a lack of relationship between scheduling self-efficacy and physical activity in COPD patients. Thus, coping with non-scheduling related barriers of exercise seem to be more relevant in COPD patients. However, the long-term associations between self-efficacy and physical activity were not assessed, therefore it is unclear if scheduling self-efficacy becomes a more salient challenge to COPD patients later on in their activity participation. It was also interesting, and novel, to note that self-efficacy for coping with exercise barriers was more important to physical activity participation than self-efficacy for coping with breathing related barriers in COPD patients. This finding suggests that while coping with breathing related barriers is important to management of COPD, there are other salient challenges that need to be addressed in this population as well. Further, this research highlights the level of specificity needed to impact the health and behavioural outcomes of interest.

Another strength of this research was that it was conducted in a homogenous disease sample of COPD patients. Pulmonary rehabilitation is available to people with many different type of respiratory diseases, including asthma, bronchiectasis, and interstitial lung diseases. Many respiratory diseases have different causes, disease courses, and slightly different symptoms. Therefore, the characteristic of people with different respiratory diseases may be different, along with the behavioural challenges, and the circumstances surrounding behavioural enactment. As such, and in line with Social Cognitive Theory (Bandura, 1997), it is important to understand the behaviour and experiences of each disease group separately.

Limitations

A limitation of the research conducted in this dissertation is the small sample sizes. Study 1 (Chapter 2) was notably underpowered to detect time by group interactions, which was only exacerbated by the amount of missing data, as discussed subsequently.

Therefore, it is possible that early and late PR may have had different effects on the self-efficacy types as well as the health and behavioural outcomes. An adequately powered study would provide more reliable results than the results of study 1. The small sample size in study 1 highlights the difficulty with recruiting from in-patient clinical settings. During hospitalization for an AECOPD, patients are experiencing marked increases in symptoms, including breathlessness (Anthonisen et al., 1987), along with fatigue an anxiety (Rodriguez-Roisin, 2000). The condition of patients may contribute to a disinterest among patients to participate in research. Thus, future initiatives aiming to encourage patients to participate in research within this environment are needed.

Although the vicarious experience intervention in study 3 (Chapter 4) had a small sample size, it was adequately powered to detect time by group interactions. Thus, these results are considered reliable. Furthermore, few behavioural interventions have been conducted in COPD patients, and the sample size of this intervention study is the largest to date. The G. F. MacDonald Centre for Lung Health in Edmonton enrolls the greatest number of COPD patients in Canada, which is approximately 400 patients per year. This suggests that this centre is a valuable location to conduct behavioural research in COPD patients, but also speaks to the limited number of potential participants nationwide. Multicentre studies are one way that a greater number of research participants could be reached. Multicentre studies would also increase the generalizability of the study results by including different geographical locations, allowing for comparison across centres, and possibly including a more diverse sample of COPD patients.

A challenge of study 1 (Chapter 2) was the amount of missing data present. While sophisticated analytical techniques for handling missing data have been developed, such as multiple imputation and full information maximum likelihood estimation, these techniques are not available for mixed ANOVA analyses. Thus, less desirable missing data techniques such as mean substitution, last observation carried forward, and list-wise deletion were implemented. These approaches to handling missing data are considered less desirable, as they are likely to produce biased parameter estimates (Graham, 2012). Mean substitution and last observation carried forward are thought to reduce variability and are overly conservative approaches to handling missing data (Graham, 2012), whereas list-wise deletion introduces bias as the sub-sample that analyses are being conducted on tends to not be representative of the whole sample (Graham, 2012). Thus, the results of the mixed ANOVAs in Chapter 2 should be interpreted with this in mind.

The amount of missing data in study 1 (Chapter 2) perhaps highlights a broader challenge of conducting research with clinical populations. In study 1, patients were hospitalized for and recovering from an AECOPD, which can be life threatening (Rodriguez-Roisin, 2000). During an AECOPD patients experience a marked increase in symptoms, including breathlessness, cough, and sputum volume (Anthonisen et al., 1987), in addition to fatigue and anxiety (Rodriguez-Roisin, 2000). Thus, the missing data likely reflects the condition of the patients along with a disinterest among some patients to return for testing. Despite the amount of missing data, study 1 provides useful information about the condition of patients hospitalized for an AECOPD and how PR can improve that condition.

It is important to acknowledge that participation in PR and participation in this study are voluntary. Thus, there may be motivational differences between those who choose to participate in PR and those who do not, as well as those who chose to participate in the studies versus those who did not. While information from people who refused study participation is unavailable, study 1 (Chapter 2) provides some information about a group of people who chose to participate in the study but did not want to participate in PR. The demographic characteristics of the AECOPD no-PR group were similar to the other AECOPD PR groups and the stable PR group. However, this group reported the lowest walking self-efficacy amongst the groups, had the lowest functional exercise capacity and took the fewest number of steps per day (i.e., 1276) – half the number of steps as the next closest group. These findings may suggest that those who are most in need of PR are not willing to participate in this valuable service. While need is found to be a stronger predictor of utilization of hospital and physician services than income, age, and gender in rural and urban areas in Canada (Allan, Funk, Reid, & Cloutier-Fisher, 2011), there may be a different pattern emerging for services that are considered not medically necessary. In a qualitative study seeking to understand why patients decline PR following AECOPD, participants reported prominent self-conscious cognitions (i.e., shame, guilt, fear of others evaluations) which were associated with lowered self-worth and reduced help-seeking (Harrison et al., 2015). Harrison and colleagues (2015) further elucidate that perceived fault for COPD seems to make patients sensitive to interactions with healthcare practitioners, which are often construed as critical and judgemental, and increase avoidance of healthcare settings such as PR. The study by Harrison et al. (2015) suggests that patients who do not attend PR are likely different from those that do; and as such, the results of this dissertation should only be generalized to the patients with COPD who attend PR.

Future directions

The research from this dissertation provide evidence for the associations of self-efficacy to clinical-health and behavioural outcomes and for the efficacy of two intervention techniques (i.e., mastery and vicarious experiences) to enhance self-efficacy in patients with COPD. Based on the results from this dissertation there are several future directions worth exploring.

An important finding of this research was that vicarious experience was found to enhance self-efficacy for an exercise experience. The environment of the intervention was a very controlled exercise test. In the future it would be beneficial to determine if vicarious experiences could have a similar impact on self-efficacy in less controlled environments. For example, video modeling interventions could be developed for PR exercise training routines that patients at PR watch before beginning their own exercise training. Or, an in vivo modeling intervention could be developed where participants are paired with trained models who demonstrate exercise tasks. The results of this dissertation indicate that the modeling interventions would be most effective if delivered by someone of a similar age and of the same gender who displays coping strategies during exercise tasks rather than performing exercise tasks flawlessly.

While developing fundamental skills for exercise tasks is an important prerequisite of regular physical activity behaviour, coping with barriers to exercise participation seems to be more important to the continued performance of the behaviour. Therefore, it would be useful to determine if a vicarious experience intervention could be developed that facilitates skills and confidence for overcoming important barriers to physical activity participation. Perhaps entertainment-education videos could be developed that use story-telling to display a coping-model approach to figuring out useful strategies for overcoming barriers of exercise. The similar-age models in the videos could portray relevant barriers to people with COPD when trying to be physically active and progressively more successful attempts when trying to figure out strategies to overcome those barriers (i.e., a coping model approach). Multiple videos on overcoming different barriers to physical activity participation could be developed.

Or perhaps the design of an in vivo peer modeling intervention to support coping self-efficacy and physical activity may be beneficial to explore. Similar others who have successfully integrated physical activity into their lives could be paired with a small group of patients who are learning to integrate physical activity into their lives. The intervention could include discussion of relevant barriers, discussion of strategies that may help overcome the barriers, the formulation of specific plans to overcome barriers, and then a discussion to talk about what worked, what did not work, why, and the next steps. The intervention would be ongoing for consecutive weeks to help support patients through the processes of overcoming different barriers as they arise. This intervention may be best if lead by a researcher or trained healthcare professional to make sure that discussions stay on topic and that important aspects of the coping experience are made apparent to the individuals. This intervention would allow individuals to observe similar others as well as provide an opportunity to go through the process themselves, and as such, this intervention would utilize both vicarious and mastery experiences.

The interventions just described could occur during PR when COPD patients and healthcare practitioners are working together to help patients manage their disease, or perhaps it may be worthwhile to explore these interventions as extensions of PR. The healthcare practitioners in PR are considered experts in respiratory disease self-management and provide a valuable rapport with patients that could be important to the success of interventions. PR is also a time where researchers and healthcare practitioners are in contact with COPD patients who are motivated to improve their disease status. For these reasons, it may be beneficial to offer interventions during PR. However, PR programs have only a limited amount of time to cover a wide range of topics related to the management of respiratory diseases and so there may not be enough time to include intensive interventions. Patients in PR are also learning a lot of new information and are exercising regularly at PR. Being active outside of PR may be physically and practically difficult for many COPD patients. Further, interventions to support self-efficacy for overcoming barriers of exercise may be most beneficial when people are in their own natural environments, or environments of their choosing. Such environments will allow more relevant experiences to individuals than a structured PR exercise environment. Perhaps then, offering self-efficacy and physical activity interventions as extensions of PR would be more feasible and beneficial. The rapport of PR programs and healthcare practitioners could be utilized when introducing physical activity interventions to people with COPD.

An important aspect of self-efficacy and physical activity interventions in COPD patients that needs to be considered is the level of specificity required for the intervention to be successful. For example, will interventions designed to overcome common barriers be just as effective as an intervention designed to overcome barriers that are specific to an individual? Will individual sessions be just as or more effective than group sessions? Are there other aspects of coping models that will be important to the success of the intervention, other than age and gender as already identified? Careful planning and consideration of all aspects of intervention components should be considered when designing interventions.

The results of this dissertation and the study by Harrison and colleagues (2015) examining the reasons patients decline PR following an AECOPD, point to the complex psychosocial processes that are at play in people with COPD. Currently, the research examining psychosocial processes of health behaviours among people with COPD is limited. Future research examining psychosocial processes in COPD is needed, including examination of both explicit and implicit cognitive processes. The explicit processing system is slow and involves deliberative activation of concepts such as when analysing, reasoning, or reflecting (Calston, 2010). Constructs and processes from this system are typically assessed by self-report questionnaires, such as self-efficacy, intention, and explicit attitudes. The implicit processing system is fast, automatic, operates at ‘the fringe of awareness’, and involves activation of associated concepts in memory when a stimulus is perceived (Calston, 2010). Processing of the implicit system is often assessed by reaction times of time-constrained tasks to assess constructs such as implicit attitudes. Research suggests that explicit and implicit exercise-related cognitions may not be independent and are likely part of a complex interrelated cognitive processing system (Berry, Rodgers, Markland, & Hall, 2016). Future research examining both explicit and implicit cognitive processes would provide researchers and clinicians with a broader understanding of the impact of COPD and may provide insight into the design of future behavioural interventions in this population group.

Conclusions

This dissertation provides insight into the development of self-efficacy with PR in patients with and without a recent AECOPD, the associations of different self-efficacy types to clinical-health and behavioural outcomes in COPD patients and provides evidence of two intervention techniques that may be useful for strengthening self-efficacy in this population group. Self-efficacy improved with PR in AECOPD and stable COPD patients, and there was no evidence to suggest that PR offered within one month or within three to four months impacts this effect. PR may need to be longer in AECOPD compared to stable COPD patients, as even after PR, AECOPD patients were still below the pre-PR levels of stable patients on self-efficacy as well as clinical-health and behavioural outcomes. Study 1 (Chapter 2) found that walking self-efficacy was a better predictor than self-efficacy for managing breathlessness for functional exercise capacity, health status, and physical activity in both AECOPD and stable COPD patients. This study, however, did not include an assessment of exercise self-efficacy (i.e., task, coping, and scheduling self-efficacy sub-types). In study 3 five types of self-efficacy were assessed (task, coping for exercise barriers, coping for breathing barriers, scheduling, and walking), and the relationships of these self-efficacy types to physical activity was examined. In this study, coping for exercise barriers was the type of self-efficacy most strongly predictive of physical activity in steps per day. Importantly, a vicarious experience intervention found that while both coping and mastery models improved the self-efficacy subtypes, it was the coping model condition that most strongly impacted coping for exercise self-efficacy. The characteristics of exercise models seem to be important to COPD observers, with models similar in age and of the same gender important to observers. This dissertation highlights the role of self-efficacy within PR environments and provides insight into intervention content that may improve clinical-health and behavioural outcomes among people with COPD.

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Appendix A

Modified Self-efficacy for Walking Scale (SEW)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), How confident are you that you can walk at a moderate pace for each of the durations indicated. A moderate pace is where you have to breathe a bit harder but can still talk while you are walking.

How confident are you that you can walk at a moderate pace for…	**Answer**
5 consecutive minutes	%
10 consecutive minutes	%
15 consecutive minutes	%
20 consecutive minutes	%
25 consecutive minutes	%
30 consecutive minutes	%
35 consecutive minutes	%
40 consecutive minutes	%
45 consecutive minutes	%

COPD Self-efficacy Scale (CSES)

Please read each item below and indicate how confident you are that you could manage or avoid breathing difficulty in each situation.

When I become too tired.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When there is humidity in the air.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I go into cold weather from a warm place.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I experience emotional stress or become upset.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I go upstairs too fast.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I try to deny that I have respiratory difficulties.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I am around cigarette smoke.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I become angry.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I exercise or physically exert myself.

d) Not at all confident
e) Not very confident
f) Somewhat confident
d) Pretty confident
e) Very confident

When I feel distressed about my life.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I feel sexually inadequate or impotent.

g) Not at all confident
h) Not very confident
i) Somewhat confident
d) Pretty confident
e) Very confident

When I am frustrated.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I lift heavy objects.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I begin to feel that someone is out to get me.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I yell or scream.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I am lying in bed.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

During very hot or very cold weather.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I laugh a lot.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I do not follow a proper diet.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I feel helpless.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I drink alcoholic beverages.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I get an infection (throat, sinus, colds, the flu, etc.).

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I feel detached from everyone and everything.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I experience anxiety.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I am around pollution.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I overeat.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I feel down or depressed.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I breathe improperly.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I exercise in a room that is poorly ventilated.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I am afraid.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I experience the loss of a valued object or loved one.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When there are problems in the home.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I feel incompetent.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

When I hurry or rush around.

a) Not at all confident
b) Not very confident
c) Somewhat confident
d) Pretty confident
e) Very confident

St. George's Quality of Life Questionnaire

About the Questionnaire:

1. These questions are to help us understand how your **BREATHING PROBLEMS** may affect your life and if our program helps you.

2. Please read the questions carefully. Ask if you do not understand.

3. Written comments are not required. Do not write "**sometimes**". Mark **"true"** if your answer is **"sometimes"**.

4. There is no right or wrong answer. Simply answer how you feel.

5. If you are with someone, do not let them answer for you.

6. You must answer every question unless it instructs you to go to the next one.

NAME ______________________ **DATE** ______________________

FOR OFFICE USE ONLY

Program Date and Class Number ______________________________

Checker's Initial ____

☐ Pre

☐ Post

☐ Six Month Follow Up

☐ One Year Follow Up

☐ Two Year Follow Up

Part 1

Questions about how many breathing problems you have had over the last year. Please check one box for each question.

	most days a week	several days a week	a few days a week	only with chest infections	not at all	
1 Over the last year, I have coughed	☐	☐	☐	☐	☐	1
2 Over the last year, I have coughed up phlegm (sputum):	☐	☐	☐	☐	☐	2
3 Over the last year, I have had shortness of breath:	☐	☐	☐	☐	☐	3
4 Over the last year, I have had attacks of wheezing:	☐	☐	☐	☐	☐	4

5 If you have a wheeze, is it worse in the morning? (If you do not have a wheeze, answer no.) 5

- no ………………… ☐
- yes ………………… ☐

6 During the past year, how many severe or very unpleasant episodes of breathing problems have you had? 6

- more than 3 times ☐
- 3 times ………… ☐
- 2 times………… ☐
- once …………… ☐
- none ……………. ☐

(Go to question 8 if you had no severe episodes)

7 How long did your worst episode last? 7

- a week or more …. ☐
- 3 or more days ….. ☐
- 1 or 2 days ……… ☐
- less than a day …. ☐

8 Over the past year, in an average week, how many good days (with few breathing problems) have you had? 8

- no good days …….. ☐
- 1 or 2 good days … ☐
- 3 or 4 good days … ☐
- nearly every day is good ……………... ☐
- every day is good ... ☐

Part 2

Section 1
How would you describe your breathing problem? (Please check one box only)

the most important problem I have …………………………………	☐	1
causes me quite a lot of problems …………………………………..	☐	
causes me a few problems ………………………………………….	☐	
causes no problem …………………………………………………..	☐	

If you have ever been employed or are now employed, please check one of these:

my breathing problem made me stop work ………………………	☐	2
my breathing problem interferes with my work or required me to change my work …………………………………………………….	☐	
my breathing problem does/did not affect my work ……………	☐	
have never been employed ………………………………………	☐	

Section 2: Questions about what activities usually make you feel breathless **these days**. For each item, please check either true or false as it applies to you.

	True	False	
Sitting or lying still …………………………………..	☐	☐	1
Getting washed or dressed ……………………………	☐	☐	2
Walking inside your home ……………………………	☐	☐	3
Walking outside on level ground……………………..	☐	☐	4
Walking up a flight of stairs ………………………….	☐	☐	5
Walking hills ………………………………………….	☐	☐	6
Playing sports or active games (ie. golfing, bowling, dancing) ………………………………………………	☐	☐	7

Section 3: Questions about your cough and breathlessness **these days**. For each item, please check either true or false as it applies to you.

	True	False	
My cough hurts ………………………………………	☐	☐	1
My cough makes me tired ……………………………	☐	☐	2
I am breathless when I talk …………………………..	☐	☐	3
I am breathless when I bend over …………………….	☐	☐	4
My cough or breathing disturbs my sleep ……………	☐	☐	5
I become exhausted easily ……………………………	☐	☐	6

Section 4: Questions about other effects that your breathing problem may have **these days**: For each item, please check either true or false as it applies to you.

	True	False	
My cough or breathing is embarrassing in public …………………	☐	☐	1
My breathing problem is a nuisance to my family, friends or neighbors ………………………………………………………..	☐	☐	2
I become afraid or I panic when I cannot get my breath …………..	☐	☐	3
I feel that I am not in control of my breathing problem …………..	☐	☐	4
I do not expect my breathing problem to get any better …………..	☐	☐	5
I have become frail or an invalid because of my breathing problem	☐	☐	6
Exercise is not safe for me ……………………………………...	☐	☐	7
Everything seems to take too much effort …………………………	☐	☐	8

Section 5: Questions about your breathing medication. If you are not prescribed breathing medication, including oxygen, go straight to **Section 6**. To complete this section please check either true or false as it applies to you.

	True	False	
My medication does not help me very much ………………………	☐	☐	1
I am embarrassed using my medication in public …………………..	☐	☐	2
I have unpleasant side effects from my medication ………………...	☐	☐	3
My medication interferes with my life a lot ………………………..	☐	☐	4

Section 6: Questions about how your activities might be affected **by your breathing**. If you do not do an activity, would your breathing allow you to do it? For each question, please check true if one or more activity applies to you. Otherwise check false.

	True	False	
I take a long time to get washed or dressed ………………………	☐	☐	1
I cannot take a bath or shower, or I take a long time ……………...	☐	☐	2
I walk slower than other people, or I stop for rests ……………………..	☐	☐	3
Jobs such as housework take a long time, or I have to stop for rests	☐	☐	4
If I walk up one flight of stairs, I have to go slowly or stop ………	☐	☐	5
If I hurry or walk fast, I have to stop or slow down ………………	☐	☐	6
My breathing makes it difficult to do things such as walking up hills, carrying things up stairs, light gardening, dancing, bowling or golfing …………………...……………………………………...	☐	☐	7
My breathing makes it difficult to do things such as carry heavy loads, dig the garden or shovel snow, jog, play tennis or swim …...	☐	☐	8
My breathing makes it difficult to do things such as very heavy manual work, run, cycle, swim fast or play competitive sports …...	☐	☐	9

Section 7: We would like to know how your breathing problem **usually** affects your daily life.
Please check either true or false as it applies to you **because of your breathing problem**.
Remember that **true** only applies to you if you cannot do something **because of your breathing**.

	True	False	
I cannot play sports or games	☐	☐	1
I cannot go out for entertainment or recreation	☐	☐	2
I cannot go out of the house to do the shopping	☐	☐	3
I cannot do the housework	☐	☐	4
I cannot move far from my bed or chair	☐	☐	5

Please check **one** box, which best describes how your breathing problem affects you:

It does not stop me from doing anything I would like to do	☐
It stops me from doing one or two things I would like to do	☐
It stops me from doing most of the things I would like to do	☐
It stops me from doing everything I would like to do	☐

Thank you for completing this questionnaire. **Please check** to make sure you have answered every question and then return it to a therapist.

Appendix B

Handling of missing data is dependent on the type or reason of missingness in the data. There are generally, three reasons for missingness, Missing Completely at Random (MCAR), Missing at Random (MAR), and Not Missing at Random (NMAR). MCAR is unlikely (Graham, 2012) but can be tested using Little's test in SPSS. If less than 5 % of data is missing than the MCAR can generally be considered tenable. MCAR is when missingness does not depend on the values of Y, missing or observed, but rather missingness is a completely random process (Graham, 2012). Essentially MCAR is when a variable causes missingness on Y, but is unrelated to Y.

Missing data that is MAR or NMAR is more likely. MAR is when missingness depends on the values of measured variables and is ok if those variables are included/controlled for in the statistical analyses (Graham, 2012). NMAR is when missingness depends on the values of some unmeasured variables, and therefore cannot be controlled for in statistical analyses (Graham, 2012). Graham (2012) contends that MAR virtually always holds. When missing data is thought to be MAR it is useful to perform attrition analyses to determine what variables should be included in the missing data analysis.

There are many approaches to handling missing data. Ultimately, the goal of an analysis is to provide unbiased estimates of population parameters (Graham, 2012), and the chosen approach to deal with missing data will have an impact on the level of bias introduced in the analyses. Some approaches (mostly older) will generate biased population parameters, including mean substitution, list-wise deletion, and pairwise deletion. Mean substitution reduces the variability in the data and will therefore provide biases parameter estimates (Graham, 2012). This approach is almost never recommended by Graham (2012). List-wise deletion (complete case analysis) can provide biased parameter estimates as well, particularly if missing data is not MCAR

(Graham, 2012). List-wise deletion introduces bias because the sub-sample that analyses are being conducted on tends to not be representative of the whole sample (Graham, 2012). Importantly, MCAR is very rare, and it is more likely that sub-sample for which there is missing data is different from the whole sample. However, complete case analysis can perform well in multiple regression (Graham, 2012), except when the proportion of cases lost to missingness is large. Also, reducing the cases as with list-wise deletion can reduce power (Graham, 2012). Pairwise deletion, uses all available data. However, the variance and covariances are made up of different subsamples of respondents; therefore parameter estimates may be biased if not MCAR . With pairwise deletion there is no way of estimating standard errors. Sample size is required to estimate standard errors and there is no obvious way to do that with pairwise deletion (Graham, 2012).

There are some other approaches to handling missing data that produce more accurate estimates of parameters, including averaging the available variables and multiple imputation (MI). Full-information maximum likelihood (FIML) is also a good approach to handling missing data, but it is not discussed here as this approach is not available for the planned analyses. Averaging the available variables is when the mean of a scale is based on partial data when participants do not provide complete for all variables making up the scale (Graham, 2012). This approach is considered a variant on simple imputation. Is not perfect but may have considerably better statistical properties than mean substation, and other deletion techniques (Graham, 2012).

Multiple imputation (MI) is the best approach for handling missing data available for some of the planned analyses and has three steps. In the first step, one imputes data generating *m* data sets, usually at least 40 is recommended (Graham, 2012). In the second step, *m* data sets are analyses with usual, complete data procedures, and the results of each analysis are recorded (parameter estimates, and standard errors recorded specifically). In the last step, the results are combined to get the average estimates over the *m* data sets. This is the preferred way of handling missing data (along with FIML – which estimates parameters based on all available data and performs analyses in one step), which has been shown to perform well in situations where MAR is held (Graham, 2012). Interestingly, multiple regression models often produce parameter estimates that are tolerably small when the cause of missingness is omitted from the model (i.e., the missing data is MNAR) (Graham, 2012). However, failing to omit causes of missingness will almost always bias parameter estimates (Graham, 2012). Therefore it is important to select variables that you know are causes of missingness and to ignore variables for which you have no clear expectations about them being the cause of missingness. Currently, MI procedures are only available with regression type analyses, and not ANOVAs, particularly repeated measures ANOVAs. This is because there is no known way to pool *F*-tests and sums of squares (Graham, 2012).

In MI, imputation can occur at either the item or the scale level. Imputing at the item level is always at least as good (often better) as imputing at the scale level (Graham, 2012). However, sometimes there are too many variables to impute everything at the item level. A general rule of thumb is that medium to large models have no more than 100 variables (this includes constructs over time by item) (Graham, 2012). However, if the number of cases is small, even 100 variables may be too large for the MI model (Graham, 2012). It is likely that the number of cases in this data-set are too small for the number of variables to be imputed. Importantly, while it is generally better to impute at the individual variable level, there are cases where the two approaches are essentially the same. Specifically, if all cases have either all data or no data for all of the individual variables making up a scale, then it makes virtually no difference whether imputation is done at the individual variable or the scale level (Graham, 2012). This ideal pattern is seldom found in empirical data, so an approach is needed to generate scores for some scales in which individuals have data for some, but not all of the variables comprising the scale (i.e., averaging available variables).

Schafer and Graham (2002) state that the averaging available variables approach can be a useful when the items come from a single, well-defined domain. If the items do not, generating scale scores based on the average of non-missing items may cause estimation bias, and is not recommended (Schafer & Graham, 2002). A well-defined scale means that it is homogeneous; that is, as long as the difference between the largest and smallest factor loading is no more than .20; AND the coefficient alpha is at least .70 (Graham, 2012). If this criteria is not met, one could consider dropping an item if it ≥.20 and the coefficient alpha is acceptable (Graham, 2012). It is important that there is data from at least half of the items in the scale, and that is the items are very homogeneous and the coefficient alpha is good (Graham, 2012). As the items become less homogenous and more heterogeneous and the alpha drops, more items in the scale are needed.

If the items are not found to be homogeneous, the scale could be broken into subscales for imputation and then combined later on if it would mean retaining more data (Graham, 2012).

Due to limitations with MI computations for ANOVA analyses, different approaches for handling missing data will need to be utilized for repeated measures ANOVA and multiple regression analyses. For multiple regression analyses, MI procedures will be used to impute the DV. For the IV's in the Multiple Regression analyses and the repeated measures ANOVAs, averaging the available variables for each scale will be used. The 'averaging available variables' approach will be used for the multiple regression models because it is anticipated that there will be too many variables in the imputation model. Therefore, it is unlikely that the MI imputation will converge. This is particularly a problem when the number of cases is low (Graham, 2012), as in this scenario. For the repeated measures ANOVAs there will still be missing data after averaging the available variables. Therefore, mean substitution of post-PR values, list-wise deletion, and last observation carried forward (intention-to-treat analyses) will also be implemented and the results of the three approaches compared. It is acknowledged that these approaches introduce bias into the parameter estimates. However, these are the only available options given the research question and data analysis software available.

Appendix C

Study 3 Baseline Questionnaire

Leisure Score Index (LSI) from the Godin-Leisure-Time Exercise Questionnaire (GLTEQ)

IMPORTANT: This next set of questions focus on leisure-time physical activity. Leisure time means activity done during your free time and does not include your work/job or household chores. Physical activity means any activity that results in a substantial increase in energy expenditure (resulting in a noticeable increase in heart rate and breathing rate).

For this next question, we would like you to recall your average weekly participation in leisure time PA during the past month.

When answering these questions please remember:

- only count physical activity sessions that lasted 10 minutes or longer.
- only count physical activity that was done during free time (i.e., not occupation or housework).
- please write the average frequency on the first line and the average duration on the second.
- if you did not do any physical activity in one of the categories, write in “0”.

Considering a typical week (7 days) over the PAST MONTH how many days on average did you do the following kinds of PA and what was the average duration?

	Times Per Week	Average Duration
VIGOROUS EXERCISE (HEART BEATS RAPIDLY, SWEATING) (e.g., running, aerobics classes, vigorous swimming, vigorous bicycling).	__________	__________
MODERATE EXERCISE (NOT EXHAUSTING, LIGHT PERSPIRATION) (e.g., fast walking, tennis, easy bicycling, easy swimming, popular and folk dancing).	__________	__________
LIGHT/MILD EXERCISE (MINIMAL EFFORT, NO PERSPIRATION) (e.g., easy walking, yoga, bowling, lawn bowling, shuffleboard).	__________	__________

The Multidimensional Self-efficacy for Exercise Scale (MSES)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), **How confident are you that you can…**	**Answer**
Complete your exercises correctly	%
Follow directions to complete the exercises	%
Perform all of the movements required for your exercises	%
Do your exercises when they cause some discomfort	%
Do your exercises when you lack energy	%
Include your exercise sessions in your daily routine	%
Complete the recommended number of sessions each week	%
Do your exercises when you don't feel like it	%
Arrange your schedule to include regular exercise sessions	%

Modified Self-efficacy for Walking Scale (SEW)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), How confident are you that you can walk at a moderate pace for each of the durations indicated. A moderate pace is where you have to breathe a bit harder, but can still talk while you are walking.

How confident are you that you can walk at a moderate pace for…	**Answer**
5 consecutive minutes	%
10 consecutive minutes	%
15 consecutive minutes	%
20 consecutive minutes	%
25 consecutive minutes	%

30 consecutive minutes	%
35 consecutive minutes	%
40 consecutive minutes	%
45 consecutive minutes	%

Perceived Difficulty

How difficult would it be for you to walk on a treadmill at a light intensity for at least 10 minutes?
(e.g., easy walking, yoga, bowling, lawn bowling, and shuffleboard).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

How difficult would it be for you to walk on a treadmill at a moderate intensity for at least 10 minutes? (e.g., fast walking, tennis, easy bicycling, easy swimming, popular, and folk dancing).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

How difficult would it be for you to walk on a treadmill at a strenuous intensity for at least 10 minutes? (e.g., running, aerobics classes, cross country skiing, vigorous swimming, vigorous bicycling).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

Study 3 Post Experiment/Control Questionnaire

The Multidimensional Self-efficacy for Exercise Scale (MSES)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), **How confident are you that you can…**	**Answer**
Complete your exercises correctly	%
Follow directions to complete the exercises	%
Perform all of the movements required for your exercises	%
Do your exercises when they cause some discomfort	%
Do your exercises when you lack energy	%
Include your exercise sessions in your daily routine	%
Complete the recommended number of sessions each week	%
Do your exercises when you don't feel like it	%
Arrange your schedule to include regular exercise sessions	%

Modified Self-efficacy for Walking Scale (SEW)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), How confident are you that you can walk at a moderate pace for each of the durations indicated. A moderate pace is where you have to breathe a bit harder, but can still talk while you are walking.

How confident are you that you can walk at a moderate pace for…	**Answer**
5 consecutive minutes	%
10 consecutive minutes	%
15 consecutive minutes	%
20 consecutive minutes	%

25 consecutive minutes	%
30 consecutive minutes	%
35 consecutive minutes	%
40 consecutive minutes	%
45 consecutive minutes	%

Perceived Difficulty

How difficult would it be for you to walk on a treadmill at a light intensity for at least 10 minutes?
(e.g., easy walking, yoga, bowling, lawn bowling, and shuffleboard).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

How difficult would it be for you to walk on a treadmill at a moderate intensity for at least 10 minutes? (e.g., fast walking, tennis, easy bicycling, easy swimming, popular, and folk dancing).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

How difficult would it be for you to walk on a treadmill at a strenuous intensity for at least 10 minutes? (e.g., running, aerobics classes, cross country skiing, vigorous swimming, vigorous bicycling).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

Rating of Model Similarity

How similar are you to the person/model in the video you just watched?

1	2	3	4	5	6	7
Exactly Like me						Completely Dissimilar

Study 3 Post Exercise Test Questionnaire

The Multidimensional Self-efficacy for Exercise Scale (MSES)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), **How confident are you that you can…**	**Answer**
Complete your exercises correctly	%
Follow directions to complete the exercises	%
Perform all of the movements required for your exercises	%
Do your exercises when they cause some discomfort	%
Do your exercises when you lack energy	%
Include your exercise sessions in your daily routine	%
Complete the recommended number of sessions each week	%
Do your exercises when you don't feel like it	%
Arrange your schedule to include regular exercise sessions	%

Modified Self-efficacy for Walking Scale (SEW)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
No Confidence										Complete Confidence

On a scale from **1 to 100%** (1- not at all confident, 100-completely confident), How confident are you that you can walk at a moderate pace for each of the durations indicated. A moderate pace is where you have to breathe a bit harder, but can still talk while you are walking.

How confident are you that you can walk at a moderate pace for…	**Answer**
5 consecutive minutes	%
10 consecutive minutes	%
15 consecutive minutes	%
20 consecutive minutes	%

25 consecutive minutes	%
30 consecutive minutes	%
35 consecutive minutes	%
40 consecutive minutes	%
45 consecutive minutes	%

Perceived Difficulty

How difficult would it be for you to walk on a treadmill at a light intensity for at least 10 minutes?
(e.g., easy walking, yoga, bowling, lawn bowling, and shuffleboard).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult

How difficult would it be for you to walk on a treadmill at a moderate intensity for at least 10 minutes? (e.g., fast walking, tennis, easy bicycling, easy swimming, popular, and folk dancing).

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Extremely Easy						Extremely Difficult

How difficult would it be for you to walk on a treadmill at a strenuous intensity for at least 10 minutes? (e.g., running, aerobics classes, cross country skiing, vigorous swimming, vigorous bicycling).

1	2	3	4	5	6	7
Extremely Easy						Extremely Difficult