Impact of a Primary Care Exercise Program on Physical Activity and Self-Efficacy in Patients with COPD

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

Faculty of Kinesiology, Sport and Recreation

University of Alberta

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Abstract

Chronic obstructive pulmonary disease (COPD) is an obstructive lung disease characterized by shortness of breath and is the fourth leading cause of death in Canada. Physical activity is a strong predictor of all-cause mortality in people who have COPD, however long-term adherence to exercise is low. Self-efficacy is the confidence one has for performing a behaviour and has been associated with physical activity behaviours in people with COPD. Currently pulmonary rehabilitation is the primary way exercise programs are provided to COPD patients; however, pulmonary rehabilitation capacity is low. Primary care may be an effective method for delivering exercise programs in this population. The purpose of this study was to examine how supervised and unsupervised exercise programs influence self-efficacy and adherence to exercise in COPD patients. Patients (N=23; mean age=65±9yrs; FEV1=68±20% predicted) were recruited after referral to a Primary Care Network exercise program. Participants chose either a 16-session supervised exercise program or an unsupervised exercise program where they received three visits with an exercise specialist. Physical activity was monitored with an accelerometer and aerobic exercise minutes were tracked by self-report; self-efficacy was assessed by questionnaire; exercise capacity was assessed by six-minute walk test; quality of life was evaluated using the COPD Assessment Test. Data were collected before (T1), immediately after (T2) and 8 weeks following the program (T3). Time spent performing aerobic exercise increased significantly from T1 to T2 in both groups with no further increase at T3. Self-efficacy for managing breathlessness increased in both groups from T1 to T2 with no further increase at T3. Quality of life also improved significantly in both groups from T1 to T2 with no further improvement at T3. Six-minute walk distance was unchanged from T1 to T2, with no change at T3. Task, coping and scheduling self-efficacy was unchanged from T1 to T2 and T2 to T3.

Employment status was significantly different between groups at baseline. In the primary analysis of steps per day the difference between groups was approaching significance. Therefore, employment status was controlled for in the analysis which resulted in no significant difference between groups in steps per day, and no change in steps per day from T1 to T2 or T2 to T3. This study suggests that supervised and unsupervised exercise programs delivered in primary care may be effective at increasing aerobic exercise, self-efficacy for managing breathlessness and quality of life in patients who have mild to moderate COPD.

Preface

This thesis is an original work by Kelsey Hurley. The embedded research project, "Comparing Physical Activity Outcomes between Supervised and Unsupervised Exercise in COPD Patients", ID No. Pro00070342 received ethics approval from the University of Alberta Health Research Ethics Board Health Panel, February 2017. The Breathe Easy sample data referred to in Chapter 3 is part of a national research collaboration led by Dr. Michael Stickland at the G.F. MacDonald Centre for Lung Health, Covenant Health, in Edmonton Alberta.

Acknowledgements

I would first like to thank my supervisors Dr.'s Rodgers and Stickland for their unwavering support over the last three and a half years and their flexibility in accommodating my needs. Dr. Rodgers provided encouragement and trust when I needed it most and always challenged me to think critically about the research process. Dr. Stickland helped guide me through the world of clinical research and allowed me to develop important skills that I will be able to apply to my career.

I am grateful to the other graduate students, professors and support staff in the Faculty of Kinesiology, Sport and Recreation. I enjoyed being immersed back into the academic world and the conversations that came with it. In particular I would like to thank my lab mate Dr. Selzler for her guidance and support through the most challenging portions of my degree.

Thank you to the Fying Dust First Nations who financially supported me through my graduate degree. I am also thankful to the Edmonton North Primary Care Network for allowing me to complete this study in their clinic. I am grateful for my colleagues who helped recruit patients to my study and helped with the implementation of the study. Thank you as well to the people with COPD who participated in my study.

I would like to thank my husband Coady for providing balance and fun in my life, for taking care of everything when I needed to focus on my studies, and for offering his precise editing skills. To my parents for being honest, hardworking role models and for always believing I can accomplish anything I put my mind to. Lastly, I would like to thank my dogs Larry and Sophie for their stress relieving capabilities.

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Chapter 1 - Introduction

1.1 Overview of Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a respiratory disease that involves airflow limitation during exhalation. This results in hyperinflation of the lungs, which causes patients to breath at higher lung volumes (GOLD, 2017). The cardinal symptoms of COPD are shortness of breath and activity limitation; the primary cause is smoking (O'Donnell et al., 2008).

The prevalence of COPD is high; based on self-report, approximately 4 % of Canadians over the age of 35 have COPD (Statistics Canada, 2014). The prevalence of COPD increases with age, with an increasing number of women developing COPD (World Health Organization, 2018). In 2003 COPD was the fourth leading cause of death in Canada behind heart disease, cancer and stroke (O'Donnell et al., 2008). It is predicted that the prevalence of COPD will continue to grow due to our ageing population (World Health Organization, 2018).

The impact of COPD on the patient is significant. Mild COPD is often brushed off as a decrease in fitness due to the normal ageing process. This leads to poor management and progressive activity limitation, lending to a progressive decrease in fitness, further limiting the patients' ability to carry out daily physical activities and leading to decreased quality of life (Ferrer et al., 1997). This decrease in physical capacity can force many patients with COPD to leave work and retire earlier than expected. In addition to this, COPD is often associated with multiple comorbidities such as ischemic heart disease, osteoporosis, metabolic syndrome, peripheral muscle dysfunction, anxiety and depression (O'Donnell et al., 2008). Obesity is also prevalent in people with COPD, however, low body weight is associated with a decreased risk of survival (Evans & Morgan, 2014).

An acute exacerbation of COPD (AECOPD) is a sustained (> 48hrs) worsening of symptoms beyond normal day to day variations that leads to a change in medication (O'Donnell et al., 2008). The prevalence of AECOPD is variable but the care involved can be quite extensive. A person experiencing an AECOPD will usually access resources such as their family physician or emergency room/hospital. In Alberta, 59% of people diagnosed with COPD were hospitalized for any reason across a two-year period (Canadian Institute for Health Information, 2017). These people accessing hospital care are considered high users with COPD and are hospitalized an average of four times per year (Canadian Institute for Health Information, 2017). Canadian hospitalization rates showed COPD to be the most common reason for hospitalization in those ages 60-74; further to this, COPD has the highest rate of hospital readmission, 18% returning once and 14% returning at least twice (Canadian Institute for Health Information, 2008). In 2013, Alberta exceeded the Canadian average for COPD hospitalization rates (Canadian Institute for Health Information, 2017). The cost of hospitalizations for AECOPD in Alberta is estimated to be $131 million which is approximately half of the total cost of COPD in Alberta ($254 million) (Waye & Jacobs, 2016). Improved management of COPD could lead to decreased hospitalization and decreased cost on the healthcare system (Bourbeau et al., 2003).

1.2 COPD Management

1.2.1 Introduction

Proper management of COPD can improve symptoms, activity levels and quality of life at all stages of the disease (O'Donnell et al., 2008). This is accomplished by slowing down the disease progression; reducing the frequency and severity of AECOPD; managing breathing and other respiratory symptoms; and improving exercise tolerance (O'Donnell et al., 2008). The comprehensive management of COPD includes early diagnosis, smoking cessation, exercise, pulmonary rehabilitation, pharmacotherapy and self-management education with an action plan and case manager (Bourbeau et al., 2017; Criner et al., 2015). COPD management should be tailored to the individual and their disease severity (GOLD, 2017; O'Donnell et al., 2008).

1.2.2 Severity-based COPD Management

The GOLD (2017) guidelines recommend categorizing COPD patients into severity level (mild, moderate, sever or very severe) based on their airway obstruction severity, exacerbation history and symptoms. Based on this assessment, COPD management programs are designed and individualized to the patient. For example, someone categorized as having mild COPD may benefit from smoking cessation, maintaining or increasing physical activity, ensuring adequate sleep and eating a healthy diet. While a more severe patient would likely benefit from pulmonary rehabilitation with more formalized exercise testing and prescription, as well as more comprehensive chronic disease management education.

1.2.3 Physical Activity and Exercise

Maintaining or increasing physical activity is recommended for all COPD patients regardless of severity (GOLD, 2017; O'Donnell et al., 2008). Physical activity can be defined as any bodily movement resulting from muscle contraction, whereas exercise tends to be more structured and done with the purpose of improving or maintaining health. Exercise improves the function of the heart, muscles and circulation which improves aerobic capacity, muscle strength, endurance and quality of life and decreases shortness of breath and fear and anxiety related to sensations of breathlessness (American College of Sports Medicine, 2010). It is recommended that people with COPD participate in at least 150 minutes per week of moderate-intensity aerobic activity, 75 minutes of vigorous aerobic activity or a combination of both. This aerobic exercise ideally should occur most days of the week and can be broken up into shorter bouts of 10 minutes if preferred (American College of Sports Medicine, 2010). Resistance exercise is also important; it is recommended that people with COPD engage in exercises to strengthen the major muscle groups at least two days per week (American College of Sports Medicine, 2010).

In addition to engaging in a regular exercise routine, it is important that COPD patients remain active during their daily lives. Waschki et al. (2011) found physical activity to be the strongest predictor of all-cause mortality for people who have COPD. Although the benefits of staying active and engaging in regular exercise are well known for people who have COPD, a systematic review comparing people with COPD to age-matched controls showed a lower activity duration, intensity and step count (Vorrink, Kort, Troosters, & Lammers, 2011).

1.2.4 Pulmonary Rehabilitation

According to GOLD (2017) guidelines, COPD patients who are categorized as moderate to very severe should participate in a pulmonary rehabilitation program. Spruit et al. (2013) describes pulmonary rehabilitation as:

> A comprehensive intervention based on a thorough patient assessment followed by patient tailored therapies that include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors. (p. e16)

Pulmonary rehabilitation provides a venue for COPD patients to safely engage in exercise under the supervision of a healthcare professional and to attend group education topics. Exercise prescriptions are tailored to the patient’s current level of physical function based on initial assessment and participants practice using breathing management strategies while receiving feedback on their technique. Due to the combination of exercise training and education, pulmonary rehabilitation has been shown to improve shortness of breath, exercise capacity, quality of life and decrease hospitalization for AECOPD (McCarthy et al., 2015).

Further recommendations on the length and specific content of pulmonary rehabilitation have been made. A recent update to global strategy for the diagnosis, management and prevention of COPD recommends that pulmonary rehabilitation programs be six to eight weeks long and that extending past 12 weeks does not seem to have any additional benefits (GOLD, 2017). Reviews of pulmonary rehabilitation found most programs to be consistent with this recommendation showing the majority of programs being eight or 12 weeks long (Camp et al., 2015; McCarthy et al., 2015).

Standardizing the length and content of pulmonary rehabilitation can ensure high program quality is maintained across different programs. Researchers and clinicians across Canada have been working to create a national standardized pulmonary rehabilitation program (Selzler et al., 2017). The content for the program is based off the "Living Well with COPD" self-management program and includes 18 education sessions, 12 which are considered essential to a comprehensive pulmonary rehabilitation program and six which are optional, based on the site and patient needs. Selzler et al. (2017) recommend a six to 10-week pulmonary rehabilitation program, with a minimum of 24 exercise sessions occurring at least three times per week with two exercise sessions per week occurring under supervision. Currently a pilot study is being conducted at two Canadian sites to evaluate the implementation and outcomes of the program (Selzler et al., 2017)

1.2.5 Pulmonary Rehabilitation Access

Although pulmonary rehabilitation provides effective management of COPD, in 2015 it was reported that the number of pulmonary rehabilitation programs could only provide capacity for 0.4% of the COPD patients in Canada (Camp et al., 2015). The need to integrate more pulmonary rehabilitation programs throughout Canada is crucial. While hospitals continue to be the most common location to run pulmonary rehabilitation programs, alternative settings such as primary care clinics and community recreation centres have begun to offer these services (Camp et al., 2015; McCarthy et al., 2015). Standardized pulmonary rehabilitation program content will create a framework for these alternative settings to offer pulmonary rehabilitation without having to create the program content, and ensures quality is maintained.

1.2.6 Home-based Pulmonary Rehabilitation

Another way to increase access to pulmonary rehabilitation is to provide home based pulmonary rehabilitation. Maltais et al. (2008) completed a multicentre randomized control trial comparing home-based pulmonary rehabilitation to hospital based pulmonary rehabilitation. Both groups received the educational components of the program in group lectures; however, the home program groups received guidance on completing the exercise portion of pulmonary rehabilitation at home on their own. Both groups showed similar improvements in dyspnea. More recently, a meta-analysis of 18 randomized control trials examining the effectiveness of home pulmonary rehabilitation reported that home pulmonary rehabilitation is an effective approach for improving health related quality of life (HRQOL) and exercise capacity (Liu et al., 2014). Therefore, home exercise prescriptions could be a potential solution for increasing access to pulmonary rehabilitation and potentially improving physical activity levels among people with COPD.

1.2.7 COPD Self-Management

One strategy that has been proposed to improve COPD outcomes and the outcomes of other chronic diseases is self-management. COPD self-management is a complex set of behaviours that "requires the knowledge and skills needed to devise, evaluate and implement one's own individual plan for health behaviour changes" (Bourbeau, Nault, & Dang-Tan, 2004). In COPD, this is very important due to the changing features and symptoms patients' experience.

There are multiple skills required to self-manage COPD, such as inhalation techniques, understanding and using an action plan during exacerbations (this usually involves changes in medication), smoking cessation and regular exercise (Bourbeau et al., 2004). The interventions used to improve health behaviours include patient education on disease management as well as support to enable the necessary behaviour changes and practice with these changes. Interventions used to improve self-management in COPD have been shown to increase health-related quality of life, reduce frequency of AECOPD and emergency room visits/ hospitalizations, and improve adherence to regular exercise (Bourbeau et al., 2003; O'Donnell et al., 2008).

1.3 Behaviour Change Theory

1.3.1 Social Cognitive Theory

COPD programming should be designed to promote self-management; however, it is important to have a theory to explain how interventions are proposed to influence behaviour change. Social cognitive theory aims to explain complex human behaviour. Bandura (1986) describes human functioning as influenced by a triadic reciprocal relationship between personal, behavioural, and environmental influences. Personal influences include individual beliefs and cognitions, which can impact the likelihood of engaging in a particular behaviour. The environment can either facilitate or impede the ability to engage in the behaviour. Additionally, behaviour itself, and the person, can influence the environment and individual beliefs. For example, an individual's beliefs about the value of regular exercise and their confidence in themselves for being able to complete exercise will influence their likelihood of engaging in exercise. The individual's environment (i.e. proximity to a fitness centre or safe place to walk) can also impact their likelihood of engaging in exercise. Further to this, engaging in the behaviour (walking) and the outcome from this (increased energy) can further influence the individual's beliefs in its value, and confidence for continuing.

1.3.2 Types of Self-Efficacy

An important component of social cognitive theory is self-efficacy. Self-efficacy is described as the confidence one has for completing tasks in order to achieve a certain outcome (Bandura, 1997). Self-efficacy beliefs affect the amount of effort a person will put into changing the behaviour and the amount of persistence they will use to continue when faced with barriers. These barriers often prevent people from completing the task and it is important to consider these challenges when measuring self-efficacy. Maddux (1995) considers self-efficacy in two dimensions, task and coping self-efficacy. Task self-efficacy is the confidence in being able to complete the behaviour itself and coping self-efficacy is the confidence in overcoming barriers to complete the behaviour. In physical activity research, some researchers considered a third type of self-efficacy, scheduling self-efficacy, this is the confidence one has to exercise regularly (Rodgers, Wilson, Hall, Fraser, & Murray, 2008). COPD patients may also have unique barriers to exercise adherence such as breathing difficulties. Self-efficacy for managing these breathing difficulties may also influence their adherence to exercise.

1.3.3 Increasing Self-Efficacy

According to social cognitive theory there are four ways to increase self-efficacy; mastery experience, the person experiencing success with the behaviour; vicarious experience, seeing others who are similar to them experience success with the behaviour; physiological/affective arousal, such as anxiety or stress; and verbal persuasion or encouragement throughout the efforts on the behaviour (Bandura, 1997).

Social cognitive theory would argue that increasing knowledge and providing adequate time to practice particular skills will increase an individual's self-efficacy for the particular skill. Increased self-efficacy along with a supportive environment should lead to improved disease self-management.

1.4 Exercise Adherence

Self-management of COPD requires patients to adhere to a regular exercise routine for the remainder of the lives. Adherence can be defined as maintaining the quantity of physical activity after structured support from the program is gone. Long-term adherence to exercise tends to be low in COPD patients. Karapolat et al. (2007) found that COPD participants in an eight week pulmonary rehabilitation program significantly increased their exercise tolerance, and significantly decreased shortness of breath at the eighth week but these reverted back by the 12 week measurement. Further to this, a study that implemented a maintenance program for 12 months post pulmonary rehabilitation, which included weekly telephone calls and monthly supervised exercise sessions, showed improvements in exercise tolerance and quality of life return back to pre-rehabilitation levels at 24 months (Ries, Kaplan, Myers, & Prewitt, 2003). While neither of these studies measured adherence to the exercise prescription after support was no longer provided, it is likely that a lack of exercise has led to the decrease in exercise tolerance and quality of life.

In addition to engaging in a regular exercise routine, it is important that COPD patients remain active during their daily lives (Waschki et al., 2011). Although the benefits of staying active are well known for people who have COPD, a systematic review showed COPD patients to have lower activity duration, intensity and step count when compared to age-matched controls (Vorrink et al., 2011).

1.5 Purpose

Exercise is an important component of a COPD management program, however long-term adherence to exercise in COPD patients is low. In a review, Young, Plotnikoff, Collins, Callister and Morgan (2014) found that the social cognitive theory can account for 31% of the variance in physical activity levels, making it a valuable theory to base physical activity behaviour change from. In addition to this, self-efficacy and goals have also been found to be consistently associated with physical activity levels in the general population (Young et al., 2014). Based on this, we would expect to see self-efficacy increase as people become more physically active. However, the different types of self-efficacy may not be consistently affected by an increase in physical activity. That is, task self-efficacy, coping self-efficacy, scheduling self-efficacy and self-efficacy for managing breathing may not all change in parallel. Additionally, the environment where the exercise is performed can influence self-efficacy and physical activity behaviours. For instance, the difference between exercising in a supervised structured program vs. an independent exercise program at home could have an impact on the development of self-efficacy and as a result, adherence to exercise.

The purpose of this study was to better understand how different exercise programs influence self-efficacy and adherence to exercise in COPD patients. This is important in helping COPD patients maintain the physical benefits from their exercise program, improve the long-term management of their disease and decrease hospital admissions and health care costs.

Chapter 2: Literature Review

2.1 COPD Management Outcomes

2.1.1 Health Status Assessment

Due to the complexity of symptoms in people with COPD, GOLD (2017) recommends assessing multiple parameters including airflow obstruction, breathlessness, health status and exacerbation risk in order to categorize disease severity (GOLD, 2017). Breathlessness in COPD patients is often measured using the medical research council (MRC) dyspnea scale. Participants are classified into a MRC grade, where grade 1 represents shortness of breath with strenuous exercise, grade 2 represents shortness of breath when hurrying on the level or walking up a slight hill, grade 3 represents walking slower than people of the same age on the level or stops for breath while walking at own pace on the level, grade 4 represents stops for breath after walking 100 yards and grade 5 represents too breathless to leave the house or breathless when dressing. Categorizing people with COPD using the MRC dyspnea scale has been shown to be a better predictor of five year mortality risk compared to categorizing by airflow obstruction alone (Nishimura, Izumi, Tsukino, & Oga, 2002).

Measuring health status in people with COPD is important because COPD is considered to have multiple symptomatic effects and a single measurement of breathlessness is not an adequate assessment of disease severity (Jones, 2001). Measuring health status using questionnaires is a common outcome of COPD management programs. One tool used to evaluate this is the COPD assessment tool (CAT). It is an eight-item questionnaire that scores participants on a 0-40 range with a lower score indicating less impairment and higher score indicating more impairment. The CAT is a widely used questionnaire that has been shown to be valid and reliable. In a systematic review Gupta, Pinto, Morogan and Bourbeau (2014) reported the CAT to have an internal consistency of 0.85-0.96 and a test-retest reliability of 0.8-0.96. The CAT was also shown to have good convergent validity when compared to other HRQOL questionnaires in COPD patients. According to the GOLD (2017) guidelines a score of greater than ten indicates the patient has a higher level of symptoms that warrants additional management strategies. The CAT score differed between patients in different GOLD stages of COPD and during exacerbation onset, indicating it is sensitive enough to detect changes in disease severity and changes in symptoms.

The minimal clinically important difference (MCID) is defined by Jaeschke, Singer and Guyatt (1989) as:

The smallest difference in a score of a domain of interest that patients perceive to be beneficial and that would mandate, in the absence of troublesome side effects and excessive costs, a change in the patient's management (p. 408)

MCID has been used to quantify changes in common outcome measures in COPD management programs. There remain limited studies to identify the MCID of the CAT however, Kon et al. (2013) suggests a MCID of two points for the CAT questionnaire. This means that informed patients who score two points higher on their CAT questionnaire will notice an increase in their symptoms and decrease in their quality of life and patients who score two points lower on their CAT questionnaire will notice a decrease in their symptoms and improvement in their quality of life.

2.1.2 Functional Exercise Capacity

Functional exercise capacity is a common outcome of COPD management programs. Field tests that consist of walking on flat ground are often used due to their ease of use and minimal equipment requirements. The six-minute walk test (6MWT) requires participants to walk back and forth as many times as they can along a 30-metre corridor for six minutes. The distance (in metres) is taken for each participant. The MCID for COPD patients is supported somewhere between 25-54 metres (Holland et al., 2010; Redelmeier, Bayoumi, Goldstein, & Guyatt, 1997). The 6MWT is a strong indicator for response to medical interventions in COPD participants (American Thoracic Society, 2002).

2.1.3 Physical Activity

With the ease of use and accessibility of physical activity trackers, more studies are measuring objective physical activity as an outcome of pulmonary rehabilitation and other physical activity interventions. Omron Healthcare Inc. (Lake Forest, IL, USA) makes and sells a variety of physical activity trackers for consumers to use in their pocket or on their hip. More recently, Omron has developed tri-axis accelerometers, however, due to the novelty on the market there are few studies that have tested their reliability and validity. Omron previously used dual-axis accelerometry in their pedometers which has been studied in COPD patients. Danilack, Okunbor, Richardson, Tevlan and Moy (2015) compared the Omron HJ-720ITC (dual-axis) to the StepWatch Activity Monitor (SAM) in COPD patients and found the pedometer registered greater than or equal to 90% of the manually counted steps for 155 of 176 participants. The pedometer also accounted for 47% +/- 16% of SAM-steps in the community. The authors concluded that the pedometer was an accurate device to measure continuous walking in COPD patients but less accurate for daily walking behaviours, this could be attributed to the four second delay built into the pedometers. In addition to this, Moy et al. (2010) compared the Omron HJ-720ITC (dual-axis) to manually counted steps over 800 feet in 49 men and two women with COPD and found the pedometer measured greater than 80% of the manually counted steps in 20 of the 23 participants (87%) and measured greater than 90% of the manually counted steps in 17 of the 23 subjects (74%). They also found that the percent difference between manually counted steps and pedometer steps was larger in those with the lowest walking speeds.

Omron tri-axis accelerometers have been assessed for step count and distance accuracy. Huang, Xu, Yu and Shull (2016) assessed step count and distance accuracy for Nike+, FuelBand, Jawbone UP, Fitbit One, Fitbit Flex, Fitbit Zip, Garmin Vivofit, Yamax CW-701 and Omron HJ-321 (tri-axis) during level, upstairs and downstairs walking in healthy adults. Devices were compared with actual step count (from video recording) and distance. The Omron HJ-321 was within 1% accuracy for level walking, Garmin Vivofit and Omron HJ-321 were the most accurate for recording stairs (error < 4%). Slow walking significantly decreased the step count accuracy for Fitbit One, Nike + Fuel band and significantly decreased distance accuracy for Yamax , Fitbit Zip, Fitbit One and Fitbit Flex but not Omron HJ-321. Slow walking was classified as 0.9 m/s. Casanova et al. (2007) showed that the average walking speed for a COPD patient in the 6MWT was 1.0m/s with a range from 0.5-1.7 m/s. This does not however take into account their average walking speed during daily activities. To conclude, although the Omron tri-axis accelerometer has not been validated in elderly or COPD patients, Huang et al. (2016) showed the Omron tri-axis accelerometer was more accurate than some other marketed activity trackers for slow walking and this pace of 0.9 m/s is within the range of average walking pace for COPD patients. This along with the assumption that the Omron technology has improved in accuracy from dual axis to tri axis accelerometry, provides evidence that the Omron tri-axis accelerometers can serve as an appropriate measure of daily physical activity in COPD participants.

Demeyer et al. (2016) reported that the minimal important difference (MID) for physical activity in patients with COPD is between 600 and 1100 steps/day with a significant reduction in hospitalization risk occurring in those who increased their daily physical activity by at least 600 steps per day.

2.1.4 Self-Efficacy for Managing Breathing

In addition to the general barriers people deal with in regard to maintaining an exercise routine, COPD patients also have to contend with barriers related to breathing difficulty. The COPD self-efficacy scale (CSES) has five categories; category three questions are related to self-efficacy for physical exertion, particularly managing breathing difficulty or avoiding breathing difficulty in situations that require patients to move their bodies (Wigal, Creer, & Kotses, 1991). Each question starts with asking participants how confident they are that they could manage breathing difficulty or avoid breathing difficulty when they go up stairs too fast, lift heavy objects, exercise or physically exert themselves, hurry or rush around, and exercise in a room that is poorly ventilated. They are asked to use a five-point Likert scale to rate their confidence in each activity ranging from very confident to not at all confident. The CSES showed to have a test-retest reliability of 0.77 and internal consistency of 0.95 (Wigal et al., 1991). Additionally, an increase in self-efficacy for managing shortness of breath has been associated with decreases in symptom severity (Davis, Carrieri-Kohlman, Janson, Gold, & Stulbarg, 2006).

2.1.5 Self-Efficacy for Exercise

As described earlier, self-efficacy for exercise can be multidimensional, such as task self-efficacy, coping self-efficacy and scheduling self-efficacy (Rodgers et al., 2008). In fact, DuCharme and Brawley (1995) showed that scheduling self-efficacy is a predictor of physical activity behaviour independent of coping self-efficacy and particularly important for long term adherence when it is higher later in the exercise program. Other studies have confirmed that these three types of self-efficacy can be distinguishable from one another (Rodgers et al., 2008; Rodgers & Sullivan, 2001). Task self-efficacy tends to be more closely related to initiation of exercise, whereas, coping (barrier) and scheduling self-efficacy are more closely related to exercise as the program progresses (Blanchard et al., 2007; Rodgers et al., 2008). Rodgers et al. (2008) developed the multidimensional self-efficacy for exercise scale (MSES) as a questionnaire to assess these three types of self-efficacy. The MSES is a nine-item questionnaire that asks participants to rate their confidence on a scale from 0-100% for being able to complete their exercises. According to Rodgers et al. (2008), coping and scheduling self-efficacy have the ability to distinguish between exercisers and non-exercises and have been shown to increase throughout a two-week exercise program. Task self-efficacy has a tendency to stay fairly constant throughout a program, suggesting people may need a certain amount of task self-efficacy to initiate an exercise program but it is less related to exercise adherence.

2.2 COPD and Self-Efficacy

2.2.1 Interventions to Increase Self-Efficacy

In 2010 Ashford, Edmunds and French (2010) completed a meta-analysis on interventions that used sources of self-efficacy to attempt to change physical activity behaviours in the general population. They found that interventions that used vicarious experiences and feedback on past or other performances had the greatest significant increases in physical activity self-efficacy than those that did not use these strategies. Whereas the interventions that aimed to use persuasion, graded mastery and barrier identification were not as effective. However, there continues to be questions about the best way to increase self-efficacy in COPD patients.

In COPD self-management, social cognitive theory would argue that increasing knowledge, and providing adequate time to practice particular skills will increase an individual's self-efficacy for the particular skill. Increased self-efficacy along with a supportive environment should lead to improved disease self-management. Due to multiple behaviours in COPD self-management, self-efficacy can be measured using different scales depending on the behaviour of interest. For instance, self-efficacy for managing shortness of breath has been studied by Scherer and Schmieder (1997) using the CSES. In an uncontrolled study they showed participants' CSES score increased significantly along with 12 minute walking distance, after a 12 week outpatient pulmonary rehabilitation program compared to pretest. This provides some preliminary evidence for the effectiveness of pulmonary rehabilitation to change self-efficacy for self-managing COPD but the lack of a control group makes it inconclusive. In addition to this, self-efficacy for exercise in COPD participants has also been studied. In another uncontrolled study, Lox and Freehill (1999) showed an increase in self-efficacy for walking at the end of a 12 week pulmonary rehabilitation program. Unfortunately, due to the lack of a control group, this does not provide conclusive evidence about which intervention components are leading to increases in self-efficacy for walking. However, both studies provide some evidence for the relationship between self-efficacy and exercise tolerance. Further research is needed to identify what components of the pulmonary rehabilitation programs lead to increased self-efficacy and if there is a relationship between self-efficacy and exercise adherence after the program is over.

2.2.2 Interventions to Increase Physical Activity

A review of 20 studies found a small but significant effect of pulmonary rehabilitation to increase physical activity levels (Wilson, O'Neill, Collins, & Bradley, 2015). Changes in physical activity ranged from a large effect size (de Blok et al., 2006) to small effect sizes (Hospes, Bossenbroek, ten Hacken, van Hengel, & de Greef, 2009) and trivial effect size (Probst et al., 2011). Probst et al. (2011) did not include any self-management or behaviour change strategies in their study and did not use their physical activity trackers as a feedback and motivational tool. Whereas de Blok et al. (2006) had their intervention group participants wear the pedometer for the full 10 weeks of the program as a type of feedback and motivational tool. Hospes et al. (2009) also used their physical activity trackers as a feedback and motivational tool and included behaviour change techniques into their counselling sessions. This provides additional clarity on the impact of specific program components on changes in daily physical activity levels. Therefore, interventions should be utilizing physical activity trackers as a motivational tool to set realistic physical activity goals in order to decrease hospitalization risk and morbidity.

Two experimental studies have looked at changes in self-efficacy through interventions with an outcome of physical activity or exercise. Atkins, Kaplan, Timms, Reinsch and Lofback (1984) completed an experimental study in COPD patients comparing a simple exercise prescription group (control group), to groups who received exercise prescription along with one of three additional interventions; behaviour modification, cognitive modification or cognitive-behaviour modification. They showed an increase in self-efficacy and exercise adherence in all experimental groups compared to the control group. This provides support for the ability to increase self-efficacy and the positive impact this can have on adherence to an exercise prescription. Interestingly, this study used unsupervised exercise (walking) as their primary exercise prescription. However, they only measured adherence to exercise over the course of three months, and over these three months, participants continued to meet with support. In addition to this, Larson, Covey, Kapella, Alex and McAuley (2014) conducted a randomized control trial using a self-efficacy enhancing intervention targeting all four sources of self-efficacy with a primary outcome of daily physical activity level. Participants completed weekly self-efficacy enhancing sessions for four months, and every three months after that until nine months. The exercise component included supervised exercise twice per week and participants were instructed to complete an additional session at home once per week. The researchers found a significant increase in physical activity levels (as measured by accelerometer) in the experimental group compared to the control group after four months of training. Unfortunately, this study did not measure self-efficacy so we are unable to conclude if the change in physical activity was a result of a change in self-efficacy. In addition to this, both Atkins et al. (1984) and Larson et al. (2014) found that the increases in physical activity were only short term. Larson et al. (2014) found that the increase in physical activity returned to baseline by 12 month follow-up, which is interesting considering participants continued to receive support every three months up until that point. There remains no conclusive evidence to support an intervention that can change levels of self-efficacy and physical activity and/or exercise adherence long term.

2.2.3 Exercise Adherence

In addressing the issue of maintenance and adherence of exercise it becomes important to address the barriers involved in maintaining an exercise routine and/or physically active lifestyle. These barriers often prevent people from completing the task and it is important to consider these challenges when measuring self-efficacy. When studying a supervised exercise program in cardiac rehabilitation, research shows a more consistent relationship between coping self-efficacy and scheduling self-efficacy and physical activity adherence, than task self-efficacy and physical activity adherence, especially as an exercise program progresses over time (Rodgers, Murray, Selzler, & Norman, 2013). This suggests that supervised exercise programs are effective at making sure subjects have adequate task self-efficacy, but indicates the need for increased focus on coping and scheduling self-efficacy for adherence. Recently the MSES was used in a pulmonary rehabilitation study by Selzler, Rodgers, Berry and Stickland (2016) to predict clinical outcomes. They found that task self-efficacy was more strongly positively related to attending pulmonary rehabilitation sessions than coping or scheduling self-efficacy. Further evaluations of these three types of self-efficacy in COPD are warranted and could be used to develop effective interventions. It would also be interesting to further evaluate how COPD patients' self-efficacy for breathing related barriers compared to their self-efficacy for overcoming general physical activity barriers.

2.2.4 Self-Efficacy and the Environment

There is little research in regard to which sources (i.e., mastery, vicarious, physiological arousal, persuasion) are most effective for increasing self-efficacy between supervised exercise environments and home exercise environments. Supervised exercise participants are typically involved in a group setting. Particularly, in pulmonary rehabilitation, all group members will have pulmonary disease providing a potential source of vicarious experience through an other person similar to themselves. Home exercise on the other hand, could be completed individually or with a friend or family member, and therefore the potential for vicarious experience based on a similar other person might be lower. Participants in both supervised exercise and home exercise would likely be provided with the opportunity to set realistic goals and experience graded mastery. Working with an exercise professional in both settings could provide a source of verbal persuasion or encouragement. In addition, group members in a supervised setting may also provide persuasion and encouragement, as well as family members or friends in a home setting.

The exercise environment can also impact self-efficacy and potentially adherence to exercise. For instance, a home exercise program requires patients to schedule their own exercise sessions into their week whereas a supervised exercise program has participants attend an appointment at a particular time and day of the week set out by the program facilitator. The research seems to support the idea of coping and scheduling self-efficacy being related to adherence to exercise (Rodgers & Sullivan, 2001). Home exercise programs and supervised exercise programs have different levels of support and may provide different opportunities to develop skills for overcoming barriers and scheduling exercise into their routine, which have the potential to increase both coping and scheduling self-efficacy. Atkins et al. (1984) was able to show an increase in self-efficacy and exercise in their home exercise study, unfortunately, there was no supervised exercise control group for comparison. More research is needed in this area to identify if home exercise programs have the potential to increase coping and scheduling self-efficacy compared to supervised exercise programs.

2.2.5 Self-Efficacy and Outcome Measures

Research has shown an association between particular types of self-efficacy and outcome evaluations. In regard to exercise capacity, a 6MWT is a validated and commonly used measure of functional exercise capacity in COPD patients. Lox and Freehill (1999) found self-efficacy for walking six minutes to have a significant positive relationship with six minute walk distance. This finding would be expected as participants in their study had 12 weeks of supervised exercise to practice walking. It does not however, address self-efficacy related to adherence to their exercise routine. Additionally, Selzler et al. (2016) used the MSES as a clinical outcome predictor and found a significant positive association between coping self-efficacy and 6MWT distance after pulmonary rehabilitation with supervised exercise. The authors suggested that coping self-efficacy could be related to the effort put into the exercises themselves, which could explain the increase in exercise function. While this may provide some insight into patients' persistence with exercise, it does not provide information about the maintenance of the 6MWT distance and coping self-efficacy's relationship to this.

2.2.6 Summary and Purpose

Previous studies in people with COPD have shown increases in both self-efficacy (Lox & Freehill, 1999) and physical activity (Wilson et al., 2015). However, these increases in physical activity are short term (Atkins et al., 1984; Larson et al., 2014) and questions remain about how to improve exercise adherence. Self-efficacy has been linked to behaviour adherence in people with COPD (Bourbeau et al., 2004). When assessing self-efficacy it is important that both disease specific self-efficacy (self-efficacy for managing breathlessness) and exercise specific self-efficacy (task, coping and scheduling self-efficacy) are assessed in people with COPD, as the barriers faced by people with COPD could be related to breathing difficulties or general physical activity barriers. The exercise environment can also impact self-efficacy and adherence to exercise (Bandura, 1997). For instance, the difference between exercising in a supervised structured program vs. an independent exercise program at home could have an impact on the development of self-efficacy and as a result, adherence to exercise. The purpose of this study is to compare differences in physical activity, exercise adherence and self-efficacy between COPD patients who complete a supervised exercise program and those who complete an unsupervised exercise program. This will provide further understanding of the impact of different types of exercise support and the environment on self-efficacy and physical activity levels.

Chapter 3: Comparing Physical Activity Outcomes between Supervised and Unsupervised Exercise in COPD Patients

3.1 Introduction

Chronic obstructive pulmonary disease (COPD) is an obstructive lung disease characterized by shortness of breath and is the fourth leading cause of death in Canada (O'Donnell et al., 2008). COPD is the most common reason for hospitalization in those aged 60-74 and has the highest rate of hospital readmission (Canadian Institute for Health Information, 2008). COPD is estimated to cost between $646 million to $736 million per annum in Canada (Mittmann et al., 2008). Improved management of COPD could lead to decreased hospitalization and decreased cost on the healthcare system.

Due to the combination of exercise training and education, pulmonary rehabilitation has been shown to improve shortness of breath, exercise capacity, quality of life and decrease hospitalizations (McCarthy et al., 2015). Physical activity is a strong predictor of all-cause mortality in people who have COPD (Waschki et al., 2011). Unfortunately, long term adherence to exercise is low (Karapolat et al., 2007; Ries et al., 2003) and people with COPD have lower activity duration, intensity and step count when compared to healthy controls (Vorrink et al., 2011). Unfortunately, capacity for pulmonary rehabilitation programs in Canada is low (Camp et al., 2015). While hospitals continue to be the most common location to run pulmonary rehabilitation programs, alternative settings such as primary care networks (PCNs) and community recreation centres have begun to offer these services as well (Camp et al., 2015; McCarthy et al., 2015). Additionally, home-based pulmonary rehabilitation programs have been shown to be effective at improving health-related quality of life and exercise capacity (Liu et al., 2014). Creative community-based exercise programs could be an appropriate exercise therapy approach to reach more people with COPD.

Using a theory of behaviour change is important when attempting to understand behavioural outcomes. Self-efficacy, as a component of social cognitive theory, has been found to be associated with self-management behaviours such as exercise in people who have COPD (Bourbeau et al., 2004). Self-efficacy is the confidence one has in performing a behaviour and is specific for the behaviour of interest (Bandura, 1997). There are multiple ways to measure self-efficacy in different contexts and situations. The multi-dimensional self-efficacy for exercise questionnaire (Rodgers et al., 2008) includes the evaluation of three types of self-efficacy for exercise 1) task self-efficacy, 2) coping self-efficacy and 3) scheduling self-efficacy. Task self-efficacy is defined as the confidence in being able to complete the exercise behaviour itself, coping self-efficacy relates to the confidence in overcoming barriers to exercise, and scheduling self-efficacy is the confidence one has to exercise regularly (Rodgers et al., 2008). In people who have COPD, self-efficacy for managing breathlessness during physical exertion may also play an important role in physical activity behaviour. These different types of self-efficacy can be used to better understand physical activity behaviours in people with COPD.

By understanding how different exercise programs influence self-efficacy, physical activity and exercise in people who have COPD, we may be able to help COPD patients maintain the physical benefits from their exercise program, improve the long-term management of their disease and decrease hospital admissions and health care costs associated with COPD treatment and management (Bourbeau et al., 2003).

The purpose of this study was to explore how alternative exercise programs supported by a Primary Care Network (PCN) for people with COPD influence self-efficacy and adherence to exercise. The primary objectives of this study were to 1) compare differences in physical activity and exercise after supervised and unsupervised exercise programs in people who have COPD, and 2) compare differences in task self-efficacy, coping self-efficacy, scheduling self-efficacy and self-efficacy for managing breathlessness in response to supervised and unsupervised exercise programs in people who have COPD. Secondary outcomes included evaluated changes in HRQOL and exercise capacity. It was hypothesized that unsupervised exercise participants would have greater adherence to physical activity and exercise after the program was over; unsupervised exercise participants would have a greater increase in coping and scheduling self-efficacy than supervised exercise participants; no difference was expected for task self-efficacy and self-efficacy for managing breathlessness between groups.

Secondary research objectives were to 1) identify if there is a relationship between self-efficacy and behaviour outcomes (physical activity, exercise and attendance) between supervised and unsupervised exercise programs in people who have COPD and 2) compare the PCN-based exercise program outcomes with a more traditional pulmonary rehabilitation program to identify baseline and end-point differences. It was hypothesized that there would be a positive relationship between coping and scheduling self-efficacy and physical activity and exercise for both supervised and unsupervised exercise programs. It was hypothesized that the PCN exercise and traditional pulmonary rehabilitation groups would have similar improvements in health-related quality of life and exercise capacity.

3.2 Method

3.2.1 Recruitment and Participants

All study procedures were approved by the University Health Research Ethics Board and by the Edmonton North PCN. This study included a convenience sample of participants recruited from a PCN in Edmonton, Alberta. PCNs target community health care needs through a network of family physicians in collaboration with health care teams that include a variety of healthcare professionals (Alberta Government, 2018). Patients were eligible for the study if they reported a diagnosis of COPD from their family physician or pulmonologist. Participants needed to be able to ambulate (with or without an aid), be free of unstable cardiovascular disease, able to read and communicate in English and not be currently engaging in any structured aerobic exercise. Recruitment occurred in one of two places; during their baseline evaluation appointment by an exercise specialist, or during the COPD information group class. An explanation of the study was provided to each participant along with the information letter and participants had an opportunity to ask questions. Patients interested in participating in the study provided written informed consent.

3.2.2 Setting

The PCN COPD management program was a self-management service for people who have COPD. The PCN required patients to be referred by their family physician directly to the COPD management program or another PCN program, in which case the patient would be internally referred by a PCN clinician. While all patients who have COPD can access care at the PCN, the goal of the PCN is to provide COPD management for mild to moderate COPD patients and to suggest referral of severe or very severe patients who use long term oxygen therapy to an outpatient pulmonary rehabilitation program. Physicians were aware that referral to the COPD management program implied clearance for exercise and should include current spirometry data (ideally within six months). If referrals did not include spirometry, the referring clinic was contacted, and spirometry was provided to the PCN. Upon referral to the COPD management program, patients were contacted and scheduled for a telephone triage appointment with a PCN clinician who provided COPD management support. The telephone triage phone call was completed using an electronic medical record template to prompt screening questions to assess the severity of breathlessness, frequency of acute exacerbation of COPD (AECOPD), smoking status, symptoms, current activity level, inhaler use, and other mental, social or financial concerns. The triage phone call allowed the clinician to highlight the importance of education/self-management topics and schedule sessions according to the needs of the patient, however, it was up to the patient as to which appointments were scheduled based on their readiness to make behaviour changes.

All COPD management education content used was from the Living Well with COPD (LWWCOPD) website. Most patients were referred to attend an introductory group session that discussed lung anatomy, pathophysiology of COPD and provided an overview of the health behaviors required to stay healthy. Patients were then connected with clinicians to address additional education and self-management topics based on their assessed severity of COPD. These one-on-one appointments typically included: 1) meeting with an exercise specialist to learn how to manage breathing, coughing and energy conservation and to start an exercise program; 2) meeting with a pharmacist to review medications, proper inhaler techniques and to create an action plan for AECOPD; 3) meeting with a dietitian to discuss proper nutrition; and 4) meeting with a mental health practitioner to learn how to manage anxiety and depression. The educational content presented followed the recommendations highlighted throughout the

LWWCOPD materials to encourage behaviour change and support the participant to develop self-management skills. To ensure those with financial limitations could access care, patients had access to the PCN compassion fund for public transit passes if necessary. Due to electronic medical record constraints, this study did not track the content of other educational sessions provided by various other clinicians at the PCN.

This study evaluated the exercise component of the COPD management program delivered by exercise specialists. Exercise specialists are Certified Exercise Physiologists through the Canadian Society for Exercise Physiology and have a minimum a bachelor's degree in kinesiology or related subject. Two of the six exercise specialists at the PCN completed a COPD educator course through Respiratory Training and Educator Course (RESPTREC). This training content was passed along to the remaining members of the team by the trained exercise specialists in meetings. In addition to this, an outline was created for each exercise specialist to follow during their first appointment with COPD patients. This outlined the education topics to discuss and coinciding handouts to provide to the patient. Exercise specialists also have training in behaviour change strategies such as motivational interviewing and goal setting through Health Change Methodology.

The second objective of this study was to compare the PCN program outcomes to a formal pulmonary rehabilitation program called the Breathe Easy program. The Breathe Easy program at the G.F. MacDonad Centre for Lung Health is an outpatient pulmonary rehabilitation program. Patients are referred by their family physician or pulmonologist. Patients choose to attend morning or afternoon group sessions. They also have the choice of attending two times per week for eight weeks or three times per week for six weeks. Each session consists of two hours of supervised exercise and one hour of education. Exercise consists of both aerobic and resistance exercises tailored to the patient as needed. Education consists of group learning sessions on various COPD management topics such as disease information, breathing management, energy conservation, exercise, medications/inhalers, managing respiratory infections and environmental factors, stress/anxiety and nutrition.

3.2.3 Procedures

This was a two-group pragmatic clinical trial comparing participants who attended a supervised exercise program and those who attended an unsupervised exercise program based out of a PCN (Califf & Sugarman, 2015). This study used data from an ongoing clinical evaluation of a COPD management program at the Edmonton North PCN. The measures described below were collected as part of PCN program procedures. When a patient provided consent to participate in the study, the data were collected and de-identified (removing name and telephone number) by the primary investigator for research purposes.

Participants completed baseline assessments (Time 1) during their initial appointment with an exercise specialist and were provided an Omron-HJ324U tri-axis pocket accelerometer to wear for the remaining 16 weeks. Baseline assessments included self-efficacy, health-related quality of life and functional exercise capacity. Due to clinical constraints, it was not practical to randomly allocate participants to groups; therefore, participants chose between supervised and unsupervised exercise programs and were booked appointments accordingly. Baseline step count was collected on the first day of their supervised exercise program or during their next visit with the exercise specialist.

The supervised exercise program consisted of 16 classes over eight weeks and required participants to attend two times per week for 90 minutes each. Groups contained a maximum of eight participants each with one exercise specialist leading the classes. The program was run at a community recreation facility. Participants were asked to provide cost recovery for admission passes into the recreation facility, if financially feasible ($90-100). Participants who were classified as low income were assisted with a free or subsidized membership to access the facility throughout the sessions. The purpose of the exercise class was to develop a safe and appropriate exercise routine that can be maintained independently after the program was completed. The program included learning aerobic, resistance, flexibility and balance exercises. Classes were a mix of participants referred for a variety of conditions (e.g. COPD, cardiovascular disease, diabetes, obesity, chronic pain), therefore, exercise content varied for each participant based on their reason for referral. Conversations took place during the exercise sessions between participants and exercise specialists that included motivational interviewing and long term goal setting, based on previous training in Health Change Methodology, however, this was not formalized or tracked.

The unsupervised exercise program consisted of three appointments with an exercise specialist at the PCN. The appointments were scheduled two to three weeks apart over approximately eight weeks. Each appointment was 60 minutes long and exercise specialist used motivational interviewing techniques and goal setting to assist patients in creating an individualized exercise plan. The mode of exercise was based on preferences and equipment available to them, that they could perform independently. The sessions included instruction for performing different aerobic, resistance, flexibility and balance exercises based on each patient's individual needs and personal goals.

Participants in both the supervised exercise sessions and unsupervised exercise sessions were encouraged to work up to the published exercise recommendations for people with COPD (American College of Sports Medicine, 2010). The goal was for patients to work up to a minimum of 150 minutes per week of aerobic activity, accumulating this time in bouts of 10 minutes or more (American College of Sports Medicine, 2010). Intensity was prescribed by the exercise specialist using the rating of perceived exertion (RPE) scale, with the goal for patients to exercise at four to six out of ten, which was equivalent to somewhat severe to more severe breathlessness and fatigue. The intensity was self-monitored in the unsupervised exercise sessions and monitored by both the exercise specialist and the patient in the supervised exercise sessions. The intensity was recorded by the participant on their exercise diary in both exercise groups. Resistance exercises are also recommended for people with COPD (American College of Sports Medicine, 2010). Exercise specialists encouraged participants to complete one to three sets of eight to twelve repetitions of four to six different resistance exercises two to three times per week.

Post-program measurements (Time 2) were completed at the end of the eight-week exercise program and included step count, exercise diary, self-efficacy, health-related quality of life and functional exercise capacity. Follow-up measurements (Time 3) were completed eight weeks after the exercise program was complete (i.e. sixteen weeks). Both groups were re-assessed using the same measurements as Time 2.

3.2.4 Measures

Demographic information including age, gender, smoking history and comorbidities were retrieved from the participant's medical file (with consent). Additionally, socioeconomic status (SES) has been shown to have an inverse relationship with physical activity (Pampel, Krueger, & Denney, 2010). Education level has been shown to be correlated with both employment status and a higher income level which is a component of SES (Ma, Pender, Welch, & Board, 2016). Therefore, education level and employment status were measured through questionnaire. In addition, marital status was obtained, as this can be a potential influence on self-efficacy (Bandura, 1997) and COPD outcomes (Benzo, Abascal-Bolado, & Dulohery, 2016).

Recent spirometry results were collected from patient's electronic medical file. Forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) were reported, where the ratio of FEV1/FVC <0.7 after bronchodilator confirms a diagnosis of COPD (GOLD, 2017). Additionally, FEV1 as a percentage of predicted was used to determine disease severity, where FEV1 > 80% was considered mild, FEV1 >50% to <80% predicted was moderate, FEV1>30 to <50% predicted was severe and FEV1 <30% predicted was very severe according to Canadian Thoracic Society guidelines (O'Donnell et al., 2008). Participant's body mass index (BMI) was also gathered from their spirometry results when available.

The medical research council (MRC) dyspnea scale was used to identify symptoms of breathlessness. Participants were classified into a MRC grade, where grade 1 represents shortness of breath with strenuous exercise, grade 2 represents shortness of breath when hurrying on the level or walking up a slight hill, grade 3 represents walking slower than people of the same age on the level or stops for breath while walking at own pace on the level, grade 4 represents stops for breath after walking 100 yards and grade 5 represents too breathless to leave the house or breathless when dressing (C. M. Fletcher, 1960).

Physical activity was monitored using the Omron-HJ324U. The Omron-HJ324U is a tri-axis accelerometer with a four second delay to prevent over recording of minor movement as steps (Omron Healthcare, 2012). The accelerometer has a built in seven-day memory that is accessible from the device. Participants were asked to wear the accelerometer for the duration of the 16-week program and recorded their daily steps on their exercise diary. In this way it may have acted as a feedback tool rather than a blind assessment of physical activity.

Exercise was monitored using an exercise diary throughout the study. All participants recorded the mode of aerobic exercise, the minutes they performed the aerobic exercise and their average RPE during the aerobic activity on an exercise diary provided to them. This provided information about non-walking behaviours such as cycling and swimming. Adherence to aerobic exercise was defined as reporting an equivalent amount of aerobic exercise at the follow-up (Time 3) compared to the amount reported at the end of the exercise program (Time 2). Attendance to the exercise program and individual appointments were recorded by the exercise specialist into the electronic medical record. Completion of the program was defined as attending at least 67% of the exercise program appointments and the post-program assessment. Sixty-seven percent was chosen as this equates to two out of the three sessions in the unsupervised exercise program.

The multidimensional self-efficacy for exercise scale (MSES) was used to assess task, coping, and scheduling self-efficacy for exercise (Rodgers et al., 2008). All items begin with "How confident are you that you can…" followed by items that focus on task, coping and scheduling self-efficacy for exercise (e.g. "...exercise when you are too tired", "...exercise when you feel you have too much work to do", "...exercise when you feel you don't have time", "...can follow directions from an instructor"). Each dimension of self-efficacy was measured with three questions for a total of nine questions. Subjects responded to questions on a zero to 100 scale; zero meaning not confident at all and 100 meaning completely confident. Separate scores were calculated for task, coping and scheduling self-efficacy. This questionnaire was piloted by Rodgers and Sullivan (2001) and further assessed for validity by Rodgers et al. (2008) using confirmatory factor analysis to demonstrate multi-dimensional validity. Discriminant validity was shown by the questionnaires' ability to discriminate between exercisers and non-exercisers. The questionnaire was also able to show change in self-efficacy as participants changed from non-exercisers to regular exercisers, showing its sensitivity to behaviour change. The internal consistency (indicated by Cronbach's alpha) of task self-efficacy subscale was .84 pre-program, .92 post-program and .83 at 16-week follow-up. The internal consistency of the coping self-efficacy subscale was .94 pre-program, .86 post-program and .98 at 16-week follow-up. The internal consistency of the scheduling self-efficacy subscale was .92 pre-program (T1), .88 post-program (T2) and .96 at 16-week follow-up (T3).

Self-efficacy for managing breathing discomfort during physical activity was assessed using factor three questions from the COPD self-efficacy scale (CSES) developed by Wigal et al. (1991). The questionnaire asked participants to rate their confidence on a five-point Likert scale for how confident they are that they can manage breathing difficulty or avoid breathing difficulty in five different physically activity situations, "when I go up stairs too fast", "when I lift heavy objects", "when I exercise or physically exert myself", "when I hurry or rush around", and "when I exercise in a room that is poorly ventilated" (Wigal et al., 1991). The CSES has been shown to have good test-retest reliability in COPD participants. The internal consistency was previously reported to be .95 for the full questionnaire and 0.89 for the physical exertion subscale (factor three questions) of the questionnaire (Wigal et al., 1991). In the current sample, the internal consistency was .89 pre-program (T1) and post-program (T2) and .94 at 16-week follow-up (T3).

To evaluate health-related quality of life (HRQOL), the COPD assessment tool (CAT) was used. It is an eight-item questionnaire that scores participants on a 0-40 range with a lower score indicating less impairment and high score indicating more impairment. The CAT is a widely used questionnaire that has been shown to be valid and reliable for measuring health status in COPD participants (Gupta et al., 2014). The internal consistency (Cronbach's alpha) of this scale was .76 pre-program (T1), .74 post-program (T2), and .82 at 16-week follow-up (T3).

Functional exercise capacity was evaluated with a 6MWT. Each participant completed one 6MWT at each time point and the distance (in metres) was taken for each participant. Participants were instructed walk at their own pace as per the American Thoracic Society (2002) guidelines and provided chairs to rest if needed. The 6MWT is a strong indicator for response to medical interventions in COPD participants (American Thoracic Society, 2002).

3.3 Statistical Analysis

3.3.1 Data Screening

Statistical analyses were performed using IBM SPSS Statistics 24. Outliers were assessed by looking at the minimum and maximum values and box plots for pre-program (T1), post-program (T2) and follow-up (T3) data points. Four data points appeared as possible outliers based on box plots. The outlier labeling rule was applied to these four values and resulted in three of the values falling within the normal range (Hoaglin, Boris Iglewicz, & Tukey, 1986). One value for exercise minutes per week was considered an outlier, therefore, Winsorizing (a technique used to limit the influence of an outlier by replacing it with a value closer to other values in the set) was used to replace this value (555 aerobic minutes per week) with the next largest value in the group (195 exercise minutes per week) for the primary outcome analysis (Field, 2013).

Normality of demographic characteristics (age, BMI, pack years, FEV1 % predicted, FEV1/FVC post) and clinical outcomes (MRC, 6MWT, CAT, steps/day, self-efficacy) were assessed with Kolmogorov-Smirnov tests of normality, Q-Q plots and skewness and kurtosis values. Pre-program, none of the distributions were significantly different from normal. In addition to this, histograms and Q-Q plots appeared normally distributed and skewness and kurtosis values all fell between ranges of ± 2.0 which indicated that scores were distributed normally (Field, 2013). Post-program MRC and exercise minutes per week were significant for non-normally distributed data points, however, skewness and kurtosis were both within ±2, and histograms looked normal for these. The deviation from normal was not of great concern based on Field (2013), therefore, no action was taken to change these distributions. At follow-up, 6MWT and scheduling self-efficacy were both significantly different than normal, however, histograms and Q-Q plots appeared normal for both 6MWT and scheduling self-efficacy, and skewness and kurtosis fell within ±2.0 for scheduling self-efficacy therefore, no changes to these distributions were made.

Using repeated measures ANOVA, to detect a small to medium, within-between interaction effect (F = 0.18) with power set to 0.8 and alpha set to 0.05, our goal was to recruit a total of 52 participants, or 26 participants per group (Cohen, 1992). The analytical plan included univariate ANOVAs run on each continuous demographic variable to identify any group differences. Chi-square analyses were run on all demographic categorical variables to identify any group differences. Running multiple ANOVAs and chi-square analyses can increase risk of type one error, therefore, a Bonferroni correction was applied to familywise comparisons to adjust the alpha level to .01 for the demographic continuous variables (age, BMI, pack years, FEV1, FEV1/FVC), .006 for demographic categorical variables (gender, smoking history, marital status, education, employment, history of pulmonary rehabilitation, comorbidities, referral type and supplemental oxygen), .013 for clinical outcome variables (steps/day, exercise minutes, 6MWT, CAT), and .013 for self-efficacy variables.

3.3.2 Missing Data

Upon review of pre-program data points, there were two missing values from questionnaires, one from the CAT questionnaire and one from the CSES questionnaire. Schafer and Graham (2002) support imputing missing values from the participants' mean of available items when the items come from a single, well-defined scale. Cronbach's alpha was used to calculate the internal consistency of each questionnaire; the CAT questionnaire had a Cronbach's $\alpha = .8$ and the CSES questionnaire had a Cronbach's $\alpha = .9$. According to Kline (2000) these scales have acceptable internal consistency. Therefore, to preserve as much of each participant's data as possible, the missing values were replaced by the average across all available scores from the scale (Graham, 2012). All subsequent analyses include these imputed values.

3.33 Drop-out Analysis

Multivariate analysis of clinical outcomes was performed to identify if missing cases were missing completely at random or not. Dummy coding was used to identify participants who completed all 16 weeks of the study and those who dropped out before eight weeks and before 16 weeks (Field, 2013). Results suggested that the missing values were missing completely at random (Little's MCAR test: Chi-Square = 238.26, DF = 3540, Sig. = 1.00). MANOVAs were run for demographic variables, pre-clinical outcomes and self-efficacy to further assess for drop-out. Results of the MANOVAs indicated that there was no significant difference in demographic variables, pre-clinical outcomes and self-efficacy between completers, eight week drops-outs, and 16 week drop-outs (*p* values between 0.16 and 0.40). Together these analyses suggest no evidence of bias with the missing data.

3.3.3 Primary Analysis

To determine differences in physical activity (steps per day), exercise (aerobic exercise minutes per week) and self-efficacy (task, coping, scheduling and breathless management) across time between COPD participants in supervised and unsupervised exercise programs delivered at a PCN, a 2x3 mixed model ANOVA with a between-subjects factor of group and a within-subjects factor of time was completed for each variable. A follow up 2x2 mixed model ANOVA with a between-subjects factor of group and a within-subjects factor of time was completed between each of T1 and T2, and T2 and T3 to specify the timing of changes if possible.

To determine differences in health-related quality of life and exercise capacity across time between COPD participants in supervised and unsupervised exercise programs, a 2x3 mixed model ANOVA with a between-subjects factor of group and a within-subjects factor of time was completed for each variable. A follow up 2x2 mixed model ANOVA with a between-subjects factor of group and a within-subjects factor of time was completed between each of T1 and T2, and T2 and T3 to specify the timing of changes if possible.

For the primary analysis missing values from questionnaires were replaced with the average across all scores. The primary analysis was completed twice, one time using an intention to treat analysis where missing values from participants that dropped out were imputed using the last observation carried forward (Heritier, Gebski, & Keech, 2003). This is a conservative strategy to preserve sample size as you would expect values to change between time points. The analysis was also performed on complete cases only; significant differences between the analyses are presented. The same Bonferroni correction to the alpha coefficient from the group comparison was applied to this secondary research analysis adjusting alpha to .013 for all analyses. All violations of assumptions are presented. To be conservative, results are based on multivariate tests reporting the *p* value of Pillai's trace for within-subject factors.

3.3.4 Secondary Analysis

To determine if there was a relationship between self-efficacy (task, coping, and scheduling self-efficacy for exercise and self-efficacy for managing breathing) and behaviour outcomes (physical activity level, exercise adherence or attendance) between supervised exercise and unsupervised exercise groups, Pearson correlations were run for the variables separately for the supervised exercise group then for the unsupervised exercise group. Fisher's r-z transformation was calculated for each difference in correlation between groups and p values are reported. For these analyses, multiple imputation was performed on the data set in order to account for missing values. It is a strategy used to account for missing values that can only be used with correlation and regression analyses due to software limitations in SPSS. This technique imputes missing values multiple times and analyzes these values to create a pooled value. Forty multiple imputation samples were created, and the results presented are from the pooled value.

To determine differences in baseline patient characteristics and outcome measures between the PCN COPD exercise program and the Breathe Easy Pulmonary Rehabilitation program, one-way ANOVAs for all continuous variables were performed and chi-square tests were performed for all categorical variables. Only Breathe Easy participants that attended their initial assessment and provided demographic information were included. Data were collected in different ways throughout the PCN and Breathe Easy trials. In the PCN trial self-efficacy for managing breathlessness was represented by an aggregated total score of five questions from the CSES questionnaire, whereas, in the Breathe Easy trial self-efficacy for managing breathlessness was an aggregated total score from three questions from the CSES questionnaire. Both trials used questions regarding confidence for managing or avoiding breathing difficulty when going up stairs too fast, carrying heavy objects and during physical exertion. The PCN trial also used questions about confidence for managing or avoiding breathing difficulty when hurrying or rushing around, or when exercising in a poorly ventilated room. In addition, the self-efficacy for managing breathlessness score in the Breathe Easy trial was a percentage whereas the PCN score was on a scale from 1-5. The PCN scores were converted to percentages in order to compare between groups.

3.4 Results

Twenty-three participants provided consent and baseline data for the study; 13 in the supervised exercise group and 10 in the unsupervised exercise group. Drop-out is summarized in

Figure 3.1. There were five drop-outs in the supervised exercise group and two drop-outs in the unsupervised exercise group prior to post-program (T2) assessment. There was one additional participant from the supervised exercise group and two additional participants from the unsupervised exercise group that did not attend for their follow-up (T3) assessments. In order to detect an effect the goal was to recruit 52 participants, or 26 participants per exercise group. The small sample size of this study limits the inferences that can be made from the data.

Demographic and baseline outcome descriptive statistics from all complete cases available are presented in Table 3.1. Pre-program physical activity (steps per day) approached significance for a difference between supervised and unsupervised exercise groups, $F(1,17) = 5.08$, $p = .038$, $\eta^2_p = .23$, with mean steps per day of 4783 (2865) in the unsupervised group and mean steps per day of 2383 (1472) in the supervised exercise group. Employment status was significantly different between groups, χ^2 $(1, N = 23) = 7.30$, $p = .01$, with the members of the unsupervised group more likely to be employed. To further understand the impact of employment status on the difference in steps per day between groups, a 2x3 ANOVA with a between-subjects factor of employment status and a within-subjects factor of time was completed. A statistically significant main effect of employment status was found, $F(1,17) = 15.56$, $p = .001$, $\eta^2_p = .48$, showing that employment status was related to physical activity and participants' choice of exercise group. Subsequent analyses were conducted both with and without controlling for employment status to assess whether differences in steps per day were more likely due to the program rather than differences in employment status.

3.4.1 Primary Analysis of Primary Outcomes

Aerobic Exercise and Physical Activity

The means and standard deviations for aerobic exercise, coinciding RPE dyspnea scores and physical activity are presented in Table 3.2 and are based on the intention to treat analysis. The assumption of sphericity assumes that the variances of differences between multiple data points of a single participant are equal. This was violated for both steps per day and exercise minutes per week in the intention to treat analysis, and steps per day in the complete case analysis. It is important to note that at baseline (T1) each participant self-reported that they were completing zero minutes of aerobic exercise per week. This resulted in no variance for the baseline score of aerobic exercise and contributed to the violation of the assumption of sphericity. The assumption of homogeneity assumes that the population variances in each group are equal. This was violated for steps per day (T1) and exercise minutes per week (T3) in the intention to complete analysis.

For aerobic exercise the time by group interaction is displayed in Figure 3.2. Across the three time points there was a statistically significant main effect of time for aerobic exercise minutes per week, $F(2,20) = 8.04$, $p = .003$, $\eta^2_p = .45$. The main effect of time was also statistically significant between T1 and T2, $F(1,21) = 16.53$, $p = .001$, $\eta^2_p = .44$, however, this effect was not statistically significant between T2 and T3, $F(1,21) = .39$, $p = .399$, $\eta^2_p = .04$. Upon review of the data across the program (T1 to T2), aerobic exercise increased from 0 (0) minutes per week to 37.00 (63.61) minutes per week in the supervised exercise group and from 0 (0) minutes per week to 86.20 (81.94) minutes per week in the unsupervised exercise group. The main effect of group was not statistically significant across the three time points, $F(1,21) = 2.51$, $p = .128$, $\eta^2_p = .11$, or between T1 and T2, $F(1,21) = 2.64$, $p = .12$, $\eta^2_p = .11$, or T2 and T3,

$F(1,21) = 2.51$, $p = .133$, $\eta^2_p = .11$. The was no significant interaction effect between time and group across the three time points, $F(2,20) = 1.29$, $p = .303$, $\eta^2_p = .11$ or between T1 and T2, $F(1,21) = 2.64$, $p = .122$, $\eta^2_p = .11$ or T2 and T3, $F(1,21) = .14$, $p = .722$, $\eta^2_p = .01$.

For steps per day there were no significant differences between groups or across time after applying the Bonferroni correction. Due to the limited sample size, results are reported nonetheless because some of the effect sizes are medium according to Cohen (1992). The time by group interaction for steps per day is displayed in Figure 3.3. Across the three time points the main effect of time was not statistically significant for steps per day, $F(2,16) = 3.60$, $p = .05$, $\eta^2_p = .31$. The main effect of time was not statistically significant between T1 and T2, $F(1,17) = 2.12$, $p = .16$, $\eta^2_p = .11$, or between T2 and T3, $F(1,17) = 4.04$, $p = .06$, $\eta^2_p = .19$. The main effect of group across the three time points was approaching significance, $F(1,17) = 5.82$, $p = .03$, $\eta^2_p = .26$. There was no main effect of group between T1 and T2, $F(1,17) = 5.94$, $p = .03$, $\eta^2_p = .26$, or between T2 and T3, $F(1,17) = 5.45$, $p = .03$, $\eta^2_p = .24$. There was no statistically significant interaction effect between time and group across the three time points for steps per day, $F(2,16) = 2.40$, $p = .79$, $\eta^2_p = .03$, or between T1 and T2, $F(1,17) = .20$, $p = .67$, $\eta^2_p = .01$, or T2 and T3, $F(1,17) = .40$, $p = .54$, $\eta^2_p = .02$. Upon review of the data across the supervised exercise program, steps per day was 2383 (1472) at T1 and 2895 (1307) at T2. In the unsupervised exercise group steps per day was 4783 (2866) at T1 and 5057 (2306) at T2.

As previously noted, employment status was significantly different between groups at T1. Therefore, the original analysis was completed again using employment status as a covariate in which the assumption of sphericity was violated. Based on this analysis of covariance, the main effect of group was not statistically significant for steps per day across all three time points,

F(1,16) = .12, p = .67, η^2_p = .01, or between T1 and T2, F(1,16) = .09, p = .77, η^2_p = .01, or T2 and T3, F(1,16) = .36, p = .56, η^2_p = .02. The main effect of time was not statistically significant for steps per day across the three time points, F(2,15) = 1.92, p = .18, η^2_p = .20, or between T1 and T2, F(1,16) = 3.88, p = .066, η^2_p = .20, or T2 and T3, F(1,16) = .45, p = .51, η^2_p = .03. There was no statistically significant interaction effect between time and group across the three time points, F(2,15) = 1.92, p = .18, η^2_p = .20, or between T1 and T2, F(1,16) = .48, p = .50, η^2_p = .03, or between T2 and T3, F(1,16) = .10, p = .76, η^2_p = .01.

Self-Efficacy Types

The means and standard deviations for self-efficacy types are presented in Table 3.2. The assumption of sphericity was violated for self-efficacy for managing breathlessness.

For self-efficacy for managing breathlessness the time by group interaction is displayed in Figure 3.4. Across the three time points there was a statistically significant main effect of time, F(2,19) = 6.63, p = .007, η^2_p = .41. This effect was also statistically significant between T1 and T2, F(1,20) = 12.62, p = .002, η^2_p = .39, but not between T2 and T3, F(1,20) = 1.20, p = .286, η^2_p = .06. Upon review of the data across the program (T1 to T2), self-efficacy for managing breathlessness increased from 2.25 (0.67) to 2.48 (0.75) (5-point Likert scale) for the supervised exercise group and from 2.69 (1.08) to 3.06 (1.10) for the unsupervised exercise group. The main effect of group was not statistically significant across the three time points, F(1,20) = 2.63, p = .121, η^2_p = .12, or between T1 and T2, F(1,20) = 1.83, p = .191, η^2_p = .08, or T2 and T3, F(1,20) = 3.10, p = .094, η^2_p = .13. The interaction effect between time and group was not statistically significant across the three time points, F(2,19) = .54, p = .590, η^2_p = .05, or between T1 and T2, $F(1,20) = .65$, $p = .431$, $\eta^2_p = .03$, or between T2 and T3, $F(1,20) = .48$, $p = .498$, $\eta^2_p = .02$.

For task self-efficacy the time by group interaction is displayed in Figure 3.5. The main effect of time for task self-efficacy was not statistically significant across the three time points, $F(2,19) = 2.59$, $p = .102$, $\eta^2_p = .21$. The main effect of time was approaching significance between T1 and T2, $F(1,20) = 5.13$, $p = .035$, $\eta^2_p = .20$, but not between T2 and T3, $F(1,20) = .048$, $p = .829$, $\eta^2_p = .002$. Upon review of the data across the supervised exercise program, task self-efficacy was 63.06% (21.99%) at T1 and 72.36% (21.61%) at T2. In the unsupervised exercise group task self-efficacy was 67.00% (21.80%) at T1 and 76.67% (16.85%) at T2. The main effect of group was not statistically significant across the three time points, $F(1,20) = .23$, $p = .636$, $\eta^2_p = .01$, or between T1 and T2, $F(1,20) = .28$, $p = .605$, $\eta^2_p = .01$, or T2 and T3, $F(1,20) = .05$, $p = .829$, $\eta^2_p = .002$. There was no significant interaction between time and group across the three time points, $F(2,19) = .03$, $p = .97$, $\eta^2_p = .003$ or between T1 and T2, $F(1,20) = .002$, $p = .966$, $\eta^2_p = .00$, or T2 to T3, $F(1,20) = .067$, $p = .798$, $\eta^2_p = .003$.

For coping self-efficacy the time by group interaction is displayed in Figure 3.6. The main effect of time was not statistically significant across the three time points, $F(2,19) = .72$, $p = .500$, $\eta^2_p = .07$, or between T1 and T2, $F(1,20) = 1.28$, $p = .271$, $\eta^2_p = .06$, or T2 and T3, $F(1,20) = .00$, $p = 1.0$, $\eta^2_p = .00$. Upon review of the data across the supervised exercise program, coping self-efficacy was 52.22% (26.11%) at T1 and 60.00% (19.75%) at T2. In the unsupervised exercise group coping self-efficacy was 51.33% (22.40%) at T1 and 54.00% (19.99%) at T2. The main effect of group was not statistically significant across the three time points, $F(1,20) = .59$, $p = .811$, $\eta^2_p = .003$, or between T1 and T2, $F(1,20) = .17$, $p = .685$, $\eta^2_p =$

.01, or T2 and T3, $F(1,20) = .09$, $p = .767$, $\eta^2_p = .004$. The interaction effect was not statistically significant across the three time points, $F(2,19) = .38$, $p = .690$, $\eta^2_p = .04$, or between T1 and T2, $F(1,20) = .31$, $p = .586$, $\eta^2_p = .02$, or between T2 and T3, $F(1,20) = .74$, $p = .399$, $\eta^2_p = .04$.

For scheduling self-efficacy, the time by group interaction is displayed in Figure 3.7. The main effect of time was not statistically significant across the three time points, $F(2,19) = .64$, $p = .538$, $\eta^2_p = .06$ or between T1 and T2, $F(1,20) = .96$, $p = .340$, $\eta^2_p = .05$, or T2 and T3, $F(1,20) = .05$, $p = .829$, $\eta^2_p = .002$. Upon review of the data across the supervised exercise program scheduling self-efficacy was 74.44% (22.03%) at T1 and 80.56% (16.75%) at T2. In the unsupervised exercise group scheduling self-efficacy was 68.33% (29.28%) at T1 and 69.00% (22.72%) at T2. The main effect of group was not statistically significant for scheduling self-efficacy across the three time points, $F(1,20) = .87$, $p = .362$, $\eta^2_p = .04$, or between T1 and T2, $F(1,20) = .94$, $p = .345$, $\eta^2_p = .05$, or T2 and T3, $F(1,20) = .19$, $p = .666$, $\eta^2_p = .01$. There was no significant interaction effect across the three time points, $F(2,19) = .35$, $p = .711$, $\eta^2_p = .04$, or between T1 and T2, $F(1,20) = .62$, $p = .441$, $\eta^2_p = .03$, or T2 and T3, $F(1,20) = .32$, $p = .578$, $\eta^2_p = .02$.

3.4.2 Primary Analysis of Secondary Outcomes

Health Related Quality of Life

For CAT score the assumption of sphericity was violated in the intention to treat analysis. Means and standard deviations for CAT score are presented in Table 3.2 and the time by group interaction is displayed in Figure 3.8. Across the three time points the main effect of time was statistically significant, $F(2,20) = 5.27$, $p = .01$, $\eta^2_p = .35$. This statistically significant effect was evident between T1 and T2, $F(1,21) = 8.53$, $p = .008$, $\eta^2_p = .29$, but not between T2 and T3, $F(1,21) = 1.87$, $p = .186$, $\eta^2_p = .08$. Upon review of the data across the program (T1 to T2), CAT score decreased from 19.64 (6.02) to 17.46 (6.49) in the supervised exercise group and from 17.2 (5.77) to 14.2 (5.07) in the unsupervised exercise group. The mean change in CAT score was -0.77 (6.95) in the supervised exercise group and -3.00 (3.86) in the unsupervised exercise group. The main effect of group for CAT score was not statistically significant across the three time points, $F(1,21) = 1.34$, $p = .261$, $\eta^2_p = .06$, or between T1 and T2, $F(1,21) = 1.50$, $p = .234$, $\eta^2_p = .07$, or T2 and T3, $F(1,21) = 1.29$, $p = .270$, $\eta^2_p = .06$. There was no statistically significant interaction effect across the three time points, $F(2,20) = .38$, $p = .690$, $\eta^2_p = .04$ or between T1 and T2, $F(1,21) = .22$, $p = .647$, $\eta^2_p = .01$, or T2 and T3, $F(1,21) = .52$, $p = .478$, $\eta^2_p = .02$.

Exercise Capacity

For 6MWT and coinciding RPE dyspnea scores the means and standard deviations are presented in Table 3.2. The time by group interaction for 6MWT is displayed in Figure 3.9. There was no statistically significant effect of time for 6MWT across the three time points, $F(2,20) = .34$, $p = .717$, $\eta^2_p = .03$, or between T1 and T2, $F(1,21) = .68$, $p = .419$, $\eta^2_p = .03$, or between T2 and T3, $F(1,21) = .20$, $p = .662$, $\eta^2_p = .01$. Upon review of the data across the supervised exercise program 6MWT distance was 368.92 (81.33) metres at T1 and 375.91 (121.59) metres at T2. In the unsupervised exercise group 6MWT was 430.10 (115.07) metres at T1 and 449.00 (126.28) metres at T2. The main effect of group for 6MWT was not statistically significant across the three time points, $F(1,21) = 2.44$, $p = .133$, $\eta^2_p = .10$, or between T1 and T2, $F(1,21) = 2.32$, $p = .143$, $\eta^2_p = .10$, or T2 and T3, $F(1,21) = 2.32$, $p = .142$, $\eta^2_p = .10$. The interaction effect between time and group was not statistically significant across the three time points, $F(2,20) = .23$, $p = .800$, $\eta^2_p = .08$, or between T1 and T2, $F(1,21) = .14$, $p = .708$, $\eta^2_p = .01$, or T2 and T3, $F(1,21) = .02$, $p = .878$, $\eta^2_p = .001$.

3.4.3 Secondary Analysis – Correlations

Due to differences between groups at baseline, the relationship between baseline demographic variables and pre-program outcome variables was calculated using Pearson correlations to identify potential associations that could help explain these differences. Results of Pearson correlations between demographic variables and pre-program outcomes are presented in Table 3.3, means and standard deviations for demographic variables and baseline outcome variables are presented in Table 3.1.

Self-Efficacy and Physical Activity

Results of the Pearson correlations between self-efficacy and physical activity are presented in Table 3.4. Means and standard deviations are presented in Table 3.2. Results indicate a significant positive association between scheduling self-efficacy and physical activity, $r(13) = .66$, $p = .012$, and self-efficacy for managing breathlessness and physical activity, $r(13) = .57$, $p = .050$, in participants prior to starting supervised exercise (T1). Results indicated no significant associations between self-efficacy and physical activity in the unsupervised group and no significant differences between exercise groups. At the end of the exercise program (T2), and at follow-up (T3), results indicate no significant associations between self-efficacy and physical activity in either exercise group.

Self-Efficacy and Exercise

Results of the Pearson correlation between self-efficacy and time spent performing aerobic exercise are presented in Table 3.4. Means and standard deviations are presented in Table 3.2. Results indicate no significant associations between self-efficacy and exercise prior to the exercise program starting (T1) or at the end of the exercise programs (T2). At follow-up (T3) results indicated a marginally significant association between self-efficacy for managing breathlessness and aerobic exercise in the supervised exercise group, $r(13) = .55$, $p = .067$. Results indicate no significant associations in the unsupervised exercise group and no significant differences between groups on these associations.

Self-Efficacy and Attendance

Results of the Pearson correlation between self-efficacy and attendance are presented in Table 3.4. Means and standard deviations are presented in Table 3.2 Results indicate a significant positive association between scheduling self-efficacy (T2) and attendance to appointments in the unsupervised group, $r(10) = .69$, $p = .026$. Results also indicate a marginally significant positive association between coping self-efficacy (T2) and attendance to appointments in the unsupervised group, $r(10) = .58$, $p = .076$. Interestingly, there was no significant correlation between scheduling self-efficacy and attendance, $r(13) = .13$, $p = .675$, or coping self-efficacy and attendance, $r(13) = .23$, $p = .484$ in the supervised exercise group There were no significant differences in these associations between exercise groups.

3.4.4 Secondary Analysis – Comparison

Means and standard deviations for the Breathe Easy and PCN samples are presented in Table 3.5. There was a significant difference in sex between samples in that the PCN sample had more females than the Breathe Easy sample, χ^2 (1, N = 333) = 3.96, p = .047. The PCN sample also had a significantly higher BMI than the Breathe Easy sample, F(1,328) = 7.008 , p = .009, η^2_p = .021. The Breathe Easy sample had a significantly higher modified medical research council (mMRC) dyspnea than the PCN sample, F(1,312) = 30.13, p = .000, η^2_p = .090 , indicating that participants in the Breathe Easy program were more short of breath than participants in the PCN program. Task self-efficacy was significantly greater in the Breathe Easy sample compared to the PCN sample pre-program, F(1,258) = 12.13, p= .001, η^2_p = .045 and post-program, F(1,284) = 4.94, p = .027, η^2_p= .017. Coping self-efficacy was also significantly greater in the Breathe Easy sample compared to the PCN sample pre-program, F(1,285) = 6.26, p = .013, η^2_p = .024 and post-program, F(1,285) = 4.67, p =.032, η^2_p = .016. Post-program self-efficacy for managing breathlessness was significantly greater in the Breathe Easy sample compared to the PCN sample, F(1,285) = 11.75, p = .001, η^2_p = .04.

3.5 Discussion

It was hypothesised that there would be greater adherence to exercise and physical activity at follow-up and a larger increase in coping and scheduling self-efficacy post-program in the unsupervised exercise participants compared to supervised exercise participants. The results of this study do not support this hypothesis. Instead, similar outcomes for exercise, physical activity, coping and scheduling self-efficacy were observed in both exercise groups. It was hypothesized that there would be no difference between groups for task self-efficacy, self-efficacy for managing breathlessness, health-related quality of life and exercise capacity, and this was supported. The final hypothesis was that there would be a strong positive relationship between coping/scheduling self-efficacy and physical activity/exercise; however, this was not the case.

3.5.1 Aerobic Exercise and Physical Activity

Regarding exercise, the present study demonstrated an increase in time spent performing aerobic exercise at the end of program, and maintenance of this aerobic exercise eight weeks post program in both exercise groups. Other studies have indicated that adherence to exercise drops off in COPD participants after their structured program is over (Brooks, Krip, Mangovski-Alzamora, & Goldstein, 2002; Karapolat et al., 2007; Ries et al., 2003). A decline in quality of life and exercise capacity was documented at one month follow-up (Karapolat et al., 2007) as well as six, 12 and 24 month follow-up (Ries et al., 2003). Similarly, when exercise compliance was reported, a deterioration of the exercises was reported over 12 months after a pulmonary rehabilitation program (Brooks et al., 2002). Therefore, the results of the present study are unique in that we showed a maintenance of aerobic exercise at follow-up. The maintenance of exercise may be due to the fact that participants had the opportunity to continue with their routine in the same environment that they started (community recreation centre or home), however, longer follow-up and a larger sample are needed in order to draw more concrete conclusions.

An increase in time spent performing aerobic exercise throughout the program was expected for both groups. This was expected because participants were only eligible for the study if they were not engaging in structured exercise at baseline and the purpose of the program was to have participants engage in structured aerobic exercise. Nevertheless, the average amount of structured aerobic exercise did not achieve the recommended 150 minutes per week (American

College of Sports Medicine, 2010). One potential reason for this may be related to the structure and content of the exercise programs. Exercise specialists in PCNs work with people with many types of chronic conditions. Often participants who had COPD had other musculoskeletal conditions, such as low back pain or knee osteoarthritis, which they wanted to learn how to manage with exercise. When this was the case, the participant was also engaging in specific rehabilitation exercises that usually involved stretches and strengthening exercises. These additional exercises may have limited the time the participant had to engage in aerobic exercise and potentially the participant's capacity for exercise. It is also important to consider that the PCN exercise program was meant to be gradually progressive, and therefore it could have taken longer than eight weeks to build up to 150 minutes of aerobic exercise per week for those who were engaging in no aerobic exercise to begin with. The results of this study indicate that a more aggressive and specific exercise prescription approach by PCN exercise specialists is needed to reach exercise guidelines and improve exercise capacity for people with COPD.

Physical activity did not increase throughout the exercise program and there were no further changes at follow-up. As a result, we cannot conclude that physical activity was maintained following the program. On the other hand, physical activity levels were approaching significantly different values between groups at baseline with a medium effect size (Cohen, 1992). Choice of group was associated with employment status and baseline physical activity, in that those in the unsupervised exercise group were more likely to be employed and walked more, while those in the supervised exercise group were less likely to be employed and walked less. Employment status may influence which exercise program COPD patients choose as the timing and commitment of supervised exercise programming may be a barrier to people who continue to work. Specifically, the supervised exercise program was two times per week in the mornings or afternoons, whereas the unsupervised exercise program required participants to attend three appointments over eight weeks, with evening availability, and the ability to complete their exercise on their own time at their convenience. This finding is important as there may be a subsample of people with COPD who will not (or perhaps cannot) attend a traditional supervised exercise or pulmonary rehabilitation program.

The relationship between baseline physical activity and age was also interesting. There was no difference in age between groups, however, older participants tended to have higher baseline physical activity levels in the supervised exercise group. In contrast to this, older people tended to have lower baseline physical activity levels in the unsupervised exercise group. This association between age and physical activity in the unsupervised exercise group is consistent with the literature. The percentage of adults achieving the recommended amount of physical activity decreases with age (Colley et al., 2015). In addition to this, COPD patients have lower levels of physical activity compared to healthy controls (Vorrink et al., 2011). In contrast to this, the positive association between age and physical activity in the supervised exercise group is not consistent with the literature and is a unique finding that may require further research and a larger sample size to understand.

There was no increase in steps per day after either PCN exercise program which is consistent with other studies looking at physical activity after pulmonary rehabilitation (Spruit et al., 2013). In addition to this, our study did not achieve the minimal important difference (MID) of an increase of 600 steps per day (Demeyer et al., 2016). Interestingly the variance in steps per day was large resulting in a distribution of values with a low central tendency which can make it difficult to detect statistically significant changes. A larger sample size would likely increase the central tendency of the distribution and increase power which could provide inferences that can be discussed more confidently. Further to this, more research is needed to identify interventions that can promote physical activity increases, particularly activity outside of the structured exercise program since people with COPD have lower activity duration, intensity and counts when compared to age matched controls (Vorrink et al., 2011).

We would expect to see similar changes in aerobic exercise and steps per day in the groups. One potential explanation for the inconsistencies in the outcomes between time spent performing aerobic exercise and steps per day is mode of exercise. Many participants chose to complete their aerobic exercise using bicycles, arm cycle ergometers and aquatic exercise. These modes would not have been captured by the accelerometer. In addition to this, it is possible for people to exaggerate their subjective recordings of aerobic minutes.

Although baseline physical activity was low compared to the Breathe Easy sample, it is possible that baseline steps per day may have been inflated due to certain factors. First is the non-blinded use of an accelerometer. There is evidence to support short-term increases in physical activity by using a device that shows physical activity level (Bravata et al., 2007). Second was the influence of the exercise specialist on the participant, prior to baseline steps per day being collected. It is possible that participants were encouraged to be more physically active during their initial appointment with the exercise specialist at the time of receiving the accelerometer. Baseline steps per day were not collected until at least one week later.

3.5.2 Self-Efficacy Types

Results of the current study showed no differences in coping or scheduling self-efficacy between groups across time, and no improvement with exercise training in either group. It was hypothesised that the independence and flexibility involved in unsupervised exercise would promote participants' confidence for overcoming barriers to exercise and schedule exercise into their routines, but this was not the case. Coping self-efficacy requires experience to develop, meaning that it requires people to experience barriers and then persist in the face of those barriers (Maddux, 1995). In order for participants to experience positive situations that could promote coping or scheduling self-efficacy, participants may need to exercise more than they did in the current study. In addition to this, they may require enough coping and scheduling self-efficacy at baseline to persist through these barriers to be successful. When we look at our PCN sample in comparison to the Breathe Easy sample, we see lower self-efficacy levels in the PCN participants. It is unclear why the PCN participants had such low self-efficacy. It is possible that this low level of self-efficacy at baseline limited the potential to persist through barriers and develop self-efficacy throughout the programs.

Associations between self-efficacy and behaviours can help us explain the sample and outcomes. We saw a positive relationship between scheduling self-efficacy and physical activity at baseline; however, this relationship is weaker at the end of program. This could be explained by persistence without success. Meaning people with higher scheduling self-efficacy tend to be more persistent with trying to be physically active, even if they are not successful. This weaker relationship at the end of program could also be explained by unequal changes in the two variables from baseline to the end of program.

In addition, there was also a positive relationship between scheduling self-efficacy and attendance to the unsupervised exercise program appointments. This is consistent with the thought that those with higher scheduling self-efficacy should be better able to organize their time which could translate to consistent attendance to appointments. This is consistent with findings in cardiac rehabilitation in which scheduling self-efficacy is related to adherence (Rodgers, Murray, Courneya, Bell, & Harber, 2009; Rodgers et al., 2013; Scholz, Sniehotta, & Schwarzer, 2005). In our study this adherence is to appointments rather than the exercise itself. Together these associations provide some support for scheduling self-efficacy playing a role in physical activity level and ability to attend appointments.

We hypothesized that task self-efficacy and self-efficacy for managing breathlessness would increase in both exercise groups. Our hypothesis was partially supported in that self-efficacy for managing breathlessness increased similarly in both groups across the program. However, task self-efficacy did not significantly increase across the program. The increase in self-efficacy for managing breathlessness is consistent with other studies evaluating pulmonary rehabilitation outcomes (Scherer & Schmieder, 1997).

This increase in self-efficacy for managing breathlessness may be the result of specific experiences during the exercise programs. Because there were no differences between groups, it leads us to believe that each exercise program had sufficient sources of self-efficacy. For instance, participants in the supervised exercise program had an exercise specialist remind them to perform pursed lip breathing techniques during their exercise (verbal persuasion), whereas participants in the unsuperviserd exercise program did not. It is likely that participants in both groups experienced physiological/affective arousal, in that they noticed improved breathing management using pursed lip breathing and this may have been adequate enough to increase self-efficacy (Bandura, 1997). These results provide support that self-efficacy for managing breathlessness increases in both supervised and unsupervised exercise programs for people with COPD.

3.5.3 Exercise Capacity

It was hypothesized that participants in both exercise groups would have similar increases in 6MWT distance; however, our study showed no increase in 6MWT distance in either group. This is inconsistent with other studies evaluating pulmonary rehabilitation, which consistently show an increase in distance (McCarthy et al., 2015). In addition to this, the Breathe Easy program reported a change in 6MWT distance of +40.19 metres. The minimal clinical important difference (MCID) for 6MWT in people with COPD is between 25-35 metres (Holland et al., 2010) and the present study did not achieve this.

One potential explanation for this is that the training quantity or quality was too low to elicit changes in exercise capacity. Participants did not achieve 150 minutes per week of aerobic exercise and while an RPE scale was used to assign an exercise intensity of 4-6/10, it appears this was not enforced as the average RPE was 3.7 in the supervised exercise group and 3.4 in the unsupervised exercise group. The average RPE at follow-up was 2.6 in the supervised exercise group and 3.5 in the unsupervised exercise group. Unfortunately, only nine participants recorded RPE on their exercise dairy throughout the exercise programs so caution must be used when interpreting this information. In summary, the training quantity and quality may need to be controlled better in order to see the hypothesized results. Exercise specialists should be more aggressive in order to prescribe the proper dose of exercise required to improve exercise capacity.

Evidence also supports a psychological component in the effort during exercise testing. Selzler, Rodgers, Berry and Stickland (2016) found that higher coping self-efficacy was related to improved effort on maximal stress testing. The PCN sample had significantly lower coping self-efficacy than the Breathe Easy sample. This could have influenced the amount of effort the PCN participants put into their walk test. This is also supported by the RPE reported during testing which averages ranged between 3.9 and 5.13 out of 10. The effort on the 6MWT may not have been high enough to provide an accurate measure of exercise capacity. It is also possible that components of the American Thoracic Society criteria for 6MWT were not followed, such as standardized encouragement (American Thoracic Society, 2002). In addition to this, the recommendation to perform a practice 6MWT was not completed due to clinical time constraints.

3.5.4 Health Related Quality of Life

The hypothesis that HRQOL would increase similarly in both groups was supported. The CAT score decreased from 19.64 (6.02) to 17.46 (6.49) in the supervised exercise group and from 17.2 (5.77) to 14.2 (5.07) in the unsupervised exercise group which is consistent with the improvement in HRQOL observed with pulmonary rehabilitation (Kon et al., 2013; McCarthy et al., 2015), and above the MCID estimation for the CAT questionnaire (Kon et al., 2013). The current study showed no change in HRQOL from after the program to follow-up which is consistent with research indicating that HRQOL is maintained after pulmonary rehabilitation (Karapolat et al., 2007).

3.5.5 PCN vs. Breathe Easy Comparison

This study also compared the PCN COPD patient sample to the Breathe Easy pulmonary rehabiliation sample. There was a difference in sex and BMI between PCN participants and Breathe Easy participants, with PCN participants having higher BMI and more likely to be female. BMI is interesting in people with COPD; while the incidence of obesity is high (Evans & Morgan, 2014), low body weight is associated with poor survial in people with severe COPD (Bourbeau, Nault, & Borycki, 2002). This may indicate a potential relationship between BMI and disease severity; this is somewhat supported by the difference in dyspnea (mMRC) between samples, in that the Breathe Easy sample has significantly greater dyspnea (mMRC) than the PCN sample. However, the amount of airflow limitation (FEV1) was not different between samples, indicating weak support for the potential relationship between BMI and disease severity.

In this comparision, we see that PCN participants had lower self-efficacy at baseline. Task self-efficacy and coping self-efficacy were significantly lower in the PCN sample at baseline compared to the Breathe Easy sample. One potential explanation for this is that the timing of the questionnaires. In the PCN program the questionnaires were provided in clinic prior to starting the exercise program. Participants were filling them out after comitting to an exercise program in a public recreation centre or exercising on their own at home. On the other hand, the Breathe Easy program handed out their questionnaires during the first week of their exercise program. At this time, participants are in the location they will continue to exercise in for the next six to eight weeks and this could inflate their self-efficacy compared to the anticipation of starting a program in a new location.

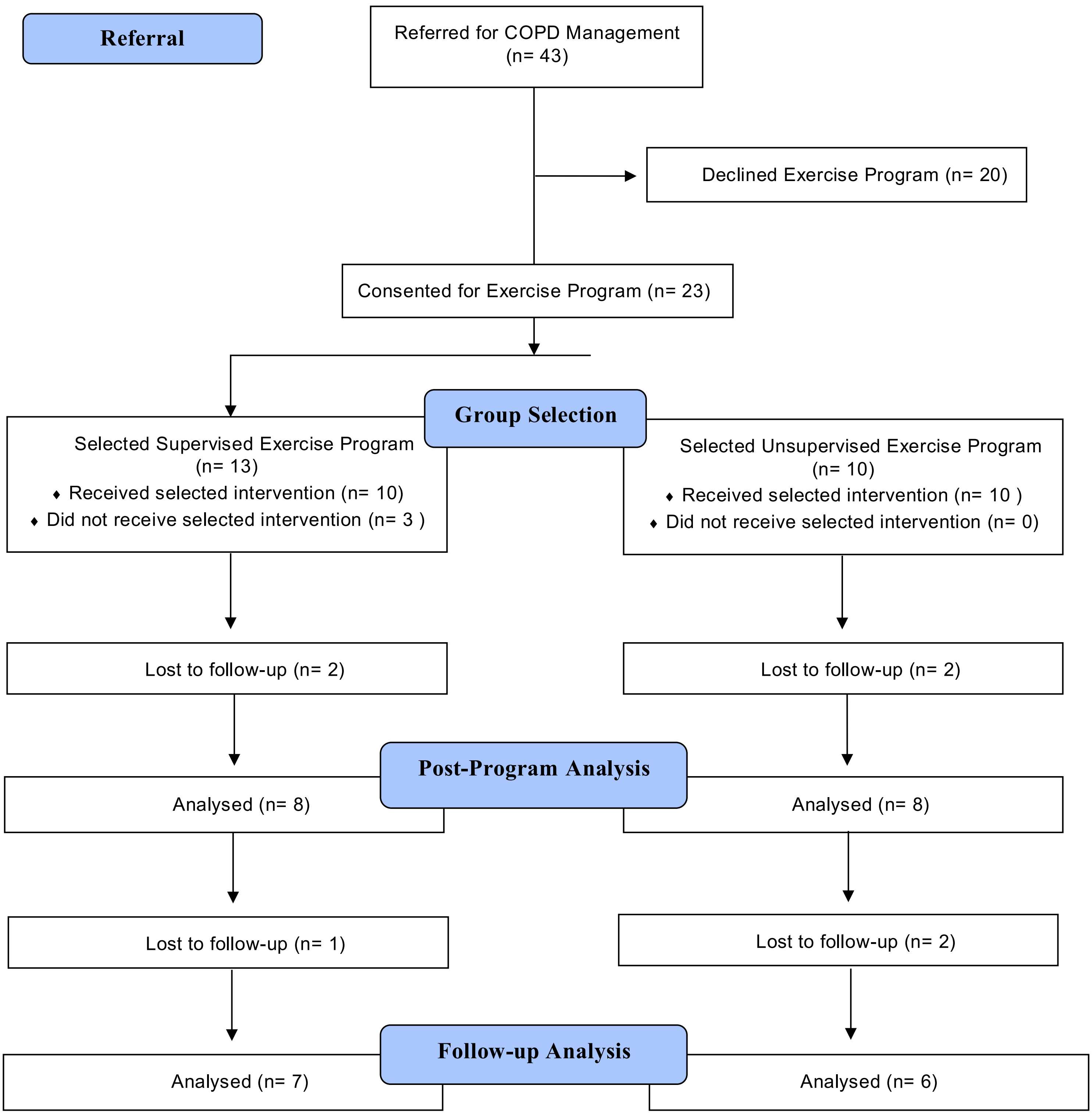
It is possible that the environment where the program is delivered may have an impact on self-efficacy (Bandura, 1997). The Breathe Easy program is located in a continuing care hospital and participants are required to complete a medically supervisored maximal exercise test. In the Breathe Easy program there is access to respiratory therapists and supplemental oxygen.These features are not available within the PCN or within the exercise programs offered to PCN participants. It is possible that these features inflate self-efficacy for exercise in the Breathe Easy group.

An important limitation to the current study that should be considered is sample size. Sample size was limited both by referrals from family physcians to the PCN and response rate. The goal of this study was to recruit a minimum of 52 participants. Family physicans referred 43 patients to COPD management services at the PCN and 20 of these patients declined exercise services. The small sample size limited the power and type of statistical analysis that were performed.

Another limitation is the self-report of exercise. While we supplemented self-report with objective accelerometer data, we recognize that the two assessments were measuring different elements of physical activity (i.e. only walking activity vs any aerobic exercise including walking). Future studies should consider using an objective measure of exercise. Finally, the lack of randomization to groups was a limitation of the current study. This left us with baseline differences in participants between groups which limits interpretation of the results.

A strength of this study is the fact that it took place in a natural clinical setting. This provides insight into how people with COPD respond to interventions that they are more likely to receive, and improves the external validity of the findings. However, the timing of assessents and questionnaires could be better controlled in this natural setting and may have impacted baseline measurements. For instance, baseline physical activity should be measured prior to counselling sessions with an exercise specialist. Additionally, the timing of baseline self-efficacy questionnaires should be standardized as the environment and support received up until that point can have an impact on self-efficacy (Bandura, 1997).

In conclusion, both supervised and unsupervised exercise programs offered through a PCN may be effective for increasing time spent performing aerobic exercise, quality of life and self-efficacy for managing breathlessness. Neither program increased physical activity, exercise capacity or self-efficacy for exercise. Evaluation of health care programs is important in order to understand the impact of the program and to help inform future changes. As the prevelance of COPD increases and more health care facilities opt to offer care, it is important that these programs meet a standard of care in order to produce results that show appropriate use of health care funds.



Referral to COPD Management Program and Subsequent Drop-out

Table 3.1

Baseline Demographic Descriptive Statistics by Group

	Supervised Exercise	Unsupervised Exercise	Between Group Difference
	M (SD)	M (SD)	p value
Age, years	66.92 (9.05)	61.50 (9.62)	.180
Sex, % female	69.20	70.00	.968
BMI, kg/m²	33.72 (7.58)	35.72 (9.38)	.613
Pack years smoking, years	43.17 (18.01)	49.22 (38.56)	.636
Smoking history, % smoking	38.50	10.00	.123
Marital status, % married	30.80	30.00	.968
Education, % less than high school	7.70	10.00	.846
Employment, % working	7.70	60.00**	**.007**
History of PR, %	33.30	10.00	.193
Comorbidities, % with 2 or more	76.90	50.00	.570
Supplemental Oxygen, %	15.40	0.00	.194
Referral type, % external	46.20	40.00	.768
MRC dyspnea, 1-5	2.83	2.70	.787
FEV1 % predicted	61.64 (21.15)	76.50 (16.20)	.115
FEV1/FVC	57.64 (15.81)	60.63 (10.50)	.649
Steps per day	2383 (1472)	4783 (2865)*	**.038**
Task Self-efficacy, %	63.06 (21.99)	67.00 (21.47)	.679
Coping Self-efficacy, %	52.22 (26.11)	51.33 (22.40)	.933
Scheduling Self-efficacy, %	74.44 (22.03)	68.33 (29.28)	.583
Self-efficacy for Managing Breathlessness, 1-5	2.25 (0.67)	2.60 (1.10)	.376
6MWT, m	368.92 (81.33)	430.10 (115.07)	.150
CAT Total score, 1-40	19.75 (6.27)	17.20 (5.77)	.337

Note. Supervised Exercise N = 13, Unsupervised Exercise N = 10; BMI = body mass index, PR = pulmonary rehabilitation, MRC = medical research council, FEV1 = forced expiratory volume in 1 second, FVC = forced vital capacity, 6MWT = six-minute walk test; CAT = COPD Assessment Test, * Difference between groups based on $p<.05$, ** Significant differences between groups based on $p<.0125$

Table 3.2
Descriptive Statistics of Outcomes Across Time by Group

	Supervised Exercise			Unsupervised Exercise		
	T1	T2	T3	T1	T2	T3
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Steps per day	2383 (1472)	2895 (1307)	2604 (1598)	4783 (2866)	5057 (2306)	4499 (2279)
Aerobic Exercise Minutes per week	0.00 (0.00)	37 (64)**	44 (68)	0.00	86 (82)**	104 (136)
Exercise RPE dyspnea, 1-10		3.7 (1.5)	2.6 (1.1)		3.4 (1.1)	3.5 (1.4)
Task Self-efficacy, %	63.06 (21.99)	72.36 (21.61)*	72.50 (21.33)	67.00 (21.80)	76.67 (16.85)*	75.00 (18.54)
Coping Self-efficacy, %	52.22 (26.11)	60.00 (19.75)	56.67 (21.46)	51.33 (22.40)	54.00 (19.99)	57.33 (28.88)
Scheduling Self-efficacy, %	74.44 (22.03)	80.56 (16.75)	74.72 (20.67)	68.33 (29.28)	69.00 (22.72)	67.67 (27.62)
Self-efficacy for Managing Breathlessness, 1-5	2.25 (0.67)	2.48 (0.75)**	2.53 (0.88)	2.69 (1.08)	3.06 (1.10)**	3.28 (0.97)
6MWT, m	369 (81)	376 (122)	369 (113)	430 (115)	449 (126)	446 (119)
6MWT RPE dyspnea, 1-10	4.54 (2.30)	5.1 (2.7)	4.2 (1.3)	4.5 (1.7)	3.9 (0.7)	4.4 (1.5)
CAT Total score, 1-40	19.64 (6.02)	17.46 (6.49)**	17.77 (6.83)	17.20 (5.77)	14.20 (5.07)**	15.20 (6.03)
Attendance, %		59.69 (38.59)			80.20 (17.04)	

Note. The data presented were calculated including the last value carried forward (intention to treat), RPE = rating of perceived exertion, Supervised Exercise N = 13, Unsupervised Exercise N = 10, T1 = pre-program, T2 = end of program, T3 = 8 weeks after program completed, 6MWT = six-minute walk test; CAT = COPD Assessment Test, * Difference across time based on $p<.05$, ** Significant difference across time based on $p<.0125$

Table 3.3

Correlations between Demographics and Baseline Data

	Steps per day (T1)			Task Self-Efficacy (T1)			Coping Self-Efficacy (T1)			Scheduling Self-Efficacy (T1)			Self-Efficacy for Managing Breathlessness (T1)		
	r^{SEP}	r^{USEP}	z-stat	r^{SEP}	r^{USEP}	z-stat	r^{SEP}	r^{USEP}	z-stat	r^{SEP}	r^{USEP}	z-stat	r^{SEP}	r^{USEP}	z-stat
Age	.54	-.61	2.6**	.01	-.25	.55	.28	-.41	1.45	.29	-.48	1.65	.23	.26	-.06
Sex	-.54	-.23	-.77	-.40	-.48	.18	-.48	-.33	-.35	-.62*	-.48	-.39	-.37	-.02	-.74
BMI	-.07	.01	-.17	-.32	.20	-1.07	-.46	.64*	-2.53**	-.22	.51	-1.59	.12	-.54	1.47
Pack years	.15	.47	-.74	-.10	.12	-.46	.07	.30	-.49	.13	.38	-.54	-.20	-.44	.55
Marital Status	-.11	-.15	.08	.14	-.05	.40	.35	.14	.46	-.07	.16	-.48	-.11	.06	-.33
Education Level	.32	.40	-.19	.32	.16	.34	.22	.59	-.93	.48	.70*	-.68	.38	-.26	1.35
Employment Status	.20	.70*	-1.34	.03	.44	-.89	-.02	.24	-.54	-.03	.34	-.78	.10	.05	.11
FEV1 % pred. post	.24	.04	.42	.46	.29	.39	.58*	-.13	1.60	.47	.10	.82	.27	.23	.09
MRC dyspnea scale	-.50	-.38	-.29	-.10	-.15	.11	-.18	-.05	-.27	-.48	-.09	-.87	-.50	-.40	-.25

Note. The data presented were calculated using multiple imputation, * Significant correlation based on p<.05, ** Significant correlation based on p<.0125, T1 = pre-program, T2 = end of program, T3 = 8 weeks after program completed, SEP = Supervised Exercise (N = 13); USEP = Unsupervised Exercise (N = 10), BMI = body mass index, FEV1 = forced expiratory volume in 1 second, MRC = medical research council

Table 3.4

Correlations between Self-efficacy and Physical Activity

	Steps per day (T1)		
	r^{SEP}	r^{USEP}	z- stat
Task Self-Efficacy (T1)	.16	.14	0.03
Coping Self-Efficacy (T1)	.28	.36	-0.02
Scheduling Self-Efficacy (T1)	.66**	.23	1.13
Self-Efficacy for Managing Breathlessness (T1)	.57*	-.13	1.57

	Steps per day (T2)			Aerobic Exercise Minutes (T2)			Program Attendance		
	r^{SEP}	r^{USEP}	z- stat	r^{SEP}	r^{USEP}	z- stat	r^{SEP}	r^{USEP}	z- stat
Task Self-Efficacy (T2)	-.40	.01	-0.87	.02	.21	-0.40	.02	.25	-0.46
Coping Self-Efficacy (T2)	-.47	.07	-1.19	-.09	.48	-1.25	.23	.58	-0.88
Scheduling Self-Efficacy (T2)	-.02	.19	-0.42	-.08	.05	-0.27	.13	.69*	-0.14
Self-Efficacy for Managing Breathlessness (T2)	.34	-.25	1.23	.31	-.31	1.30	-.22	.10	0.25

	Steps per day (T3)			Aerobic Exercise Minutes (T3)		
	r^{SEP}	r^{USEP}	z- stat	r^{SEP}	r^{USEP}	z- stat
Task Self-Efficacy (T3)	.18	.52	-0.78	.16	.29	-0.27
Coping Self-Efficacy (T3)	.13	.41	-0.63	.17	.43	-0.59
Scheduling Self-Efficacy (T3)	.27	.53	-0.62	.29	.41	-0.29
Self-Efficacy for Managing Breathlessness (T3)	.43	-.32	1.61	.55	.34	0.55

Note. The data presented were calculated using multiple imputation, * Significant correlation based on $p<.05$, ** Significant correlation based on $p<.0125$, T1 = pre-program, T2 = end of program, T3 = 8 weeks after program completed, SEP = Supervised Exercise (N = 13); USEP = Unsupervised Exercise (N = 10)

Table 3.5
Comparing PCN and Breathe Easy Programs

	PCN				Breathe Easy				Difference between samples	
	T1		T2		T1		T2		T1	T2
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	ρ value	ρ value
Age, years	23	64.57 (9.49)			311	65.37 (11.16)			.735	
Sex, % female	23	69.57			311	48.1*			.047	
BMI, kg/m²	19	34.56 (8.20)			311	29.77 (7.63)**			.009	
Pack years smoking, years	21	45.76 (27.97)			248	40.46 (42.57)			.573	
Currently Smoking, %	23	26.10			302	18.2			.351	
mMRC Dyspnea, 0-4	22	1.77 (1.11)			292	2.99 (.98)**			.000	
FEV1 % Predicted	19	67.89 (20.18)			293	60.74 (24.57)			.215	
FEV1/FVC	19	58.89 (13.57)			293	53.86 (16.62)			.197	
6MWT, m	23	396 (100)	14	427 (126)	284	371 (116)	254	411 (123)	.325	.639
CAT Total Score, 1-40	23	18.58 (5.91)	15	16.00 (5.72)	295	19.52 (7.58)	267	17.37 (7.69)	.563	.497
Steps per day	19	3646 (2566)	15	4596 (3185)	232	4596 (3184)	138	5346 (3637)	.206	.311
Task Self-Efficacy	22	64.85 (21.47)	14	79.52 (17.14)	238	81.32 (21.19)**	272	88.40 (14.44)*	.001	.027
Coping Self-Efficacy	22	51.81 ± 23.92	15	62.89 (17.36)	238	66.11 (25.78)*	272	74.57 (20.53)*	.013	.032
Scheduling Self-Efficacy	22	71.67 ± 25.13	15	75.78 (19.36)	238	74.18 (25.54)	272	79.92 (19.61)	.658	.426
Self-Efficacy for Managing Breathlessness	22	49.91 ± 17.46	15	54.67 (19.46)	238	60.83 (28.26)	272	75.76 (23.38)**	.076	.001

Note. * Significant difference between PCN and Breathe Easy based on p<.05, ** Significant difference between PCN and Breathe Easy based on p<.0125, T1 = pre-program, T2 = end of program, BMI = body mass index, mMRC = modified medical research council, FEV1 = forced expiratory volume in 1 second, FVC = forced vital capacity, 6MWT = six-minute walk test, CAT = COPD Assessment Test

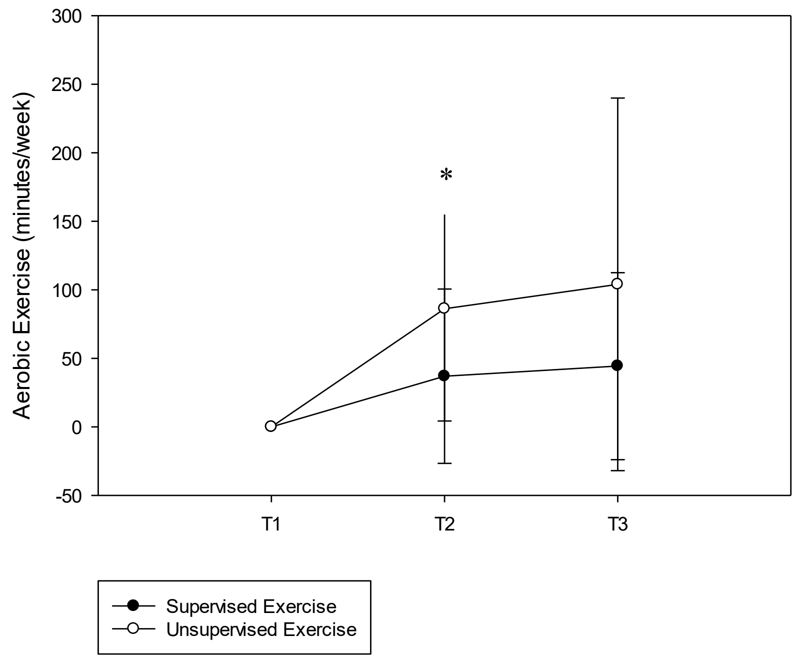


Figure 3.2 *Time Spent Performing Aerobic Exercise*. * $p < .0125$ vs. T1 for both groups

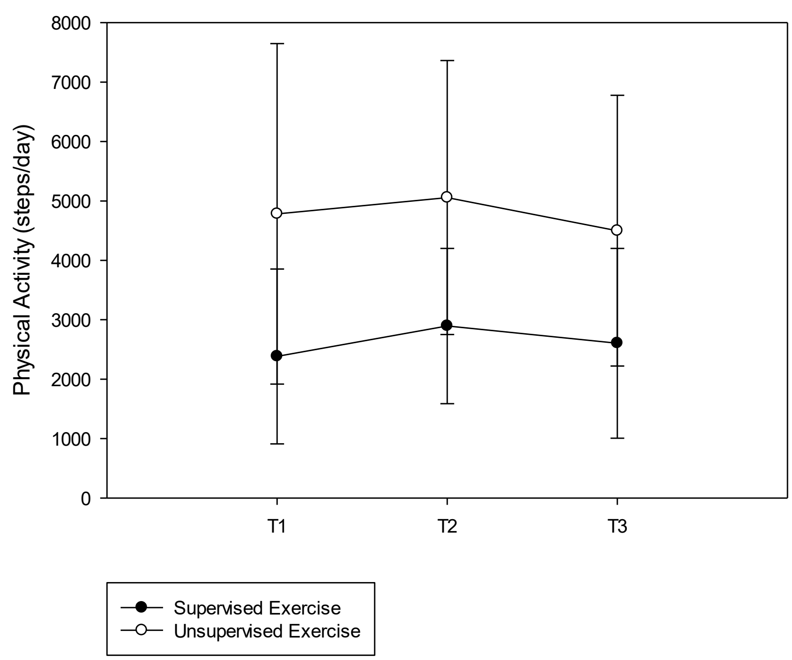


Figure 3.3 *Steps Per Day*

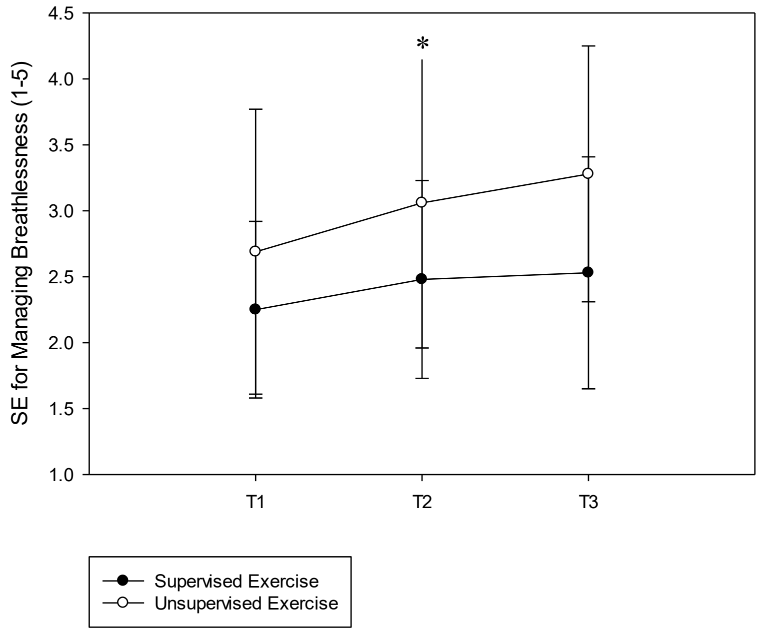


Figure 3.4 *Self-Efficacy for Managing Breathlessness*. * $p < .0125$ vs. T1 for both groups

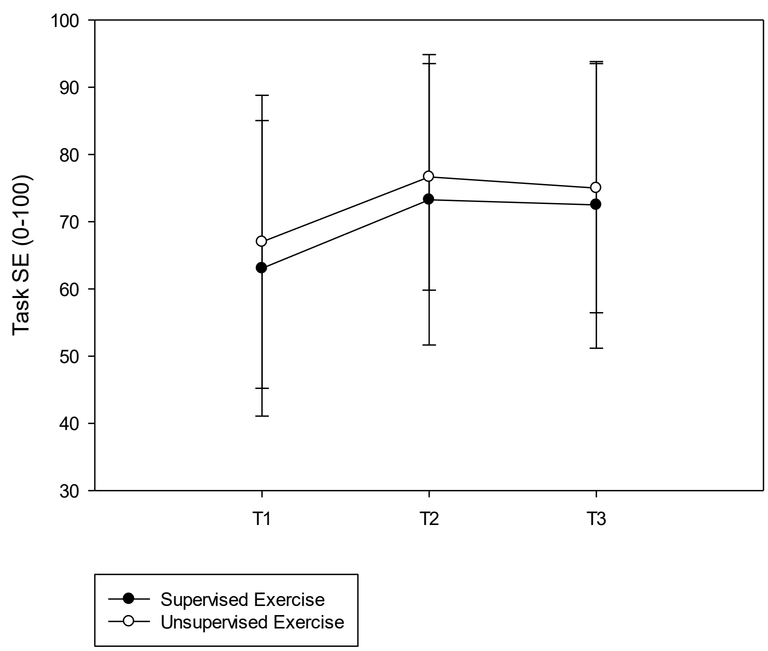


Figure 3.5 *Task Self-Efficacy*

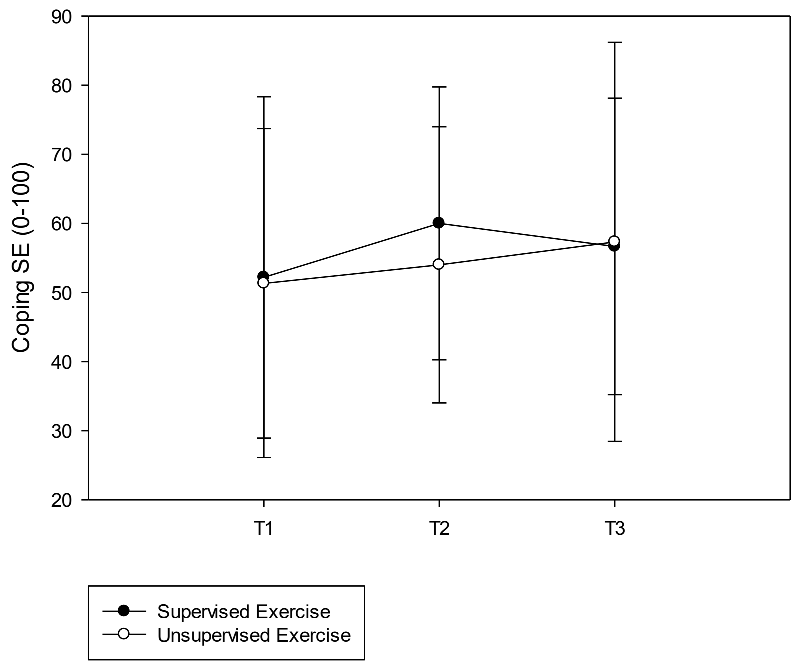


Figure 3.6 *Coping Self-Efficacy*

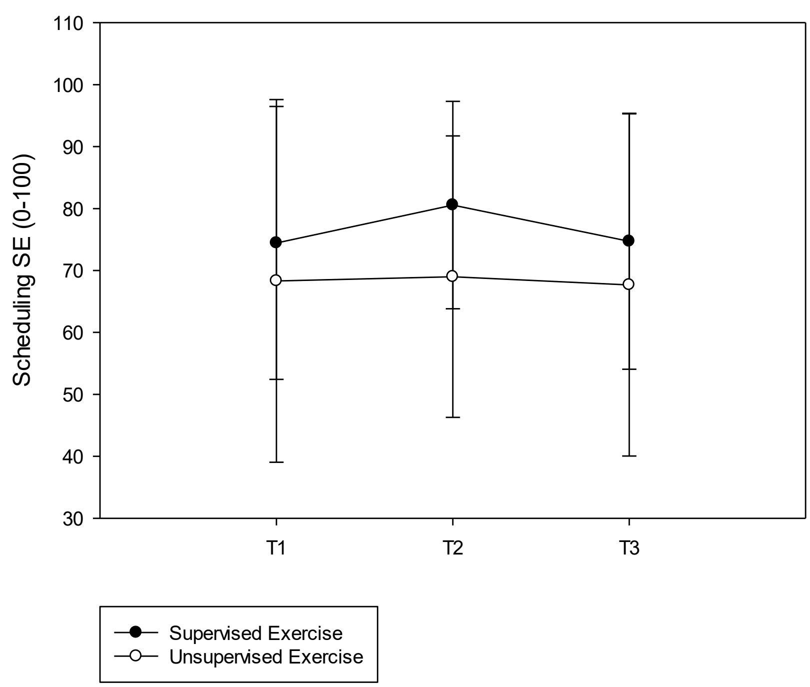


Figure 3.7 *Scheduling Self-Efficacy*

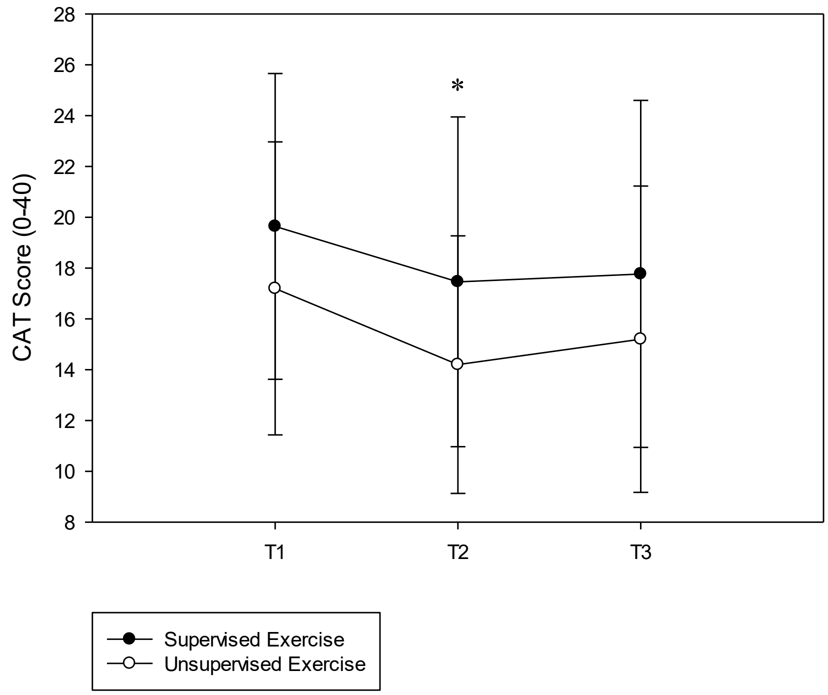


Figure 3.8 *Health Related Quality of Life – CAT.* * *p* < .0125 vs. T1 for both groups

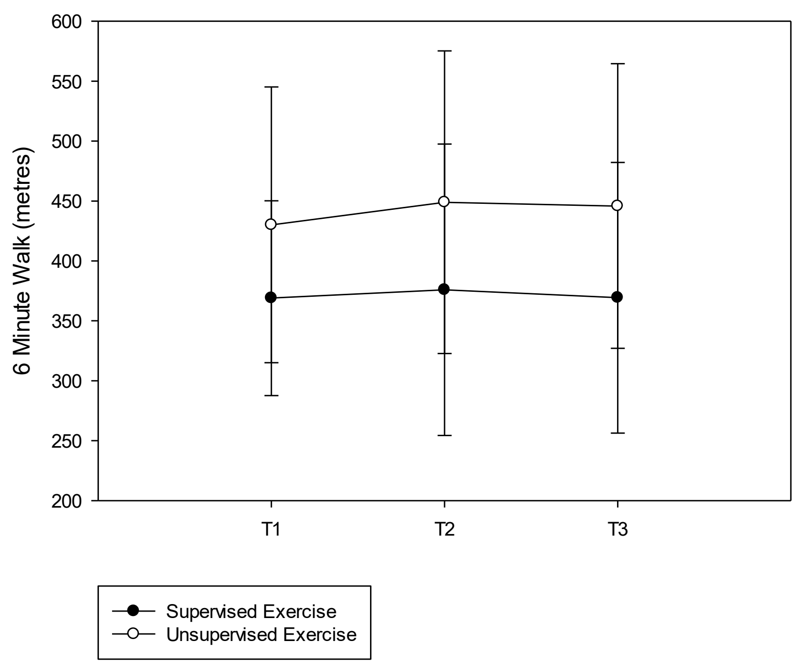


Figure 3.9 *Exercise Capacity – Six-minute walk test*

Chapter 4: General Discussion

This thesis adds to the literature that aerobic exercise minutes, self-efficacy for managing breathlessness, and HRQOL increase after both supervised exercise and unsupervised exercise programs in people who have COPD in a PCN setting. These outcomes are consistent with the literature supporting both supervised exercise programs, such as pulmonary rehabilitation (O'Donnell et al., 2008) and home-based exercise programs for people who have COPD (Liu et al., 2014; Maltais et al., 2008).

4.1 COPD Programming

The most common COPD program is pulmonary rehabilitation, which consistently shows improvements in dyspnea, quality of life and exercise capacity (O'Donnell et al., 2008). This study showed some weaknesses in the program that should be addressed for future programming. The first is the educational component of the COPD management service. The literature strongly supports self-management education as a component of COPD management (Criner et al., 2015; O'Donnell et al., 2008). In the current study, the amount of COPD management education provided was not collected. Collection of this data was difficult because the education component was not standardized into classroom learning sessions as it normally is in formal pulmonary rehabilitation programs. Education was provided on an individual, as needed basis by various health care providers, and the tracking of content was difficult to capture in a quantitative way (i.e. descriptions in chart notes). This study showed no change in self-efficacy for exercise. Self-management education typically improves self-efficacy, and the lack of formalized education in the two exercise programs may explain the lack of improvement in self-efficacy for exercise in the current study (Bourbeau et al., 2004).

The second weakness in the programming was the quantity and quality of aerobic exercise. The current study showed that the patients' quantity of aerobic exercise did not reach the recommendations of 150 minutes per week and the intensity was lower than the 4-6/10 RPE range recommended. This likely contributed to the lack of improvement in exercise capacity observed in this study. It is important to note, that the exercise environment and intake process in the PCN is quite different than pulmonary rehabilitation and this could impact the exercise specialist's prescription. For instance, the lack of supplemental oxygen, emergency crash carts and maximal cardiopulmonary exercise test prior to program may influence an exercise specialist to lower the intensity prescription for a patient in a community recreation facility. Exercise prescribed for unsupervised exercise may be influenced by the same factors. The performance of the exercise and the resulting self-efficacy might similarly be influenced by the low challenge and low perceived technical sophistication of the environment. This is consistent with social cognitive theory (Bandura, 1986) that stipulates that behaviour (intensity of the exercise performed) will be influenced by the environment (the exercise program directions and the supports available), as well as personal (self-efficacy), and behavioural aspects. If COPD patients were required to undergo a maximal cardiopulmonary exercise test prior to joining the exercise program this would likely decrease any apprehension the exercise specialist may have in how aggressive they are with the intensity of their program.

In addition to this, PCN exercise specialists are trained in techniques of motivational interviewing. Motivational interviewing includes a person-centred approach and autonomy supportive communication styles; there is evidence to support its use for contributing to long term physical activity behaviour change (Gro, Geir, Barth, Williams, & Meland, 2017) and increases in self-efficacy in other elderly populations (O'Halloran, Shields, Blackstock, Wintle, & Taylor, 2016). This approach often encourages patients to identify their own motivators and specific goals. Sometimes this means encouraging changes that may not be the exact quantity and quality (intensity) of the recommended guidelines. Interestingly the current study showed adherence to aerobic exercise in follow-up. It is possible that a person-centred approach may improve exercise adherence in this population, however, more research is needed on this topic. The quantity and quality of aerobic exercise performed by people with COPD could be impacted by the exercise environment, the intake process, and the training of exercise specialists. Future exercise programs should adopt a more standardized approach to pulmonary rehabilitation outlined by (Selzler et al., 2017) who recommend 12 essential education sessions and exercising at least three times per week at the recommended intensity for six to 10 weeks.

4.2 Exercise Options

Within the current study, COPD patients were not randomized into the two different exercise groups because the existing PCN program allowed patients to choose their exercise program. This study was a pragmatic evaluation of a clinical program with a purpose of using outcomes from the study to inform future programming decisions. Randomization is important in order to assess the relative effectiveness of a treatment and provides stronger internal validity than non-randomization. However, non-randomization provided a better understanding of the characteristics that potentially led people to choose their specific program and stronger generalizability than a randomized study. The present study indicated that people with COPD who continue to work chose differently than those who do not. The data also suggest that these working individuals may be younger and have less severe COPD than the non-working population, however, a larger sample size is needed to better understand these differences. These differences between exercise groups provide evidence that working COPD patients might be less likely to commit to supervised exercise and may not attend traditional pulmonary rehabilitation. It is important that exercise support is available to suit the needs of these patients and unsupervised exercise may be an effective option. It is important to consider alternative COPD management interventions, like unsupervised exercise provided by a PCN, as an early intervention for those with less severe COPD. This could have a potential impact on the healthcare system and on the future lives of these people with COPD.

4.3 Access and Referral

This study was unique in that it did not follow traditional sampling of COPD patients from pulmonary rehabilitation. Instead this study sampled COPD patients from a PCN and provided preliminary evidence that this sample may be different than those who access pulmonary rehabilitation, particularly in body mass index (BMI), sex, dyspnea and self-efficacy. Interestingly age was not different between the PCN and Breathe Easy sample and unfortunately employment status was not collected for the Breathe Easy sample. These differences are important because not only is access to pulmonary rehabilitation insufficient to meet the needs of the COPD population (Camp et al., 2015), but referral to pulmonary rehabilitation is low as well (Louis-Philippe Boulet, Bourbeau, Skomro, & Gupta, 2013). It has been reported that less than 10 percent of people with COPD are being referred to pulmonary rehabilitation (Louis-Philippe Boulet et al., 2013).

Low referral to pulmonary rehabilitation could result in a substantial portion of the COPD population not having access. This theory is supported in cardiovascular disease management where certain patient groups are less likely to access cardiac rehabilitation such as women, ethnocultural minority groups, and those with lower socioeconomic status (SES) (Grace, Turk-Adawi, Santiago, & Alter, 2016). If relevant in pulmonary disease management, simply increasing referral and availability of traditional pulmonary rehabilitation programs may not improve access for certain patient populations. For instance, people with low SES may not have the resources to access a pulmonary rehabilitation program in a hospital where there may be a cost for parking. Additionally, people who speak a language other than English as their first language may not access group education sessions and may prefer individualized support for self-management.

One of the objectives of PCNs is to provide services that match the needs of the specific community in which it exists (Alberta Government, 2018). This could include targeted services for communities with higher proportions of ethnocultural minority groups and lower SES. The integration of pulmonary rehabilitation services into community-based programs such as PCNs has the potential to improve access. It was reported that 19% of pulmonary rehabilitation programs reported barriers with the effectiveness of referral systems to pulmonary rehabilitation (Camp et al., 2015). It is possible that having multiple sites and program selections could increase confusion of the referring physician. As new pulmonary rehabilitation sites are developed, a central referral process could help decrease referral barriers to pulmonary rehabilitation. PCNs should be involved in this process as certain patient populations may be more likely to access a community-based program than traditional pulmonary rehabilitation.

4.3 Strengths/Contributions

A strength of this study was the use of a behaviour change theory to understand behavioural outcomes. This study used social cognitive theory which explains behaviour change as an outcome of personal, behavioural and environmental factors (Bandura, 1997). This theory was chosen because it recognizes the importance of the environment on behaviour change. When comparing two different programs that take place in different environments it is important that this is accounted for. A major component of social cognitive theory is self-efficacy (Bandura, 1997). Self-efficacy is related to COPD management behaviour modification (Bourbeau et al., 2004) and allows us to understand the components and potential interventions that may contribute to behaviour change. In addition to this, the use of multiple types of self-efficacy was a strength of this study. People with COPD are influenced not only by their symptoms of dyspnea during exercise but also the barriers that all other people experience, and it is important to measure both in order to describe the potential reasons for particular behaviours. This study contributed to the literature by showing inconsistencies in the improvement of different types of self-efficacy in patients with COPD.

The current study also had strong ecological validity by evaluating an exercise program in its natural state. This study contributes to the literature by providing information about a clinical exercise program, the types of people that access the program and how patients responded to this program. Having strong ecological validity allows for good generalizability of the results.

Another strength of this study was the use of objectively collected physical activity data through accelerometry which improves the reliability of the results. Finally, this study compared between a supervised and an unsupervised exercise programs and compared between a PCN sample and a traditional pulmonary rehabilitation program sample. This provides information regarding what type of patients choose certain programs as well as allowing us to see differences in outcome measures between different programs.

4.4 Limitations

A limitation of this study was the sample size. While we aimed to recruit 52 participants, we were only able to collect data from a total of 23 participants. The main limitation in recruitment was referral from family physicians to the PCN health care team. Across 10 months there were only 43 referrals for COPD management support. In addition to this, 20 patients declined support from an exercise specialist. Future studies may want to compare between those who participate in an exercise program and those who decline. An additional limitation of the current study is the lack of randomization. By having unequal samples and different types of patients in each group our findings need to be interpreted with caution. In addition to this, we relied on self-report measures of aerobic exercise and it is possible that participants inflated their recording of their activity in order to please their exercise specialist or researcher. Finally, methodological control was a limitation. The timing of providing the accelerometers may have inflated the baseline reading of physical activity due to physical activity counselling that could have taken place during the initial appointment.

4.5 Future Directions

The results of this study provide insight into future directions for both programming and evaluation of COPD management programs. As new community-based programs are developed for COPD management, they should follow standardized pulmonary rehabilitation recommendations (i.e., education and exercise prescriptions) to ensure their effectiveness. The inconsistent outcomes of this study when compared to pulmonary rehabilitation (i.e. exercise capacity) support this.

By offering pulmonary rehabilitation in PCNs it may also improve access to a greater range of COPD patients. As new sites offer pulmonary rehabilitation it is important that they offer a certain level of flexibility to meet the needs of all types of COPD patients. For example, unsupervised exercise prescriptions and evening education options may improve access for COPD patients who continue to work. Offering the exercise component within community facilities and within the home may allow patients to continue with their routine in the same environment that they started, and this may have an impact on adherence. In addition to this, a central referral process may improve ease of referrals to pulmonary rehabilitation by family physicians. PCNs should be involved in this to improve access and promote programming within the patients' community.

As new sites offer pulmonary rehabilitation it will be important that they are evaluated to ensure effectiveness and to guide future programming. This would include using outcomes of quality of life, exercise capacity and AECOPD hospitalizations when possible. More research is needed to identify effective strategies for increasing physical activity and improving exercise adherence in COPD patients. The use of behaviour change theory is important when looking at physical activity behaviour outcomes and should be included as well. These outcomes would require larger sample sizes and longer follow-up periods.

4.6 Conclusions

This study adds to the literature that exercise can improve outcomes for people with COPD. It also provides support for both supervised and unsupervised exercise program for increasing aerobic exercise, quality of life and self-efficacy for managing breathlessness. The current study did not result in improvements in physical activity, exercise capacity of self-efficacy for exercise after supervised and unsupervised exercise. There are methodological and programming differences that help to explain why we did not see improvements in these variables. Importantly these methodological limitations require us to interpret the results of this study with caution and provide support for future studies to look at similar outcomes.

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Appendix A

Please rate how your shortness of breath impacts your daily activities by circling the number (1-5) next to the description that describes you best.

MRC DYSPNOEA SCALE (for COPD patients)	
Grade	**Impact**
1	Not troubled by breathlessness except on vigorous exertion
2	Short of breath when hurrying or walking up inclines
3	Walks slower than contemporaries because of breathlessness, or has to stop for breath when walking at own pace
4	Stops for breath after walking about 100 m or stops after a few minutes' walking on the level
5	Too breathless to leave the house or breathless on dressing or undressing

Modified COPD Self-efficacy Scale

The following questions ask about your breathing.

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

When I go up stairs too fast

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 exercise or physically exert myself

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

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

Multidimensional Self-efficacy for Exercise Scale

Please indicate how confident you are that you can perform each of the exercise related tasks below by circling the appropriate percentage. Exercise refers to activities like walking, swimming, aerobics, riding a bike, golfing, yoga, and using weights.

How confident are you that you can complete your exercises correctly?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can follow directions to complete the exercises?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can perform all of the movements required for your exercises?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can do your exercises when they cause some discomfort?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can do your exercises when you lack energy?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can include your exercise sessions in your daily routine?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can complete the recommended number of sessions each week?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can do your exercises when you don't feel like it?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

How confident are you that you can arrange your schedule to include regular exercise sessions?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NONE MEDIUM COMPLETE

(CONFIDENCE LEVEL)

Exercise Diary

DAY	WEEK							
	1	2	3	4	5	6	7	8
MON	Aerobic Minutes Intensity /10							
TUE								
WED								
THU								
FRI								
SAT								
SUN								

Record your **minutes** of aerobic exercise you complete each day

Record the **type** of aerobic exercise

Example: W-10 mins is 10 minutes of walking or B-20mins is 20 minutes of biking

Record your **intensity** (/10) using the scale on the back