Implementation Evaluation of a Pilot RCT: The Roles of Peers and Functional Tasks in Enhancing Exercise Training for Adults with Chronic Obstructive Pulmonary Disease

Meaghan A. Osborne

Department of Kinesiology and Physical Education

Faculty of Education

McGill University, Montreal

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Table of Contents

List of Tables

List of Figures

Abstract

Many studies reporting on behaviour change interventions do not conduct implementation evaluations (delivery fidelity and participant engagement). We evaluated the implementation of a pilot randomized controlled trial on the role of peers and functional tasks in enhancing exercise training for adults with chronic obstructive pulmonary disease. Individuals randomized to the intervention (n=11) participated in a synchronous, home-based, exercise and peer support program, grounded in self-determination theory and led by a kinesiologist and behaviour change specialist. Individuals randomized to the control (n=11) participated in a phone-based exercise program led by two kinesiologists. For the intervention, delivery fidelity and participant engagement (primary objective) were assessed using reports from participants (metric 1), providers (metric 2), and independent evaluators (metric 3). For the control arm, delivery fidelity and participant engagement (secondary objective) were evaluated using participant and provider reports. Eight participants completed the intervention and 10 completed the control. Intervention participants perceived the kinesiologist (M=6.94/7) and behaviour change specialist (M=6.97/7) to be need-supportive. Adherence rates to the intervention protocol for the kinesiologist and behaviour change specialist were self-reported as 85% and 80%, respectively, and independently reported as 81% and 73%, respectively, which exceeded our *a priori* criterion of success (>50%). The kinesiologists' adherence rate to the control protocol (96%) also exceeded our *a priori* indicator of success (>90%), although session lengths were shorter than intended. For engagement, 7/8 intervention and 9/10 control participants met our *a priori* attendance rate criterion of 70%. Overall, the intervention was delivered as intended while the control was not.

Keywords: delivery fidelity, participant engagement, self-determination theory, leisure-time physical activity

Résumé

Plusieurs études portant sur les interventions visant à modifier le comportement n'effectuent pas des évaluations de la mise en œuvre (fidélité de la prestation et engagement des participants). Nous avons évalué la mise en œuvre d'un projet pilote d'essai contrôlé randomisé sur le rôle des pairs et des tâches fonctionnelles dans l'amélioration de l'entraînement à l'exercice pour les adultes avec la maladie pulmonaire obstructive chronique (MPOC). Les personnes randomisées dans l'intervention (n=11) ont participé à un programme synchrone, à domicile, d'exercice et de soutien par les pairs, fondé sur la théorie de l'autodétermination et dirigé par un kinésiologue et un spécialiste du changement de comportement. Les personnes randomisées dans le groupe témoin (n=11) ont participé à un programme d'exercices par téléphone dirigé par deux kinésiologues. Pour l'intervention, la fidélité de la prestation et l'engagement des participants (objectif principal) ont été évalués à partir des rapports des participants (mesure 1), des intervenants (mesure 2) et des évaluatrices indépendantes (mesure 3). Pour le groupe témoin, la fidélité de la prestation et l'engagement des participants (objectif secondaire) ont été évalués à partir des rapports des intervenants et des prestataires. Huit participants ont terminé l'intervention et 10 ont complété les activités du groupe témoin. Les participants à l'intervention ont perçu le kinésiologue (*M*=6,94/7) et le spécialiste du changement de comportement (*M*=6,97/7) comme répondant à leurs besoins. Les taux d'adhésion au protocole d'intervention pour le kinésiologue et le spécialiste du changement de comportement ont été auto-déclarés comme étant de 85% et 80%, respectivement, et indépendamment déclarés comme étant de 81% et 73%, respectivement, ce qui est plus grand que notre critère *a priori* de réussite (>50%). Le taux d'adhésion des kinésiologues au protocole de contrôle (96 %) a également dépassé notre indicateur *a priori* de réussite (>90 %), mais la durée des séances ait été plus courte que prévu. En ce qui concerne

l'engagement, 7/8 participants à l'intervention et 9/10 participants au contrôle ont satisfait à notre critère *a priori* de taux de présence de 70%. Dans l'ensemble, l'intervention a été réalisée comme prévu, mais le contrôle ne l'était pas.

Mots clés : fidélité de la prestation, engagement des participants, théorie de l'autodétermination, activité physique de loisir

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Contribution of Authors

M. Osborne is the primary author of all chapters and carried out the data collection, data analyses, and writing of the thesis.

Dr. S.N. Sweet, Associate Professor, Department of Kinesiology and Physical Education, McGill University, and the candidate's supervisor, was actively involved in every step and decision made regarding the research study and the completion of all chapters of the thesis.

L. Saletsky, Undergraduate Student, Department of Kinesiology and Physical Education, McGill University, was a contributing author for the manuscript and involved in the design of the research study.

E. Michalovic, Ph.D., Department of Kinesiology and Physical Education, McGill University, was a contributing author for the manuscript and involved in the design of the research study.

J. Herbison, Postdoctoral Fellow, Department of Kinesiology and Physical Education, McGill University, was a contributing author for the manuscript and involved in the design of the research study and data analysis.

M. A. Rocchi, Assistant Professor, Department of Communication, University of Ottawa, was a contributing author for the manuscript and involved in the design of the research study.

D. Jensen, Associate Professor, Department of Kinesiology and Physical Education, McGill University, was a contributing author for the manuscript and involved in the design of the research study.

Chapter 1: Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a common, progressive, and disabling respiratory condition. It is characterized by abnormalities in the airways of the lungs and includes emphysema and chronic bronchitis (Vogelmeier et al., 2017). COPD is the third leading cause of death and the seventh leading cause of disability worldwide (World Health Organization, 2020). Despite the many available pharmacological treatments, individuals living with COPD continue to experience physiological and psychological symptoms that impact their quality of life, daily activities, and well-being (Miravitlles & Ribera, 2017). Breathlessness, or dyspnea, is widely recognized as the most common and disabling symptom of COPD. The first symptom of COPD is often exertional dyspnea and over time, as the disease progresses, dyspnea becomes prevalent in all aspects of daily life (Disler et al., 2014; O'Donnell et al., 2016). To avoid breathlessness, individuals with COPD often reduce their physical activity levels which leads to deconditioning and further reductions in physical activity. This "vicious cycle of inactivity" affects one's participation in daily activities and health-related quality of life (Miravitlles & Ribera, 2017, p. 5; Troosters et al, 2013).

Michalovic et al. (2020) conducted a survey in the Montreal area with 200 adults with COPD and found that relieving breathlessness and increasing exercise ability were two of the top five healthcare and research priorities, irrespective of disease severity. They found that only 26% of the 200 individuals included in the study were satisfied with their level of participation in physical activity and movement-related activities. Furthermore, the majority of participants (54%) wished to increase their participation in leisure, community, and/or leisure social activities. Participation, i.e. "one's involvement in a life situation", and activity, i.e. "the execution of a task or action by an individual", are two important elements of health (World

Health Organization, 2001, p. 213). In fact, participation in activities of daily living has been associated with health-related quality of life among individuals with COPD (Kaptain et al., 2020). Given that many individuals with COPD are not satisfied with their activity levels, it is imperative that interventions to enhance participation in daily and social activities and, in turn, quality of life, be available and offered to this population (Marciniuk et al., 2010).

One non-pharmacological intervention that has been shown to enhance the quality of life of individuals living with COPD is exercise. In fact, exercise training has been shown to reduce dyspnea in daily life while also improving health-related quality of life, symptoms of anxiety and depression, and functional capacity (Emtner & Wadell, 2016). Moreover, exercise helps to break the vicious cycle of inactivity (Troosters et al., 2013). The American Thoracic Society and the European Respiratory Society recommend that individuals with COPD achieve 150 minutes of moderate-to-vigorous physical activity per week, which is in line with the Canadian physical activity guidelines for older adults (Garvey et al., 2016; Tremblay et al., 2011; Watz et al., 2014). Currently, only 17% of older adults meet the Canadian physical activity guidelines (Statistics Canada, 2017). Physical activity levels are significantly lower in individuals with COPD when compared to healthy controls, even for individuals in the early stages of COPD (Gouzi et al., 2011; Jagroop & Dogra, 2018; Vorrink et al., 2011). Therefore, interventions to promote physical activity among individuals with COPD are warranted.

Pulmonary rehabilitation (PR), which includes both an education and exercise component, has substantial support as an intervention strategy for promoting physical activity, relieving dyspnea, increasing functional capacity, and improving health-related quality of life (McCarthy et al., 2015). However, it is estimated that only 0.4% of Canadians living with COPD have access to PR (Camp et al., 2015). Moreover, it appears that individuals with COPD do not

maintain their physical activity levels after PR (Spruit et al., 2013; Mesquita et al., 2017; Holland et al. 2017). As such, there is a need to develop and test novel exercise interventions for individuals with COPD that are more accessible and that promote maintenance of physical activity.

Michalovic (2022) developed a telehealth exercise, peer support, and behavioural intervention to promote participation in daily and social activities for individuals with COPD. The exercise component, led by a certified kinesiologist, consists of functional task exercises that mimic the daily and social activities of individuals with COPD. The peer support component, led by a behaviour change specialist, engages participants in conversations about their physical activity experiences, goals, and daily challenges. In addition, participants are taught how to apply behaviour change techniques to promote physical activity participation in their daily life. The intervention is grounded in self-determination theory (SDT; Deci & Ryan, 2002) whereby both the kinesiologist and behaviour change specialist are asked to adhere to a number of intervention behaviours to foster a need-supportive environment. These intervention behaviours were selected based on prior research (Michalovic et al., 2022b) and a meta-analysis by Gillison et al. (2019) which outlines intervention components that have been used to target autonomy, competence, and relatedness (i.e. need) support.

Through a proof-of-concept study, Michalovic et al. (2022c) found support for the preliminary feasibility of the intervention. The overall adherence rate to the program was 98% and three out of the four participants achieved significant improvements on the Canadian Occupation Performance Measure (Law et al., 1990) which assesses individuals' perceived performance of daily and social activities. To further test the intervention, a pilot randomized controlled trial (RCT) was conducted to determine its feasibility and preliminary efficacy

(Saletsky et al., 2022). Intervention participants reported that the exercise and peer support components of the intervention were acceptable, appropriate, and feasible. Furthermore, intervention participants reported greater levels of physical activity, greater autonomous motivation, and more emotional and informational social support post-program when compared to control participants (Saletsky et al., 2022).

To confidently conclude that study outcomes are a direct result of the intervention, it is important to assess whether the intervention was delivered as intended (i.e. treatment integrity) and whether participants were engaged with the intervention (i.e. participant engagement). It is also necessary to evaluate the implementation of the control arm and whether the intervention and control arms differed from one another in the intended ways (i.e. treatment differentiation). An "implementation evaluation" involves assessing delivery fidelity and/or participant engagement. In addition to improving confidence in study findings, implementation evaluations can facilitate theory testing and help to identify or confirm mechanisms of action (Borrelli, 2011). Despite the importance of implementation evaluations, the majority of studies reporting on behaviour change interventions do not conduct these evaluations (Walton et al., 2017) and there has been a call in the literature for more implementation evaluations of physical activity interventions grounded in SDT (Fortier et al., 2012; Rocchi et al., 2021).

1.1 Purpose of the Study

The purpose of this study was to evaluate the implementation of a pilot RCT on the role of peers and functional tasks in enhancing exercise training for adults living with COPD. The primary objective was to determine whether the intervention was delivered as intended and whether participants were engaged with the intervention. The secondary objective was to determine whether the active control was delivered as intended, whether participants were

engaged with the control program, and whether the control arm differed from the intervention arm in the intended ways.

Chapter 2: Literature Review

2.1 COPD Definition, Pathophysiology, Diagnosis, and Treatment

According to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) "COPD is a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases" (Vogelmeier et al., 2017, p. 7). While cigarette smoking is the primary risk factor for COPD, other risk factors include other forms of tobacco (e.g. cigar, pipe), marijuana, environmental tobacco smoke, and indoor and outdoor air pollution (Vogelmeier et al., 2017). Under-appreciated risk factors include occupational exposure to gases, dust, and fumes (Mannino & Buist, 2007). The airflow limitation is caused by chronic inflammation which leads to the narrowing of the conducting airways, destruction of the lung parenchyma (i.e. the area of the lungs where gas exchange occurs), and a loss of lung elasticity (Barnes, 2000). This airflow limitation manifests as an expiratory flow limitation whereby an individual with COPD cannot expire air as quickly as a healthy individual. Diagnosis of COPD is based on a post-bronchodilator spirometry test. Individuals are asked to exhale forcibly from their point of maximum inspiration and the volume of air expired in the first second of the exhalation (forced expiratory volume in one second; FEV_1) is divided by the total volume of air expired (forced vital capacity; FVC). Individuals with a post-bronchodilator FEV_1/FVC ratio less than 0.70 are diagnosed with COPD (Vogelmeier et al., 2017).

The GOLD has also set criteria for classifying COPD severity based on the degree of airflow limitation (Vogelmeier et al., 2017). The post-bronchodilator FEV_1 score is compared to the age-, sex-, and height-predicted FEV_1 (Coates et al., 2016). Individuals with an FEV_1 score greater than or equal to 80% of the predicted value are classified as GOLD Stage 1 (mild).

Individuals with an FEV_1 score 50-79% predicted, 30-49% predicted, and < 30% predicted are classified as GOLD Stage 2 (moderate), GOLD Stage 3 (severe), and GOLD Stage 4 (very severe), respectively (Vogelmeier et al., 2017). While the GOLD stages are the most common method for classifying the severity of COPD, the extent of airflow limitation is only weakly correlated with the symptom burden of COPD (Han et al., 2013). Therefore, it is recommended that patients also undergo a symptomatic assessment (Singh et al., 2019).

The modified Medical Research Council Questionnaire (mMRC; Fletcher, 1960) is used to assess an individual's perceived dyspnea. Individuals are asked to indicate which of the following four items best describes their breathlessness: 1 - *I only get short of breath when hurrying on level ground or walking up a slight hill;* 2 - *I walk slower than people the same age on the level surface because of breathlessness, or I have to stop for breath when walking at my own pace*; 3 - *I stop to catch my breath after walking about 100 meters or after a few minutes on level ground*; or 4 - *I am too breathless to leave the house or I am breathless when dressing*. Given that dyspnea is not the only symptom experienced by individuals with COPD, it is also recommended that the COPD Assessment Test (CAT; Jones et al., 2009) be used to assess an individual's overall disease burden. Individuals are asked to respond to eight items related to their symptoms on a semantic differential six-point scale (e.g., my chest does not feel tight at all – my chest feels very tight). Results from the mMRC, CAT, and an individual's exacerbation history are used to classify individuals into one of four groups, A through D, whereby A represents the most mild symptom-burden and lowest risk of exacerbation and D represents the most severe symptom burden and the greatest risk of exacerbation (Singh et al., 2019). Post-bronchodilator spirometry data, patient symptom burden, and exacerbation history are all used to inform the individualized treatment plan (Singh et al., 2019).

According to the Canadian Thoracic Society, proper management of COPD involves both pharmacological and non-pharmacological treatments (O'Donnell et al., 2008). Pharmacotherapy mainly involves the prescription of bronchodilators which work by decreasing smooth muscle tone in the airways thereby decreasing hyperinflation and increasing expiratory flow rates (O'Donnell et al., 2008). The majority of individuals with COPD are prescribed a short-acting bronchodilator for acute breathlessness. For individuals who are more symptomatic, a long-acting bronchodilator is prescribed for daily use. Short- and long-acting beta agonists and muscarinic antagonists promote improvements in dyspnea, physical activity performance, and pulmonary function (Bourbeau et al., 2019). For more severe forms of COPD, corticosteroids and oxygen may also be prescribed (Bourbeau et al., 2019). Non-pharmacological interventions include smoking cessation and physical activity. Smoking cessation can decrease the rate of lung function decline and the symptomatic burden of COPD (O'Donnell et al., 2008). In addition, individuals, regardless of disease severity, are encouraged to exercise and maintain an active lifestyle. The Canadian Thoracic Society recommends that individuals who remain symptomatic despite optimal pharmacological treatment be referred to pulmonary rehabilitation (PR; Marciniuk et al., 2010). Therefore, it is usually only individuals with moderate to severe COPD who are referred to PR.

2.2 The Burden of COPD on Participation in Daily and Social Activities

In their review, Miravitlles and Ribera (2017) describe the impact of COPD symptoms on the burden of the disease in terms of quality of life, health status, daily activities, physical activity, sleep, anxiety, and depression. Symptoms including breathlessness, cough, sputum production, and chest tightness have been shown to affect levels of physical activity among individuals with COPD (Miravitlles et al., 2014). Furthermore, individuals with COPD have also

repeatedly reported that COPD symptoms compromise their ability to perform daily activities including going up and down stairs, performing household chores, participating in sport and hobbies, and performing their morning routine (including getting out of bed, washing, and dressing; Miravitlles & Ribera, 2017). Michalovic et al. (2020) conducted a survey in the Montreal area to understand the participation in daily and social activities among adults with COPD. They found that only 26% of the 200 individuals included in the study were satisfied with their level of participation in physical activity and movement-related activities (e.g. walking up a hill, participating in regular exercise, climbing up two or more flights of stairs). In addition, the majority of participants (54%) wished to increase their participation in leisure, community, and/or leisure social activities. When asked about the facilitators and barriers to participation in daily and social activities, incorporating activities of daily and social living into one's routine was found to be the most common facilitator and breathlessness and fatigue were reported as the most common barriers. In fact, participants indicated that relieving breathlessness and increasing their ability to exercise were two of their top five research priorities (Michalovic et al., 2020).

2.3 Physical Activity and Exercise Interventions for Individuals with COPD

Physical activity is defined as any movement produced by the skeletal muscle whereas exercise is physical activity that is planned, structured, and repetitive (Caspersen et al., 1985). Exercise interventions are an effective strategy for relieving breathlessness and increasing individuals' exercise capacity. In a narrative review, which included data from six systematic reviews, Emtner and Wadell (2016) found moderately strong evidence (grade +++) for exercise as an effective intervention for decreasing dyspnea, anxiety and depression, and improving health-related quality of life among individuals with COPD. They also found limited evidence (grade ++) that exercise can improve physical capacity. Emtner and Wadell (2016) conclude that

the benefits of exercise are independent of age, gender, level of dyspnea, and disease severity and should be prescribed to all individuals with COPD. In Canada, the prescription of exercise for individuals with moderate to severe COPD is usually in the form of PR. In 2015, Camp et al. identified 155 PR programs in Canada, of which 129 responded to a survey. In terms of setting, Camp et al. (2015) found that 64% of the programs were hospital-based, 24% were located in health units, 8% were delivered in recreational centres, and 4% were home-based/telehealth programs. In terms of content, they found that most programs included patient assessment, education, psychosocial support, and exercise training. Bourbeau et al. (2020) published an article outlining recommendations for the exercise component of PR using the "FIIT" principle (frequency, intensity, time, and type). Bourbeau et al. (2020) recommend that aerobic exercise be prescribed three to five times per week, for 20-60 minutes per session, targeting a Borg rating of 4 to 6 (out of 10) using one of the following modalities: cycle ergometer, treadmill, ground walking, stair climbing, upper extremity ergometer. In terms of strength training, Bourbeau et al. (2020) recommend one to four sets of eight to twelve repetitions, two to three times per week at an intensity of 60-70% of the 1-repetition maximum using bodyweight, free weights, machines, or resistance bands.

There is substantial support for the inclusion of PR in the treatment of COPD. McCarthy et al. (2015) conducted a meta-analysis that included 65 randomized controlled trials (RCTs) comparing PR versus usual care. They found moderately strong support (grade +++) for PR as an effective intervention to improve quality of life, breathlessness, and maximal exercise capacity (via incremental shuttle walk test). In addition to the benefits for individuals with COPD, PR programs have also been shown to reduce healthcare costs (Camp et al., 2015). Despite the many benefits of PR, it is estimated that only 0.4% of Canadians with COPD have access to PR (Camp

et al., 2015). To remedy this issue, many researchers and practitioners have explored home-based or tele-PR as an alternative to hospital-based PR. Wuytack et al. (2018) conducted a systematic review and meta-analysis to compare outpatient (hospital-based) and home-based exercise training programs for individuals with COPD. Across ten trials, they found that outpatient and home-based PR were equally effective at improving aspects of health-related quality of life (including dyspnea, fatigue, and emotional function) and exercise capacity. The Canadian Thoracic Society recently released a position statement regarding pulmonary rehabilitation during the COVID-19 pandemic supporting the use of home-based PR (Dechman et al., 2020). While home-based PR addresses the issue of accessibility, a limitation of both outpatient and home-based PR is that individuals with COPD do not maintain their physical activity levels post-program and most patients return to baseline levels after six to 12 months (Mador et al., 2011; McCarthy et al., 2015; Holland et al., 2017). Therefore, there is a need to develop and test home-based exercise programs for adults with COPD that promote the maintenance of physical activity.

Meis et al. (2014) conducted a qualitative study to explore participants' experiences during PR and their feelings towards transferring their physical activity to their home environment post-program. They reported that it is difficult to transfer their "new habits into their usual daily routine" (Meis et al., 2014, p. 508). Incorporating functional task exercises, i.e. exercises that mimic activities of daily living, may help individuals maintain exercise post-program given that these exercises can be more easily incorporated into one's daily routine. As an example, participants who are taught how to perform a farmer's walk with grocery bags during an exercise program may choose to carry their groceries home instead of having them delivered. De Vreede et al. (2005) conducted a study whereby 98 women (>70 years of age) were

randomly assigned to a functional task exercise program, a resistance exercise program, or a control group. They found that only those in the functional task exercise program maintained their functional performance six months post-program. The Lifestyle integrated Functional Exercise (LiFE) study provides further support for incorporating functional tasks into exercise programs. Clemson et al. (2012) found functional capacity and frequency of participation in life tasks (personal, social, and community tasks) to be significantly greater in the LiFE group (n=107) when compared to the structured exercise (n=105) and gentle exercise (n=105) groups at 12 months follow-up. These findings provide support for including functional task exercises in an exercise program for individuals with COPD to promote participation in daily and social activities and maintenance of physical activity.

Robinson et al. (2018) conducted a systematic review of qualitative research exploring the barriers and facilitators of physical activity participation following PR. Three overarching themes were identified: beliefs, social support, and environment. Within the social support theme, two sub-themes were identified: relationship with health care professionals and peer interactions. Robinson et al. (2018) explain that participants' relationships with the health care professionals were important in helping individuals to feel safe and motivated to perform physical activity. As a result, lack of sustained professional support after PR was found to be a barrier to physical activity post-program. Interaction with peers was a facilitator to physical activity maintenance as peers made physical activity more enjoyable and helped reduce feelings of loneliness. Furthermore, peer interactions enabled individuals with COPD to discuss their symptoms with others in similar situations reducing fears surrounding their physical activity participation.

Peer support within the context of COPD can be defined as "support received from and/or provided to another individual with COPD in the form of informational, emotional, and/or physical support; with the goal of sharing knowledge relevant to living with COPD and/or supporting a specific behaviour for people with COPD" (Michalovic et al., 2022a). Despite the benefits of peer support, few studies have explored how peers can be integrated into physical activity programs for individuals with COPD (Michalovic et al., 2022a). Michalovic et al. (2022b) conducted focus groups to understand the physical activity program needs of individuals living with COPD. Participants discussed how peers can act as a source of information, social interaction, and motivation within physical activity interventions. They also clearly expressed that exercising with other individuals with COPD was more important than exercising with age-matched individuals. Therefore, incorporating peer support within an exercise program may be a beneficial way to foster both social interaction and physical activity maintenance among individuals with COPD.

2.4 The Roles of Peers and Functional Tasks in Enhancing Exercise Training for Adults with COPD

Michalovic et al. (2022c) developed a telehealth exercise, peer support, and behavioural intervention to promote participation in daily and social activities for individuals with COPD. In a proof-of-concept study, four participants attended two, one-hour sessions per week via Microsoft Teams. The exercise component (approximately 30 minutes) was led by a certified kinesiologist and consisted of functional task exercises that mimic the activities of daily and social living of individuals with COPD. The peer support component (approximately 30 minutes) was led by a behaviour change specialist who engaged participants in conversations about their physical activity experiences, goals, and daily challenges. In addition, participants were taught

how to apply behaviour change techniques (BCTs) to promote physical activity participation in their daily life. Three *a priori* indicators of feasibility were used: adherence, engagement, and activity participation. The *a priori* indicator of adherence (all participants attending 70% of sessions) was achieved with an overall rate of 98%. Furthermore, each participant initiated an average of 3.25 unique conversations per session which was much greater than the *a priori* indicator of engagement (one unique conversation initiated per participant in 70% of the sessions). Third, three out of the four participants achieved significant improvements on the Canadian Occupation Performance Measure which assesses individuals' perceived performance in daily and social activities. Finally, participants reported high mean scores of intervention acceptability (*M*=5/5), appropriateness (*M*= 5/5), and feasibility (*M*=4.9/5). The success of the proof-of-concept study supports testing the intervention in a pilot, feasibility RCT to determine whether the incorporation of functional task exercises and peer support can improve performance in daily and social activities above and beyond a standard home-based PR exercise program.

Guiding Theoretical Framework

Grounding physical activity interventions in behaviour change theory has been strongly recommended in the literature (Davis et al., 2015). First, the determinants of behaviour change as outlined by theory can be targeted in an intervention to increase the effectiveness of the intervention (Michie et al., 2008). Second, theoretical mechanisms of action can be tested to gain an understanding of how the intervention was able to bring about positive change (Davis et al., 2015). As an example, in the case of an unsuccessful intervention, knowing that the intervention had no effect on the proposed mediators or that the mediators had no effect on the outcomes could help inform the refinement of the intervention. Third, grounding interventions in theory can support the testing and refinement of behaviour change theories (Rothman, 2004). Finally,

applying a theoretical framework can help researchers select appropriate BCTs for their intervention (Michie et al., 2008). Michalovic et al.'s (2022c) telehealth exercise, peer support, and behavioural intervention is grounded in self-determination theory (SDT; Deci & Ryan, 2002), a theory that is widely supported in the behaviour change literature.

Self-Determination Theory. SDT is a meta-theory for understanding human motivation and behaviour that consists of six-mini theories: organismic integration theory, cognitive evaluation theory, causality orientation theory, basic psychological needs theory, goal contents theory, and relationships motivation theory (Ryan & Deci, 2017). According to organismic integration theory, individuals are motivated along a continuum of self-determination (Ryan & Deci, 2017). The most self-determined form of motivation is intrinsic motivation which occurs when one participates in a behaviour for inherent pleasure and satisfaction. On the other hand, extrinsic motivation occurs when one participates in a behaviour for instrumental reasons, i.e. reasons extrinsic to the behaviour itself. There are many sub-types of extrinsic motivation which can be divided into controlled and autonomous types. Controlled motivation includes external regulation where one is motivated to satisfy external demands and introjected regulation where one is focused on shame, guilt, and/or pride. Autonomous motivation includes identified regulation where one sees the value of a behaviour for oneself and integrated regulation where one integrates the behaviour into their self-identity. Finally, amotivation is defined as having no desire to engage in a behaviour. Individuals who are more self-determined (or autonomously motivated) to engage in a behaviour are more likely to sustain that behaviour over time (Deci & Ryan, 2017). Individuals can move along the continuum of motivation and movement from controlled to more self-determined forms of motivation can be facilitated or hindered based on social and environmental factors (Ryan & Deci, 2017).

Cognitive evaluation theory is concerned with how an individual's intrinsic motivation to engage with a behaviour can be facilitated or hindered by either satisfying or frustrating three "basic psychological needs": autonomy, competence, and relatedness. *Autonomy* is defined as an individual's desire for volition and choice when engaging in a behaviour. *Competence* is defined as an individual's need to feel capable of performing and/or mastering a behaviour or action. Finally, *relatedness* is defined as an individual's inherent need to feel a sense of belonging, connection, and significance when interacting with others (Ryan & Deci, 2017). When an individual's autonomy, competence, and relatedness are supported by the individual's environmental and/or social context, intrinsic motivation is enhanced, supporting the performance of the behaviour. In the context of physical activity interventions, providers of the intervention can either support or undermine participants' need satisfaction and in turn self-determination (Ryan & Deci, 2017).

Research on SDT in the Behaviour Change Literature. Ng et al. (2012) conducted a meta-analysis of 184 data sets that used SDT-based measures to explore the relationships between autonomy support, psychological need satisfaction, autonomous motivation, and mental and physical health. Autonomy support significantly predicted the satisfaction of all three basic psychological needs. Ng et al. (2012) also found positive associations between need satisfaction and autonomous forms of motivation. Overall, an autonomy-supportive climate was associated with the satisfaction of the three psychological needs, need satisfaction was associated with autonomous motivation, and autonomous motivation was associated with improved physical and mental health. While Ng et al. (2012) found support for cognitive evaluation theory, many of the studies included were cross-sectional and therefore directionality and causality cannot be inferred.

Ntoumanis et al. (2021) conducted a meta-analysis to determine the effects of SDT-based interventions on need support, motivation, health behaviour, physical health, and psychological health. Seventy-three studies were included in the analysis of which 58 used an RCT design. They found that overall, interventions grounded in SDT were able to enhance autonomy, competence, and combined need satisfaction in addition to autonomous motivation. No intervention effect was found for relatedness support. Furthermore, after the removal of a multivariate outlier study, they found that changes in need support and autonomous motivation at the end of the SDT-based interventions predicted participant health behaviours at follow-up. Therefore, the meta-analysis by Ntoumanis et al. (2021) provides support for (1) the ability of interventions grounded in SDT to enhance need support and autonomous motivation and (2) the role of need support and autonomous motivation in promoting health behaviour change.

Gillison et al. (2019) extended the SDT literature by identifying and synthesizing all SDT-based intervention components and techniques used in behavioural interventions. From the 74 studies included in the meta-analysis, 70 SDT-based intervention components were identified. These 70 intervention components were organized into 18 SDT-based intervention strategies and each SDT strategy is linked with either autonomy, competence, or relatedness need support. Their classification system provides a guiding framework for researchers designing behaviour change interventions grounded in SDT. Gillison et al. (2019) also demonstrated that SDT-based intervention components and techniques have large positive effects on autonomy satisfaction, moderate positive effects on competence satisfaction, and small positive effects on relatedness satisfaction and autonomous motivation. However, Gillison et al. (2019) found individual intervention components to have limited effects on need satisfaction and motivation which suggests the need for researchers to use multiple SDT-based intervention components to create a

need supportive environment and enhance autonomous motivation. Michalovic et al. (2022c) created an intervention protocol to ensure the kinesiologist and behaviour change specialist foster a need-supportive environment throughout the intervention. The protocol contains 10 intervention behaviours to be used by the kinesiologist and 15 intervention behaviours to be used by the behaviour change specialist. Each intervention behaviour targets either autonomy, competence, or relatedness support. These intervention behaviours were informed by prior research (Michalovic et al., 2022b) and the meta-analysis by Gillison et al. (2019).

Research on SDT in the Physical Activity Literature. SDT has been extensively used to understand and enhance motivation towards physical activity in exercise interventions. Teixeira et al. (2012) conducted a systematic review to examine the relationship between SDT constructs and exercise and physical activity outcomes. They examined interventions grounded in SDT that targeted healthy adults, adults with chronic disease, overweight adults, and regular exercisers. They found that autonomous forms of motivation predicted exercise participation and this finding was significant across the range of populations. This review supported the idea that enhancing autonomous motivation can promote exercise.

Fortier et al. (2012) conducted a review of three RCTs grounded in SDT. In all three interventions, providers were trained to create a need-supportive environment through the use of SDT intervention components (Fortier et al., 2007a; Fortier et al., 2007b; Jolly et al., 2009; Silva et al., 2008). All three RCTs provide support for the "SDT motivational process model" whereby physical activity interventions grounded in SDT can enhance need satisfaction and foster autonomous motivation leading to behaviour change (Fortier et al., 2012, p. 3). While all three studies included some form of implementation evaluation to support the validity of their studies, Fortier et al. (2012) suggested that future SDT-based interventions include systematic

implementation evaluations in addition to outcome assessment. Moreover, they suggested that the delivery fidelity of the control group be assessed in addition to the delivery fidelity of the intervention group.

2.5 Implementation Evaluation Practices

Implementation evaluation is a multi-disciplinary term used to describe the process of assessing how well an intervention or program has been translated from the drawing board into action (Newcomer et al., 2015). Implementation evaluations often include an assessment of treatment fidelity which is a concept that has developed over time. Treatment fidelity was formally defined in 1991 by Moncher and Prinz (p. 247-248) as two interrelated concepts: treatment integrity (i.e. "the degree to which a treatment condition is implemented as intended") and treatment differentiation (i.e. "whether treatment conditions differ from one another in the intended manner"). Later in 1994, Lichstein et al. proposed that two additional concepts need to be assessed to effectively evaluate the implementation of an intervention: treatment receipt (i.e. whether participants understand and demonstrate knowledge of treatment skills/components) and treatment enactment (i.e. whether participants apply the intervention skills/components in their daily life). In other words, their "treatment implementation model" involved both assessing and optimizing treatment fidelity, receipt, and enactment (Lichstein et al., 1994).

In 1999, the Behaviour Change Consortium was established to enable collaboration among 15 National Institute of Health-funded behaviour change studies. The main goal of these studies was to test behaviour change theories across diverse health behaviours. Due to the difficulty in implementing novel interventions across a diverse set of populations and behaviours, a Treatment Fidelity Workgroup was formed to refine the definition and assessment of treatment fidelity (Nigg et al., 2002). Bellg et al. (2004) describe the treatment fidelity

recommendations of the Behaviour Change Consortium workgroup and provide strategies for monitoring and enhancing treatment fidelity in five areas: study design, training providers, delivery of treatment, receipt of treatment, and enactment of treatment skills.

Borrelli et al. (2005) and Borrelli (2011) expanded on the work of Bellg et al. (2004) by outlining assessment tools that can be used for implementation evaluations. In general, treatment fidelity can be assessed using three metrics: participant reports, provider reports, and/or objective reports (Borrelli, 2011). Participant self-report questionnaires can be administered to determine whether participants perceived the delivery of treatment components and whether they were satisfied with the delivery. A limitation of participant self-report questionnaires is the potential inaccuracy due to memory bias and response bias (e.g., participants only giving positive ratings of providers). Provider self-report checklists can also be used to assess treatment fidelity. A strength of using provider checklists is that it enables providers to self-monitor their delivery fidelity over time, reminding them of the intervention components. Again, a limitation is response bias given that a provider may rate their adherence more favourably than an independent evaluator. The gold standard technique according to Borrelli (2011) is evaluation by an independent observer via audio or videotapes of the intervention as it enables objective evaluation of the behaviours of both the provider and participants. A limitation of objective evaluations is that they can be costly and time-consuming. Borrelli (2011) advocates for participant and provider self-report as supplements to objective data by an independent evaluator.

While the Behaviour Change Consortium and Borrelli (2011) group delivery fidelity (integrity and differentiation), receipt, and enactment under the umbrella term “treatment fidelity”, more recently, Walton et al. (2017) made a distinction between the elements that assess

the providers versus the participants. While treatment integrity and treatment differentiation focus on the provider, treatment receipt and treatment enactment focus on the participant. As such, Walton et al. (2017, p. 873) described *participant engagement* as "whether participants understand the intervention, whether they can perform the skills required by the intervention (intervention receipt), and whether they use these skills in daily life (intervention enactment)". Thus, for this thesis, the term *delivery fidelity* will be used to refer to treatment integrity and treatment differentiation and the term *participant engagement* will be used to describe intervention receipt and enactment.

For the assessment of delivery fidelity, Borrelli (2011) advocates for evaluating both treatment integrity and treatment differentiation. Treatment integrity can be evaluated by assessing adherence to treatment components (including non-specific components such as expressing empathy). Evaluating adherence to the treatment components requires (1) operationalization of the treatment components and (2) mapping the components onto behaviour change theory. Once the intervention protocol has been developed, adherence can be assessed using participant reports, provider reports, and/or objective reports. Methods of evaluating treatment differentiation include developing manuals for each treatment arm and assessing adherence to each manual, monitoring provider expectations, and asking independent groups to review the audio or videotapes and predict the treatment arm (Borrelli, 2011).

Rixon et al. (2016) systematically reviewed the literature for methods used to assess intervention receipt in health intervention studies. Across 55 studies, 60.6% assessed receipt as understanding and 42.4% assessed receipt in relation to performance of skills taught in the intervention. Other operationalizations of receipt included receipt/completion of intervention components (16.4%), satisfaction with the intervention (14.5%), engagement (i.e. level of

participation, involvement, enjoyment, or communication; 14.5%), attendance (14.5%), acceptability (10.9%), use of intervention materials (7.3%), and behaviour change/maintenance (7.2%).

Among the 55 studies included in the review by Rixon et al. (2016), five targeted physical activity participation (Michie et al., 2008; Pretzer-Aboff et al., 2011; Resnick et al., 2005; Resnick et al., 2011; Robbins et al., 2012). Michie et al. (2008, p. 35) assessed receipt as the "frequency of relevant utterances" regarding behaviour change or maintenance of physical activity. Pretzer-Aboff et al. (2011) assessed receipt by asking participants to demonstrate the exercises and techniques taught in the intervention to ensure understanding. Resnick et al. (2005) provided a case example on how to use the Behaviour Change Consortium's comprehensive model of treatment fidelity. They evaluated the receipt of their Exercise Plus program using a checklist where an observer is asked to respond, yes or no, to six items (e.g. demonstrates ability to perform exercises; demonstrates ability to establish goals and review goals). In another study by Resnick et al. (2011, p. 619), receipt was evaluated using both attendance logs and a 2-item checklist ("Participant verbalizes understanding of training intervention" and "Participant appropriately performs training intervention as intended"). Robbins et al. (2012, p. 74) used a similar approach to Resnick et al. (2011) by asking an independent evaluator to review audiotapes of motivational interviewing sessions and respond to an 11-item checklist, two items of which were related to receipt and engagement ("Did the participant have any difficulty understanding any part of the counselling session?" and "Was the participant actively involved in the session?"). While it appears that checklists are the most common method of assessing receipt in the physical activity literature (Rixon et al., 2016), few studies report on the validity of these measures (Walton et al., 2017). In the context of Michalovic et al.'s (2022c) behavioural

intervention, it is unclear whether independent evaluators could accurately assess participants' understanding of the functional task exercises and BCTs via observation alone. Thus, there is a need to develop and test alternative measures of receipt.

Walton et al. (2017) conducted a systematic review of measures of delivery fidelity and participant engagement (receipt and enactment) within behaviour change interventions. Of the sixty-six studies included in the review, 13 studies targeted exercise/physical activity behaviour and another 10 targeted multiple health behaviours, including exercise/physical activity. Within this subset of 23 studies, the two most common measures of engagement were attendance at intervention sessions (5 studies) and adherence to prescribed physical activity (via exercise logs; 5 studies). Thus, it can be inferred that adherence to prescribed physical activity is the most common method of assessing enactment. However, according to Resnick et al. (2005, p. 143) enactment is the most challenging element to assess given that "it is often confused with study outcomes". They propose that when assessing enactment, researchers should focus on "the skills required to achieve study outcomes". In the case of Michalovic et al.'s (2022c) behavioural intervention, these skills would be the BCTs.

Similar to Resnick et al. (2005), Hankonen (2021, p. 186) posits that enactment must be conceptualized as the "usage of active ingredients" of an intervention that promote behaviour change. BCTs are common active ingredients within behaviour change interventions and in their seminal commentary, Hankonen (2021) advocates for the measurement of BCT enactment. BCT enactment is defined as "the performance of behavioral and cognitive tasks directed at facilitating behavior change" (p.185). Hankonen (2021) argues that the assessment of BCT enactment, in addition to delivery fidelity and receipt, is critical to both intervention evaluation and to the advancement of our understanding of behaviour change processes. Hankonen et al.

(2017) describe a measurement tool to assess BCT enactment. The item stem used is "During the last 2 weeks, have you done the following?" and is followed by a list of the BCTs taught during the intervention. Response options then differ depending on whether BCT enactment requires a one-time use or frequent use. For BCTs that require one-time use, individuals respond on a 5-point scale: 1(not at all true) – 5 (true). For BCTs that require frequent use, individuals use a different 5-point scale (1 = not once, 2 = about once in 2 weeks, 3 = about 1–2 times per week, 4 = about every second day, 5 = daily). Hankonen et al.'s (2017) BCT enactment questionnaire (2017) appears to be a feasible and applicable tool to assess enactment in our study.

Importance of Implementation Evaluations

Implementation evaluations are a critical component of behaviour change interventions for a number of reasons. First, implementation evaluations can help researchers confidently conclude that significant changes or outcomes are a direct result of the intervention components. In fact, by forgoing an implementation evaluation, there is an increased risk of Type I error (Borrelli, 2011). For example, researchers may conclude that a treatment effect is significant when in fact the treatment was not delivered as intended and therefore the effect is due to some other unknown factor. Implementation evaluations can also help to avoid type II errors (Borrelli, 2011). As an example, a researcher may conclude that a treatment effect was not significant when in reality the potentially significant treatment components were not properly delivered. The acceptance of ineffective interventions or the rejection of effective interventions has financial, public, and scientific costs (Borrelli, 2011). The acceptance of ineffective interventions could lead to unwarranted, and costly, large-scale trials. Furthermore, ineffective interventions could become standards of care which presents a cost to society. Finally, type I and type II errors could inhibit the advancement of behaviour change knowledge and practice.

In addition to enhancing confidence in intervention outcomes, implementation evaluations facilitate theory testing (Bellg et al., 2004). Delivery fidelity involves first mapping the intervention components onto theory. This mapping ensures that the theory is reflected throughout the intervention design and can lead to greater changes among the mediating variables that are hypothesized to lead to the intervention outcomes. In the case of SDT, ensuring that the intervention components foster autonomy, competence, and relatedness can lead to greater changes in individuals' need satisfaction and self-determined motivation, making it easier to test SDT. Implementation evaluations can also help identify or confirm mechanisms of action that can inform the implementation of future iterations of the intervention. Finally, in order to effectively compare treatment arms, it is important to assess treatment differentiation. Testing whether the treatment arms differed among certain parameters can help researchers explain differences between groups (Borrelli, 2011).

Implementation Evaluations Within SDT-based Interventions

Despite the importance of implementation evaluations for the field of behaviour change, most studies within the behaviour change literature do not report on delivery fidelity and/or participant engagement (Rixon et al., 2016; Walton et al., 2017). Among physical activity interventions grounded in SDT, few studies report on delivery fidelity and participant engagement (Fortier et al., 2012; Rocchi et al., 2021). To my knowledge, the physical activity counselling RCT was the first study grounded in SDT to demonstrate how to incorporate an implementation evaluation into the study design (Fortier et al., 2007). The implementation evaluation involved monitoring attendance, measuring delivery fidelity, and participant satisfaction in both the intervention and control group.

The implementation evaluation of the intervention group involved both participant self-report assessments and objective assessments. Intervention participants responded to the Health Care Climate Questionnaire (Williams et al., 2006) and the Basic Need Satisfaction in Relationships Scale (La Guardia et al., 2000) to determine if the counsellor satisfied their three basic psychological needs. They were also asked to rate their satisfaction with the intervention on a scale of 1-7. In addition to self-report questionnaires, two independent evaluators assessed the delivery integrity of the intervention via the recordings of three out of the 20 intervention participants. The evaluators used coding schemes to assess (1) whether the intervention protocol was delivered as intended and (2) whether the counsellor attempted to satisfy the three basic psychological needs. The intervention components were mapped onto the three basic psychological needs (see Fortier et al., 2007, p. 1177).

The implementation evaluation of the control intervention involved participant self-report assessments only. Similar to the intervention participants, control participants were asked to rate their satisfaction with the intervention and to respond to the Health Care Climate Questionnaire and the Basic Need Satisfaction in Relationships Scale (La Guardia et al., 2000). In addition, they were asked to assess their counsellor's adherence to the control protocol via nine, yes or no, items adapted from the Physical Activity Exit Interview (Sciamanna et al., 2004).

While the work of Fortier et al. (2007) formed the foundation for the assessment of delivery fidelity within SDT-based physical activity interventions, the assessment of participant engagement was limited to reports of attendance and satisfaction. When reporting on the results of the physical activity counselling RCT and two other RCTs based in SDT, Fortier et al. (2012, p. 10) called for more "systematic", or methodical, implementation evaluations in the field. Rocchi et al. (2021) extended the work of Fortier et al. (2007) by providing a systematic method

of assessing both delivery fidelity and participant engagement for physical activity interventions grounded in SDT. They evaluated the implementation of a tele-health intervention whereby 10 participants completed eight physical activity counselling sessions via video conferencing. They used three metrics to systematically assess delivery fidelity and participant engagement, in line with the recommendations of Borrelli (2011). For metric 1, participants reported their perceptions of delivery fidelity (via the Health Care Climate Questionnaire; Williams et al., 2006) and self-reported their engagement (via the Short Feedback Questionnaire; Kizony et al., 2006). For metric 2, the provider (behaviour change counsellor) self-reported whether they used each behaviour in the intervention protocol (to determine adherence) and the quality of use. They also reported whether participants were engaged in each session using a 5-point Likert scale. Finally, for metric 3, two independent coders reported delivery fidelity by performing second-by-second coding of the counsellor's intervention behaviours. They also evaluated participant engagement by rating engagement on a 5-point Likert scale, by reporting the session lengths, and by calculating the percentage of time the participant spoke compared to the counsellor. Strengths of the study include the clear operationalization of the intervention protocol and the use of multiple metrics of delivery fidelity and participant engagement. Each intervention behaviour in the protocol was associated with either autonomy, competence or relatedness support and a definition and example of each behaviour was provided. Moreover, incorporating three metrics, including the gold standard metric, helps to reduce any biases in the implementation evaluation.

While Rocchi et al. (2021) addressed an important gap in the literature by providing a systematic implementation evaluation, they noted a number of limitations and future directions for implementation evaluation research. First, their intervention protocol may have included too many behaviours, leading to fatigue and a lack of critical self-reflection by the behaviour change

counsellor. Second, the research team designed and evaluated the intervention and they noted that different results may have been found if the evaluation was conducted by an independent group. Finally, no clear operational definition of engagement was used and receipt and enactment were not independently evaluated. This limits the ability to compare findings across studies and is important given that participant engagement was related to greater changes in the outcome variables. In fact, Rocchi et al. (2021) note that future research should further explore predictors of participant engagement.

In addition to evaluating the implementation of a pilot RCT, my thesis research aimed to improve upon implementation methodology by addressing some of the limitations reported in previous work (Rocchi et al., 2021; Walton et al., 2017). First, this thesis research included measures of enactment in line with Hankonen et al. (2021) who argued that the assessment of BCT enactment is critical to both intervention evaluation and to the advancement of our understanding of behaviour change processes. We also included measures related to sociability and motivation for participating in research to help understand the predictors of participant engagement. This is important given that engagement is positively correlated with intervention effectiveness (Short et al., 2018; Walton et al., 2017; Rocchi et al., 2021). Finally, we described the use of minute-by-minute independent evaluator coding which is a less resource-intensive, but reliable, approach compared to the second-by-second coding conducted by Rocchi et al. (2021).

Chapter 3: Manuscript

Implementation Evaluation of a Pilot RCT: The Roles of Peers and Functional Tasks in Enhancing Exercise Training for Adults with Chronic Obstructive Pulmonary Disease

Meaghan A. Osborne, Lauren Saletsky, Emilie Michalovic, Jordan Herbison, Meredith A. Rocchi, Dennis Jensen, & Shane N. Sweet

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a common, progressive, and disabling respiratory condition. It is the third leading cause of death and the seventh leading cause of disability worldwide (World Health Organization, 2020). Breathlessness is widely recognized as the most common and disabling symptom of COPD. To avoid breathlessness, individuals with COPD often reduce their physical activity levels which leads to deconditioning and further reductions in physical activity (Troosters et al., 2013). This "vicious cycle of inactivity" affects one's participation in activities of daily living and health-related quality of life (Miravitlles & Ribera, 2017, p. 5). Exercise interventions such as pulmonary rehabilitation (PR) can help break this negative cycle (Troosters et al., 2013). While PR has substantial support as an intervention strategy for increasing physical capacity and improving health-related quality of life (McCarthy et al., 2015), it is estimated that only 0.4% of Canadians living with COPD have access to PR (Camp et al., 2015). Thus, there is a need to develop and test novel and accessible physical activity interventions for adults with COPD.

To address this need, Michalovic et al. (2022c) developed a telehealth exercise, peer support, and behavioural intervention grounded in self-determination theory (SDT) to promote participation in daily and social activities for adults with COPD. SDT is a leading meta-theory for understanding human motivation and behaviour that consists of six-mini theories including organismic integration theory and cognitive evaluation theory (Ryan & Deci, 2017). According to cognitive evaluation theory, when an individual's three basic psychological needs of autonomy, competence, and relatedness are supported by the individual's environmental and/or social context, intrinsic motivation is enhanced, supporting the performance of the behaviour (Ryan & Deci, 2017). In the context of physical activity interventions, providers of an

intervention can support participants' need satisfaction and in turn self-determination by using behaviours that foster autonomy, competence, and relatedness support (Gillison et al., 2019).

To test Michalovic et al.'s (2022c) intervention, a pilot randomized controlled trial (RCT) was conducted to determine its feasibility and preliminary efficacy (Saletsky et al., 2022). Intervention group participants reported high agreement that the exercise and peer support components of the intervention were acceptable, appropriate, and feasible. Compared to the control participants, intervention participants reported greater levels of physical activity, greater autonomous motivation, and more emotional and informational social support post-program (Saletsky et al., 2022). To confidently conclude that study outcomes are a direct result of the intervention, it is important to assess whether the intervention was delivered as intended (i.e. treatment integrity) and whether participants were engaged with the intervention (i.e. participant engagement). It is also necessary to evaluate the implementation of the control arm and whether the intervention and control arms differed from one another in the intended ways (i.e. treatment differentiation).

Implementation Evaluations

An *implementation evaluation* is broadly defined as the process of assessing how well an intervention has been translated from the drawing board into action (Newcomer et al., 2015). Implementation evaluations can help researchers avoid Type I and Type II errors whereby a treatment effect is deemed significant or non-significant when in fact the treatment was not delivered as intended (Borrelli, 2011). Type I and Type II errors can inhibit the advancement of behaviour change knowledge and practice. Further, the acceptance of ineffective interventions or the rejection of effective interventions has financial, public, and scientific costs (Borrelli, 2011).

Implementation evaluations involve the assessment of *delivery fidelity* and *participant engagement.* Delivery fidelity is defined as two interrelated concepts: *treatment integrity* (i.e. "the degree to which a treatment condition is implemented as intended") and *treatment differentiation* (i.e. "whether treatment conditions differ from one another in the intended manner"; Moncher & Prinz, 1991, p. 247-248). Participant engagement can also be defined as two interrelated concepts: *treatment receipt* (i.e. whether participants understand and demonstrate knowledge of intervention components) and *treatment enactment* (i.e. whether participants apply the intervention components in their daily life; Lichstein et al., 1994; Walton et al., 2017).

Despite the importance of implementation evaluations, most studies reporting on behaviour change interventions do not conduct these assessments (Walton et al., 2017). In the COPD literature, few studies on PR or exercise interventions report on delivery fidelity (Selzler, et al., 2021; White et al., 2020; Butler et al., 2020) and even fewer report on both delivery fidelity and participant engagement (O'Neil et al., 2018). In the physical activity literature, there has been a call for more implementation evaluations of interventions grounded in SDT (Fortier et al., 2012; Rocchi et al., 2021). Rocchi et al. (2021) provided a systematic method of conducting implementation evaluations on physical activity interventions grounded in SDT assessing both delivery fidelity and participant engagement. They used a three-metric evaluation system as proposed by Borrelli (2011) which consists of participant reports (metric 1), provider reports (metric 2), and independent evaluator reports (metric 3). Borrelli (2011) advocates for participant and provider reports being supplementary to the more objective, metric 3 data.

The purpose of this study was to evaluate the implementation of a pilot RCT on the role of peers and functional tasks in enhancing exercise training for adults living with COPD. The

primary objective was to determine whether the intervention was delivered as intended and whether participants were engaged with the intervention. The secondary objective was to determine whether the active control was delivered as intended, whether participants were engaged with the control program, and whether the control arm differed from the intervention arm in the intended ways.

Methods

Design

To evaluate the implementation of the pilot RCT, a repeated measures, three metric design was used and consisted of participant reports (metric 1), provider reports (metric 2), and objective independent evaluator reports (metric 3; the gold standard; Borrelli, 2011).

Participants

Twenty-two adults with COPD were recruited to participate in the pilot RCT of which 11 were randomized to the intervention and 11 to the control. To be eligible to participate in the pilot RCT, individuals had to a) be at least 18 years of age, b) have no diagnosed cognitive impairment, c) have a COPD diagnosis (any stage), d) be medically able to participate in exercise (confirmed by healthcare professional in the past 2 years), e) have access to a computer with a camera and internet, f) speak English or French, and g) have the intention to become physically active in the next 2 months or have been minimally active (<150 minutes per week of moderate-vigorous aerobic physical activity) in the past 2 months. To be eligible to participate in the implementation evaluation, individuals had to be enrolled in the trial.

Procedures

Intervention Arm Procedures

Intervention participants followed Michalovic et al.'s (2022c) 8-week, synchronous, home-based behavioural intervention for adults with COPD. Participants engaged in two, one-hour sessions per week consisting of approximately 30 minutes of exercise and 30 minutes of peer support. To safely deliver the exercises and effectively deliver the peer support component online via Microsoft Teams, intervention participants were divided into two groups (group 1: n = 6 and group 2: n = 5).The exercise component, led by a certified kinesiologist, consisted of functional task exercises that mimic the daily and social activities of individuals with COPD. The peer support component, led by a behaviour change specialist, engaged participants in conversations about their physical activity experiences, goals, and daily challenges. In addition, participants were taught how to apply eight behaviour change techniques (BCTs) to promote physical activity participation in their daily life: values identification, goal setting, action and coping planning, physical restructuring, self-monitoring, social restructuring, resource finding, and self-belief. Participants were taught new BCTs (one new technique per session) in weeks 1, 3, 5, and 7. In weeks 2, 4, 6, and 8, the techniques taught in the previous week were re-visited allowing participants to share their experiences and strategies using the BCTs and participating in physical activity with their peers.

Throughout the sessions, the providers were asked to adhere to intervention behaviours to foster a need-supportive environment (Figure 1). The providers were trained in the intervention behaviours using a training manual (Appendix A). The providers were asked to review the manual on their own and then met with the primary author one-on-one to review a video recording and discuss the presence or absence of intervention behaviours.

Control Arm Procedures

The control exercise program was adapted from the exercise component of Holland et al.'s (2017) home-based PR program (Holland et al., 2017; https://homebaserehab.net/). During week 1 of the program, participants received a video call (approximately one hour in duration) from a certified kinesiologist who prescribed an exercise program, supervised the first exercise session, and provided a copy of a home exercise diary. In the following seven weeks of the program, participants were to receive a structured phone call (20-30 minutes in duration) once a week from the kinesiologist to discuss participants' exercise goals and barriers. Participants were encouraged to engage in two or more exercise sessions per week, on their own, targeting both endurance and muscular strength, and were asked to document their weekly exercise in their home diary. The kinesiologist who led the intervention program was assigned to provide the control program to 9/11 control participants. Another certified kinesiologist (and master's student in our group; N.S.) was assigned to provide the control program to two participants.

Implementation Evaluation Procedures

Delivery fidelity of the intervention and participant engagement with the intervention (primary objective) were evaluated using three metrics (Borrelli, 2011; Rocchi et al., 2021). For metric 1, intervention participants reported their perceptions of treatment integrity and self-reported their engagement with the intervention via an online survey administered at four time-points (sessions 2, 4, 9, and 11 for group 1 and sessions 5, 7, 14, and 16 for group 2). For metric 2, the kinesiologist and behaviour change specialist self-reported their treatment integrity and reported their perceptions of participant engagement after every session using an online survey. For metric 3, two independent evaluators, Meaghan Osborne (primary author and master's student) and Monica Lubczynski (fourth year undergraduate research practicum student) reported on treatment integrity and participant engagement by coding a counterbalanced sample of 25%

of the intervention session video recordings (sessions 2, 4, 9, and 11 for group 1 and sessions 5, 7, 14, and 16 for group 2). The data collection time-points for metrics 1, 2, and 3 were aligned so that the data could be cross-referenced. Figure 2 provides an overview of the data collection process for the primary objective.

Delivery fidelity of the control program and participant engagement with the control program (secondary objective) were evaluated using provider self-report data collected after every session and participant self-report data collected at the end of the study. Data from independent evaluators were not obtained for the control program due to the time-consuming nature of these objective evaluations.

The study procedures received approval from the Research Ethics Office of the Faculty of Medicine and Health Sciences at McGill University (IRB #: A00-B60-21B).

Measures

Intervention Arm

Metric 1 (Intervention Participants). To evaluate treatment integrity, participants responded to a modified version of the brief Health Care Climate Questionnaire (HCCQ; Czajkowska et al., 2017). On a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), six items were used to measure participants' perceptions of need-supportive behaviours from the kinesiologist and behaviour change specialist (e.g., "I feel that my kinesiologist/behaviour change specialist has provided me choices and options about my physical activity.").

To evaluate participant engagement during the intervention sessions, participants were asked to rate on a 7-point Likert scale to what extent they took part in (1) the exercises taught, (2) conversations surrounding the BCT taught/reviewed, and (3) conversations with other group

members (1 = to an extremely small extent and 7 = to an extremely large extent). During the initial data collection time point (session 2 for group 1 and session 5 for group 2), participants were asked two questions related to their sociability from the Big Five Inventory–2 (e.g. "I am someone who is outgoing, sociable."; Soto & John, 2017) and four questions related to their motivation for participating in our study (e.g. "I signed up because this study might be able to help future individuals in my situation."; Soule et al., 2016). These questions were used to detect potential predictors of engagement.

To evaluate engagement outside of the intervention sessions, peer contact and BCT enactment were evaluated. To evaluate peer contact outside of the intervention, participants were asked how often they reached out to another participant outside of the exercise sessions in the past week on a scale from 1 (*not once*) to 5 (*daily*). To evaluate BCT enactment, participants completed a questionnaire that asked them to rate on a scale from 1 (*not once*) to 5 (*daily*) how frequently they have each BCT taught in the program during the past two weeks (adapted from Hankonen et al., 2017). Appendix B includes all metric 1 measures.

Metric 2 (Intervention Providers). To evaluate treatment integrity, the kinesiologist and behaviour change specialist self-reported whether they used each intervention behaviour within the intervention behaviour protocol (yes=1 and no=0). The providers then rated their overall performance using the behaviours on a 10-point Likert scale: 1 (*poor*) – 10 (*excellent*). The behaviour change specialist also reported whether they taught/reviewed each element of the BCT worksheet. To evaluate participant engagement, attendance was recorded. Furthermore, the kinesiologist rated the extent to which each participant took part in the exercises taught on a 7-point Likert scale. The behaviour change specialist rated the extent to which each participant

took part in conversations surrounding the BCT taught/reviewed and conversations with other group members on a 7-point Likert scale. Appendix C includes all metric 2 measures.

Metric 3 (Independent Evaluators). Two independent evaluators (M.O. and M.L.) performed minute-by-minute coding of 8/32 intervention sessions (459 minutes of coding in total). These eight sessions corresponded to the eight sessions where metric 1 data was collected. The intervention providers were kept blind to the sessions that would be coded by the independent evaluators.

To assess treatment integrity, the evaluators coded whether each intervention behaviour within the protocol was used (yes = 1 and no =0) minute-by-minute. Behaviours were recorded when they were *initiated.* Therefore, a behaviour was only coded once per initiation, even if it carried over into the next minute. The evaluators at the end of each session rated the providers' overall performance using the behaviours "in a capacity that provided a need-supportive environment" on a 10-point Likert scale: 1 (*poor*) – 10 (*excellent*). The evaluators also reported whether the behaviour change specialist taught/reviewed each element of the BCT worksheet.

To evaluate participant engagement, the evaluators reported the extent to which each participant took part in (1) the exercises taught, (2) conversations surrounding the BCT taught/reviewed, and (3) conversations with other group members on a 7-point Likert scale (in line with metric 1 and 2 measures). To further evaluate engagement with the exercise segments, the evaluators reported whether each participant attempted each exercise prescribed. If a participant did not attempt an exercise, the evaluators documented whether it was due to (1) physical limitation, (2) breathlessness, (3) disengagement, or (4) other. To further evaluate engagement with the BCT training and peer support segments, the evaluators coded whether each participant responded to the behaviour change specialist or a peer minute-by-minute. One-

word answers (e.g. yup, yes, no, good, hello, and goodbye) were not coded as responses as they represent social transitions rather than engagement in the intervention content. For each response, the evaluators documented whether the response was related to (1) behaviour change, (2) living with COPD, or (3) other. In addition, the independent coders recorded whether each participant initiated a conversation and whether it was related to (1) behaviour change, (2) living with COPD, or (3) other minute-by-minute. When "other" was coded, the specific topic was also documented. Finally, the evaluators recorded the number of instances of emotional support (i.e. acts of care, encouragement, attentive listening, and reassurance that enhance self-esteem), appraisal support (i.e. acts that validate an individual's emotions, thoughts, and behaviours), and informational support (i.e. suggestions, provisions of factual information, and feedback that contribute to problem-solving) from each participant minute-by-minute (Dennis, 2003). Appendix D includes the independent evaluator protocol.

Training. The independent coder training consisted of five steps. First, both coders completed the BCT Taxonomy Training which provides trainees with the knowledge and practice required to identify all 93 BCTs. In step 2, the coders familiarized themselves with intervention behaviours that have been shown to target autonomy, competence, and relatedness support (Gillison et al., 2019). In step 3, the coders studied the intervention behaviour training manual which also acted as the independent evaluator coding manual. In step 4, M.O. and M.L. watched eight 10-minute video segments (four exercise segments and four peer support segments from the pilot RCT) and practiced coding the intervention behaviours, the types of responses to the behaviour change specialist and their peers, and the types of peer support provided. For the first two segments (one exercise and one peer support segment), the evaluators practiced their coding together. Afterwards, the coding was completed independently. M.O. and M.L. would

discuss and resolve any disagreements only after each 10-minute segment was completed. In addition, across the eight video segments, M.O. and M.L. created rubrics for the 7-point Likert Scales used to evaluate participant engagement with the exercises, conversations surrounding BCT taught/reviewed, and conversations with other group members (Appendix E).

Finally, in step 5, the evaluators practiced minute-by-minute coding and coded a total of 20 minutes of video (10 minutes from an exercise segment and 10 minutes from a peer support segment). The intraclass correlation (ICC2) estimates were calculated based on a single-measures, absolute-agreement, 2-way mixed-effects model in SPSS version 27. The ICC2 at step 5 was calculated to be 0.96 for treatment integrity coding and 0.94 for participant engagement which is considered excellent agreement and as such the training was deemed complete. Note that for treatment integrity, the ICC2 was calculated to assess agreement on both the presence and absence of intervention behaviours. However, for engagement, the ICC2 was calculated to assess the agreement on only the *presence* of engagement. M.O. and M.L. met for a total of 10 hours.

Control Arm

To assess treatment integrity of the control program, the certified kinesiologist self-reported whether they adhered to each element of the standardized program (yes=1 and no=0) via a procedural checklist. To assess participant engagement, the kinesiologist recorded attendance and length of each session. Furthermore, control participants kept an exercise diary outlining the frequency, duration, and type of exercise performed. To assess treatment differentiation, the kinesiologist self-reported whether they used any of the intervention behaviours from the intervention protocol while delivering the control program. Control

participants also responded to the BCT enactment questionnaire pre- and post-program (adapted from Hankonen et al., 2017). Appendix F includes all control arm measures.

Data Analysis

Intervention Arm Implementation Evaluation

Delivery Fidelity. To assess treatment integrity, descriptive statistics were calculated for metrics 1, 2, and 3 data. Adherence to each intervention behaviour was determined by calculating the percentage of sessions in which each intervention behaviour was used. The kinesiologist's and behaviour change specialist's overall adherence to the intervention protocol were also calculated. While metric 1 and 2 data helped describe the implementation of the intervention, the objective data obtained from metric 3 were used to make conclusions about delivery fidelity and participant engagement given that metric 3 represents the gold standard (Borrelli, 2011). To conclude that the intervention was delivered as intended, an a priori indicator of success of 50% adherence to the intervention protocol was used. This percentage was chosen based on the results of previous research that have evaluated the implementation of intervention behaviours via independent evaluators (e.g. 42% in Davis et al., 2000; 45% in Hardeman et al., 2008; 42% in Rocchi et al., 2021).

Participant Engagement. To assess engagement, descriptive statistics (sums and means) were calculated. To assess participant motivations for participating in the study, relevance scores for each item (intellectual motivation, altruistic motivation, health-related motivation, and financial motivation) were calculated by subtracting the item score from the mean of the other three item scores for each participant. A positive relevance score means that a participant aligns with that type of motivation more strongly than average. A negative relevance score means that a participant aligns more strongly with the other types of motivation (Soule et al., 2017). To

conclude that participants were sufficiently engaged with the intervention, an attendance rate of 70% (~ 11/16 sessions attended by all participants) was used (Holland et al., 2017; Williams et al., 2013). Although no thresholds exist for determining whether participants were highly engaged with the intervention components, a mean engagement score of 5 was chosen as the a priori indicator of success given that this represents above-average engagement.

Control Arm Implementation Evaluation

Delivery Fidelity. For treatment integrity, overall adherence to the control protocol was calculated as a percentage using data from the control program checklists. To conclude that the control sessions were delivered as intended, an *a priori* indicator of success of 90% adherence to the control checklist was used. This percentage was chosen based on the results of previous research that have evaluated the implementation of interventions using procedural checklists (e.g. 90.8% in Resnick et al., 2005; 94% in Skidmore et al. 2014). To assess treatment differentiation, the kinesiologist's adherence to the intervention protocol during the intervention sessions was compared to the kinesiologists' adherence rate during the control program sessions using a one-sample *t*-test. To conclude that the intervention arm differed from the control arm as intended, a significant difference ($p<0.05$) between the adherence rate to the intervention protocol during the intervention vs. the control sessions was required.

Participant Engagement. For participant engagement, attendance (as a percentage) and mean length of the phone call sessions were calculated. In addition, adherence to the exercise recommendations (i.e. two sessions of both endurance and strength training per week) was calculated as a percentage using the data from participants' exercise diaries. For example, an individual who demonstrated that they participated in two endurance and two strength training exercise sessions per week for eight weeks was said to have an adherence rate of 100%. To

conclude that participants were *sufficiently* engaged with the control program, an *a priori* indicator of success of 70% attendance was used (Holland et al., 2017). To conclude that control participants were *highly* engaged, an *a priori* indicator of success of 70% adherence to the exercise recommendations (i.e. two sessions per week) was used. This percentage was chosen based on the results of previous research that used exercise diaries/logs to assess engagement (e.g. 65% in Baker et al., 2001; 71% in Dannhauser et al., 2014; 68-70% in Duncan et al., 2003).

Results

Of the 22 participants that were randomized, 18 completed the study. Two participants withdrew before the first session (n=1 from the intervention arm and n=1 from the control arm), one participant withdrew from the intervention at week 4 due to a health concern, and one participant was removed from the intervention at week 1. Therefore, eight participants completed the intervention program (group 1: n = 4 and group 2: n = 4) and 10 participants completed the control exercise program (only one control participant was led by N.S as the second participant withdrew before the first session). Data from the 18 participants that completed the trial is presented.

Intervention Arm Implementation Evaluation

Treatment Integrity

For metric 1, intervention participants, across the eight data collection time points, reported very high need support from both the kinesiologist and the behaviour change specialist (*M*=6.94/7, *SD*=0.55; M=6.97/7, *SD* = 0.16, respectively; Table 1). For metric 2, the kinesiologist and behaviour change specialist completed a checklist of intervention behaviours used for 25 out of the 32 total sessions and self-reported an overall adherence rate of 85.3% and 80.2%, respectively (Table 2). The kinesiologist and behaviour change specialist also rated their

overall performance delivering the behaviours in the top quartile of the Likert scale (*M*=8.50/10, *SD*=1.03; M=8.00/10, *SD* = 0.73, respectively). The behaviour change specialist reported a mean adherence rate to the BCT worksheets of 84.7%.

Given the high agreement between M.O. and M.L. for the coding of treatment integrity (ICC2 = 0.87), the primary author's (M.O.'s) codes (metric 3) were used for reporting (Baum, 2002). The adherence rate to the intervention protocol was 81% and 73% for the kinesiologist and behaviour change specialist, respectively, which exceeded our *a priori* criterion of success of >50% (Table 2). M.O. also rated the kinesiologist's and behaviour change specialist's performance delivering the behaviours in the top quartile of the Likert scale (*M*=7.75/10, *SD*=1.03; M=7.63/10, *SD* = 1.19, respectively). The mean adherence rate to the BCT worksheet was 71.0%. According to M.O., the kinesiologist adhered to nine out of the 12 intervention behaviours in 100% of the sample sessions with "demonstration of behaviour" (sum =114), "instruction on how to perform a behavior" (sum =97), and "provide a rationale for suggestions" (sum =64) used most often. For the behaviour change specialist, M.O. reported an adherence rate of 100% for 12 out of the 20 behaviours with "paraphrasing/reflective listening" (sum = 54), "provide positive feedback" (sum = 54), and "acknowledge and support perspectives" (sum =52) used most often (Table 2).

Participant Engagement

For metric 1, intervention participants self-reported that they were engaged with the exercises and the conversations surrounding BCTs to a very large extent, (*M*=6.38/7, *SD*=0.70; *M*=5.71/7, *SD*=1.14, respectively) and were engaged in conversations with peers to a large extent (*M*=5.22/7, *SD*=1.59; Table 3). Across the eight data collection time points, no participants reported that they reached out to another participant outside of the exercise sessions. Post-

intervention, intervention participants self-reported enacting on average 86% of the BCTs (range: 67% - 100%) taught throughout the intervention compared to 64% (range: 0% - 100%) pre-intervention (Table 4).

For metric 2, the kinesiologist reported that participants were engaged with the exercises to an extremely large extent (*M*=6.97/7, *SD*=0.33). The behaviour change specialist reported that the participants were engaged in the conversations surrounding BCTs and conversations with peers to a moderate extent (*M*=4.54/7, *SD*=1.48; *M*=4.30/7, *SD*=1.68, respectively; Table 3). The overall attendance rate was 84.4% and only one participant did not meet our *a priori* criterion of *sufficient* engagement (56.3% < 70%). This participant was unable to attend many morning sessions due to medical appointments.

Given the excellent agreement between M.O. and M.L. for the coding of participant engagement (ICC2 = 0.93), the primary author's (M.O.'s) data (metric 3) is presented. Overall, M.O. reported that participants were engaged with the exercises, conversations surrounding BCTs, and conversations with peers to a large extent (*M*=5.33, *SD*=1.27; *M*=5.46, *SD*=1.47; *M*=4.78, *SD*=2.01, respectively). Three participants did not meet our *a priori* indicator of *high* engagement (metric 3 engagement score ≥5/7; Table 3). Interestingly, the five participants exceeding our *a priori* indicator had higher sociability scores (*M*=4.3/5, *SD*=1.23) when compared to the three participants who did not meet our indicator of success (*M*=2.67/5, *SD*=1.50). In terms of motivation for participating in the study, all participants had positive relevance scores for intellectual, altruistic`, and health-related motivation and had a negative relevance score for financial motivation.

Across the eight sample exercise sessions, participants in attendance attempted all exercises with the only exception being in the case of a technical difficulty. Across the eight

sample BCT and peer support sessions, M.O. coded a total of 230 responses to the behaviour change specialist, 85 responses to peers, and 10 conversations initiated by participants (Table 5). Of the 230 responses to the behaviour change specialist, 68.7% were related to behaviour change, 4.8% were related to COPD, and 26.5% were related to other topics (including the intervention program, 6.5%; weekend activities, 4.8%; technical difficulties, 2.2%; and activities of daily and social living, 2.2%). As for responses to peers, 43.5% were related to behaviour change, 11.8% were related to COPD, and 44.7% were related to neither. Common topics coded as "other" were activities of daily and social living (11.8%), location of homes/places (11.8%), and reading (11.8%). Of the 10 conversations initiated by participants, zero were related to behaviour change, four were related to COPD, and six were related to other topics (including activities of daily and social living and the intervention program). On average, there were more responses to the behaviour change specialist, peers, and more conversations initiated in the review sessions (M=30.25, SD=2.36; M=16.75, SD=5.38: M=1.75, SD=1.50, respectively) compared to the BCT teaching sessions (M=27.25, SD=3.77; M=4.50, SD=4.51; M=0.75, SD=0.96, respectively). In terms of social support from group members, there were six instances of emotional support, 22 instances of informational support, and 15 instances of appraisal support (Table 5). In addition, there were more instances of peer support in the review sessions (M=9.00, SD=6.48) when compared to the BCT teaching sessions (M=1.75, SD=0.96). Appendix G presents examples of emotional, informational, and appraisal support documented by M.O.. In general, there were more responses, more conversations initiated, and more acts of social support by participants who met our *a priori* criterion of high engagement compared to those who did not (Table 6).

Control Arm Implementation Evaluation

Delivery Fidelity

For treatment integrity, the primary kinesiologist's and N.S.'s self-reported adherence to the control program checklist was calculated to be 95.8% and 100%, respectively, which exceeded our *a priori* criterion of success (>90%). The primary kinesiologist reported a mean session duration of 50 minutes for the first video call and 10 minutes for all phone calls. N.S reported that the first video call session was 58 minutes and the first phone call session was 36 minutes. The average length of N.S.'s week 3 through week 7 phone calls was 22 minutes and the final, week 8, phone call was 30 minutes in duration. Despite the high adherence to the control program checklist, the primary kinesiologist's recorded phone calls were shorter than described in the protocol.

For treatment differentiation, the kinesiologists reported an overall adherence to the intervention behaviour protocol of 64.8% while delivering the control program (65.9% for the primary kinesiologist and 55.21% for N.S.). The one-sample *t*-test revealed a statistically significant difference ($t(9) = -3901.78$, $p < 0.001$) between the adherence rate to the intervention protocol during the intervention (85.3% based on metric 2, provider, data) and control program (64.8%). The one-sample *t*-test remained statistically significant ($t(9) = -3717.41$, $p < 0.001$) when the metric 3 (primary independent evaluator) adherence rate was used (81.3%). These results indicate that the intervention and control arms differed from one another whereby significantly more intervention behaviours were used by the kinesiologist when delivering the intervention versus the control program. Furthermore, post-intervention, intervention participants self-reported enacting more BCTs (*M*=86%; range: 67% - 100%) than the control participants (*M*=55.6%; range: 44.4% -77.8%; Table 4).

Participant Engagement

For engagement, the overall attendance rate was 85.0% and only one participant did not meet our *a priori* indicator of success (62.5%<70%). Of the 10 control participants, eight returned their exercise diaries. One participant discarded their home diary before collection and another participant was hospitalized for COVID-19 and was unable to return their home diary. The overall adherence rate to the exercise recommendations based on the eight returned diaries was 79.69%. Only one participant did not meet our *a priori* adherence rate (37.50% <70%) and this was the same participant who did not meet our *a priori* indicator for attendance.

Discussion

The purpose of this study was to evaluate the implementation of a pilot RCT, specifically the implementation of an SDT-based, tele-health, behavioural exercise intervention, and the implementation of an active control exercise program. Our results indicate that the behavioural intervention was delivered as intended, 7/8 intervention participants were sufficiently engaged with the intervention, and 4/7 were highly engaged with the intervention. Our secondary objective results indicate that while the control program components were delivered with high fidelity, session lengths were shorter than intended, and thus overall, the program was not delivered as intended. Nine out of 10 control participants were found to be sufficiently engaged with the program and at least seven participants were highly engaged with the program. Finally, we found support for treatment differentiation whereby the intervention treatment components (specifically, need supportive behaviours and BCTs) were delivered to a larger extent in the intervention arm as compared to the control arm.

Treatment Integrity of the Behavioural Intervention

The results from all three metrics revealed that the intervention components were delivered as intended by both the kinesiologist and behaviour change specialist. In terms of

metric 1, participants reported that the providers were highly need-supportive with scores greater than 6 on a 7-point scale (on the HCCQ). These high scores are encouraging but we must be mindful of a likely positivity bias, or fading effect bias (FEB), whereby unpleasant emotions fade more quickly than pleasant emotions (Gibbons et al., 2011). Despite keeping the questionnaire length to five minutes to encourage participants to answer immediately after the session, the median time to complete the questionnaire was 18 hours post-session (range: 14 minutes - 101 hours). Given that the FEB occurs within 12 hours after an event (Gibbons et al., 2011), need-thwarting experiences may have been forgotten. Future research should consider having the questionnaires embedded within their interventions (e.g. provide five minutes at the end of a session to complete a survey or use video software polling) to avoid positivity bias. In this scenario, it would be crucial to have the provider(s) leave the session and have an independent person (e.g. research assistant) join the session to administer the questionnaire and remind participants that responses are confidential to minimize social desirability bias (Fisher, 1993).

In terms of adherence to the intervention protocol (metrics 2 and 3), the providers reported higher, but comparable adherence rates to the primary coder. The metric 2 adherence rates fell within the range of self-reported adherence rates in the literature (e.g. 65% on 31 behaviors in Rocchi et al., 2021; 90% on 15 tasks in Davis et al., 2000; 100% on nine BCTs in Hardeman et al., 2008). The metric 3 adherence rates, however, were higher than those reported in previous work (e.g. 42% in Rocchi et al., 2021; 42% in Davis et al., 2000; 45% on 14 BCTs in Hardeman et al., 2008). Higher adherence rates reported in our study may be because our intervention protocol was less complex than those in previous work. For example, Hardeman et al. (2008) noted the complexity of their ProActive UK program protocol (with 208 behaviours categorized under 14 BCTs) as a reason for their low adherence rate. Furthermore, Rocchi et al.'s

(2021) intervention protocol contained 31 intervention behaviours which is considerably more than the 12 and 20 behaviours used by the kinesiologist and behaviour change specialist, respectively, in our study. Rocchi et al. (2021) also noted that not all 31 behaviours were meant to be used in every session and that the behaviours used depended on participants' readiness for change. In contrast, in our study, each behaviour had the potential to be used in every session (with the exception of "Review behaviour goals"). Given that intervention complexity can negatively impact treatment fidelity (Walton et al., 2017), researchers should try and reduce their interventions to the most effective and/or evidence-based components to ensure that they are delivered as intended.

The providers also reported higher, but comparable ratings of performance delivering the intervention behaviours as compared to the primary coder. It is difficult to compare or make conclusions about this data given that a rubric was not developed to help providers and coders rate their overall performance on a 10-point Likert scale. Future implementation evaluations on SDT-based interventions should consider having providers and independent evaluators rate overall performance delivering intervention behaviours using a modified version of the HCCQ (Czajkowska et al., 2017)**.** Using this scale would improve the credibility of the ratings while allowing comparisons to be made across all three metrics (Rocchi et al., 2021).

Engagement With the Behavioural Intervention

Overall, our results revealed that 7/8 intervention participants were *sufficiently* engaged with the intervention. Our *a priori* attendance criterion of 70% (i.e. our criterion of sufficient engagement) was informed by Holland et al. (2017) and a review by Williams et al. (2014), which reported on attendance rates and *a priori* criteria in exercise and PR programs for adults with COPD. While the way in which attendance is reported varies in the literature (some studies

report mean rates while others report the percentage of participants meeting *a priori* criterion; Walton et al., 2017), we decided to report on the percentage of participants meeting the 70% attendance rate, in line with the review by Williams et al. (2014). Given the current definition of engagement as a collective term for *participant receipt* and *enactment*, we decided that 100% of participants meeting our *a priori* attendance criterion of 70% was important to conclude that participants were engaged with the program. We recognize, however, that in larger-scale trials, it may be unrealistic that all participants attend 70% of sessions. Documenting reasons for absences is crucial for making conclusions about overall program engagement. In our intervention, the one participant who did not meet our *a priori* criterion of sufficient engagement was absent due to medical appointments and respiratory symptoms rather than lack of engagement.

In our study, we also used 7-point Likert scales to assess participants' engagement with the program. Participants' self-reported ratings of engagement were generally higher than those reported by the providers and primary independent evaluator. Explaining these differences across metrics is difficult because the rubrics to determine *high engagement* were only created for the independent evaluators. While these engagement scales did not directly measure receipt, the education literature provides a rationale for their use. Within the education literature, engagement is thought to precede learning (or receipt) and consists of four dimensions: behavioral, cognitive, emotional, and agentic (Reeve et al., 2013; Chiu et al., 2022). The education literature, therefore, suggests that the concept of engagement is different from that of receipt and that engagement is needed to promote receipt (or learning). Our rubrics assessed aspects of behavioural and agentic engagement. For example, if participants asked questions, asked for feedback/clarification, and/or asked for adaptations, which are signs of initiative (i.e.

agentic engagement), they were rated as more engaged. The BCT and peer support engagement ratings were informed by the number of responses and the frequency of both verbal and non-verbal active listening (signs of behavioural engagement). Given that receipt is challenging to assess, engagement rubrics (assessing the level of participation, active involvement, and/or communication) could be used by researchers as a proxy for receipt (Rixon et al., 2016).

To assess enactment (i.e. whether participants apply the intervention skills/components in their daily life), we used a modified version of a BCT enactment scale developed by Hankonen et al. (2017). According to Resnick et al. (2005, p. 143) enactment "is often confused with study outcomes". They propose that when assessing enactment, researchers should focus on "the skills required to achieve study outcomes". In the case of our pilot RCT, these skills would be the BCTs. We found that the percentage of participants enacting all nine BCTs increased from pre- to post-intervention. While we did not have an *a priori* criterion of successful enactment, Hankonen (2021) argues that not all BCTs must be enacted by all participants in an intervention and that enacting 80% would indicate very high fidelity. Overall, the eight intervention participants were enacting 86% of the BCTs taught in the intervention compared to 57% for the 10 control participants. Thus, we can conclude that all eight intervention participants were successfully enacting the BCTs.

Delivery Fidelity of and Participant Engagement With the Active Control

While the adherence rate to the control procedures was very high and comparable to previous work (e.g. 90.8% In Resnick et al., 2005; 94% in Skidmore et al., 2014) the low adherence to the session length guidelines suggests that the program was not delivered as intended. While a control program training manual was created and provided to both kinesiologists (based on https://homebaserehab.net/), more hands-on training should have been implemented. For

example, part of the program developed by Holland et al. (2017) involves the use of motivational interviewing strategies. While educational resources on motivational interviewing (MI) were provided, the kinesiologists did not have formal training in MI. This could explain the shorter length of the sessions whereby the kinesiologists may not have been adequately trained to counsel participants on their motivation to participate in physical activity (Miller & Rollnick, 2013). If Holland et al.'s (2017) standardized program is used in a larger scale RCT, it would be necessary to hire individuals who are trained in MI or allocate funding for proper MI training. More hands-on training in the form of role-playing would also be crucial in addition to setting *a priori* training performance criteria (Borrelli, 2011).

Our results revealed that the majority of control participants (90%) were *sufficiently* engaged with the phone program which is consistent with the results of Holland et al. (2017). While exercise diaries were also used to assess engagement with the program, these diaries are susceptible to reduced validity due to forgetfulness and missing data (Bollen et al., 2014; Frost et al., 2016). In our study, one diary was discarded before data collection and three diaries were difficult to interpret due to missing data and required follow-up. While the components necessary to optimize the validity of exercise diaries are still inconclusive (Frost et al., 2016), our findings suggest that designing more structured home diaries (e.g. by incorporating "fill in the blanks") would increase their validity.

Treatment Differentiation

Overall, our findings indicated that the intervention treatment components (i.e. need supportive behaviours, BCTs, and peer support) were delivered to a greater extent in the intervention arm compared to the control arm. While we found that the need-supportive intervention behaviours were delivered to a lesser extent in the control program, this finding is

limited by potential reporter bias given that the kinesiologists were not blinded to which program was the intervention and which program was the control. In terms of BCT enactment, we found that post-program, intervention participants were enacting more BCTs than control participants which provides support for their effective delivery during the intervention by the behaviour change specialist. Interestingly, we found that more conversations with peers and more instances of peer support were coded during the BCT review sessions when compared to the BCT teaching sessions of the intervention arm. This finding provides support for incorporating BCT review sessions within the intervention protocol to promote peer support. These review sessions also fostered autonomy-support as participants were given more autonomy to direct the conversation according to their needs.

Methodological Considerations

In this study, we described the use of minute-by-minute coding (for metric 3) which is a less resource-intensive coding approach compared to the second-by-second coding conducted by Rocchi et al. (2021). Furthermore, we double-coded the data and calculated ICCs to ensure that the training and coding processes were trustworthy. Our systematic behavioural coding process also enabled us to effectively evaluate the peer support component of the intervention. To help understand why some participants are more engaged than others, we included measures related to participant sociability and motivation for participating in the program in line with Rocchi et al.'s (2021) recommendation. Participants who perceived themselves to be more sociable were also perceived by the primary independent coder as more engaged with the exercises, BCTs, and conversations with peers. Given that engagement is positively correlated with intervention effectiveness (Short et al., 2018; Walton et al., 2017; Rocchi et al., 2021), more work is needed

to understand the predictors of engagement and what intervention components could be used to enhance engagement, especially among participants who are less sociable.

The primary coder was involved in the design of the RCT and was the main contributor to the design of the implementation evaluation. While this likely introduced some biases in the coding, it also ensured that the primary coder had an in-depth understanding of the intervention and its components. Future research should consider having an independent research team conduct the implementation evaluation, although we recognize the financial and/or personnel implications of this recommendation. Only eight of the 32 intervention sessions were evaluated by the independent evaluators. While these sessions were counterbalanced and chosen *a priori,* they may not have been representative of the entire program. For example, while we only coded three instances of "encouraging social support seeking" by the behaviour change specialist, there likely would have been more recorded instances had we coded the BCT session on social restructuring. Future research should consider coding a larger sample of sessions or coding 10-minute segments from each intervention session. Finally, while we found that the intervention components were delivered to a lesser extent in the control program (i.e. the two arms differed as intended), this finding is limited by potential biases in self-report data. Objective, independent evaluations of both treatment integrity of the control program and treatment differentiation would improve confidence in these findings.

Conclusion

The SDT-based behavioural exercise and peer support intervention was delivered as intended while the control exercise program was not. Furthermore, most participants were sufficiently engaged with both arms and the intervention and control arms differed as intended. Researchers should continue to conduct implementation evaluations alongside their interventions

to (1) improve confidence in study findings, (2) facilitate theory testing, and (3) contribute to the operationalization, measurement, and standardization of delivery fidelity and participant engagement within the behaviour change literature. In this study, we incorporated an implementation evaluation methodology within an RCT design in hopes that this will become standard practice.

Table 1

Intervention Participants' Perceived Need-Support From the Kinesiologist and Behaviour Change Specialist Across the Intervention

	Need Support T1			Need Support T2			Need Support T3			Need Support T4		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	S*D*	*n*	*M*	*SD*
Kinesiologist												
Group 1	2	7.00	0.00	4	6.83	0.64	4	7.00	0.00	3	7.00	0.00
Group 2	2	7.00	0.00	3	7.00	0.00	4	7.00	0.00	3	7.00	0.00
BCT Specialist												
Group 1	2	6.92	0.35	4	6.92	0.28	4	7.00	0.00	3	7.00	0.00
Group 2	2	6.92	0.29	3	7.00	0.00	4	7.00	0.00	3	7.00	0.00

Note. T1 through T4 corresponds to sessions 2, 4, 9, and 11 for group 1. For group 2, T1 through T4 corresponds to sessions 5, 7, 14, and 16

Table 2

Self-Reported Treatment Integrity, Independent Coder Treatment Integrity, and Total Frequencies of Coded Behaviours

	Metric 2- Self Reported Adherence						Metric 3 - Independent Report Adherence and *f*					
	Adherence (G1)		Adherence (G2)		Adherence (overall)		Adherence (overall)		Frequencies (overall)			
Behaviours	Sum	%	Sum	%	Sum	%	Sum	%	Sum	*M*	*SD*	Range
Kinesiologist												
Autonomy Support												
Acknowledge and support perspectives	12	92.3	11	91.7	23	92.0	8	100.0	60	7.50	2.56	2-11
Provide a rationale for suggestions	12	92.3	11	91.7	23	92.0	8	100.0	64	8.00	2.13	5-11
Provide choice	13	100.0	11	91.7	24	96.0	8	100.0	40	5.00	1.41	4-7
Autonomy Total	37	94.9	33	91.7	70	93.3	24	100.0	164	6.83	2.41	
Competence Support												
Adapt exercises to individuals' needs/capabilities	12	92.3	12	100.0	24	96.0	8	100.0	40	5.00	1.41	4-7
Connects exercises to daily and social activities	12	92.3	9	75.0	21	84.0	6	75.0	14	1.75	1.67	0-5
Demonstration of behaviour	13	100.0	12	100.0	25	100.0	8	100.0	97	12.13	1.89	10-16
Instruction on how to perform a behavior	11	84.6	7	58.3	18	72.0	8	100.0	114	14.25	2.31	12-19
Provide positive feedback	11	84.6	12	100.0	23	92.0	8	100.0	51	6.38	2.26	3-10
Task climate	7	53.8	11	91.7	18	72.0	0	0.0	0	0.00	0.00	0-0
Verbal persuasion about past capability	5	38.5	3	25.0	8	32.0	0	0.0	0	0.00	0.00	0-0
Competence Total	71	78.0	66	78.6	137	78.3	38	67.9	316	5.64	5.56	
Relatedness Support												
Act in a warm and caring way and avoid judgment or blame	13	100.0	12	100.0	25	100.0	8	100.0	-	-	-	-
Express empathy	12	92.3	12	100.0	24	96.0	8	100.0	-	-	-	-
Relatedness Total	25	96.2	24	100.0	49	98.0	16	100.0	-	-	-	-
Overall Total	133	85.3	123	85.4	256	85.3	78	81.3	480	6.00	4.85	
Behaviour change specialist												

Autonomy Support												
Acknowledge and support perspectives	14	100.0	11	100.0	25	100.0	8	100.0	52	6.50	2.14	3-9
Involve adults in every decision related to their physical activity	12	85.7	9	81.8	21	84.0	8	100.0	-	-	-	-
Provide a rationale for suggestions	14	100.0	11	100.0	25	100.0	8	100.0	44	5.50	2.67	2-9
Provide choice	13	92.9	8	72.7	21	84.0	8	100.0	17	2.13	0.83	1-3
Autonomy Total	53	94.6	39	88.6	92	92.0	32	100.0	113	4.71	2.73	
Competence Support												
Assist in clarifying outcome expectations	13	92.9	6	54.5	19	76.0	4	50.0	4	0.50	0.53	0-1
Assist in identifying barriers	11	78.6	8	72.7	19	76.0	3	37.5	3	0.38	0.52	0-1
Focus on past success	5	35.7	5	45.5	10	40.0	1	12.5	3	0.38	1.06	0-3
Instruction on how to perform a behavior	10	71.4	9	81.8	19	76.0	8	100.0	41	5.13	2.30	3-9
Normalize feelings, behaviours, and experiences	14	100.0	11	100.0	25	100.0	8	100.0	23	2.88	1.46	1-5
Provide positive feedback	8	57.1	8	72.7	16	64.0	8	100.0	54	6.75	3.62	1-12
Review behaviour goals	5	35.7	7	63.6	12	48.0	3	37.5	4	0.50	0.76	0-2
Task climate	11	78.6	9	81.8	20	80.0	1	12.5	1	0.125	0.35	0-1
Verbal persuasion about past capability	5	35.7	6	54.5	11	44.0	0	0.0	0	0.00	0.00	0-0
Competence Total	82	65.1	69	69.7	151	67.1	36	50.0	133	1.85	2.81	
Relatedness Support												
Act in a warm and caring way and avoid judgment or blame	14	100.0	11	100.0	25	100.0	8	100.0	-	-	-	-
Express empathy	14	100.0	11	100.0	25	100.0	8	100.0	-	-	-	-
Encourage social support seeking	7	50.0	4	36.4	11	44.0	3	37.5	3	0.38	0.52	0-1
Group co-operation	13	92.9	9	81.8	21	84.0	5	62.5	5	0.63	0.52	0-1
Paraphrasing/Reflective listening	14	100.0	11	100.0	25	100.0	8	100.0	54	6.75	2.31	3-10
Staying silent	14	100.0	11	100.0	25	100.0	8	100.0	-	-	-	-
Use open-ended questions	14	100.0	11	100.0	25	100.0	8	100.0	46	5.75	1.67	4-9
Relatedness Total	90	91.8	68	88.3	158	90.3	48	85.7	108	3.38	3.26	
Overall Total	225	80.4	176	80.0	401	80.2	116	72.5	354	3.31	3.11	

Note. The kinesiologist's self-reported adherence (metric 2) was based on 13 sessions for Group 1 and 12 sessions for Group 2. The behaviour change specialist's self-reported adherence (metric 2) was based on 14 sessions for Group 1 and 11 sessions for Group 2. Metric 3 adherence was based on 8 sessions.

Table 3

Participant Engagement with the Exercises, BCTs, and Peers

	Metric 1 – Intervention Self-Report								Metric 2 – Provider Report								Metric 3 – Independent Report							
	Exercises		BCTs		Peers		Overall		Exercises		BCTs		Peers		Overall		Exercises		BCTs		Peers		Overall	
Participant	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
P1	6.0	0.00	4.66	0.58	5.00	0.00	5.22	0.67	7.00	0.00	5.00	1.76	5.33	1.30	5.78	1.52	5.50	0.71	5.00	0.00	5.50	0.71	5.33	0.70
P2	7.0	0.00	7.00	0.00	7.00	0.00	7.00	0.00	7.00	0.00	5.83	0.72	6.00	0.67	6.28	0.76	6.00	1.41	6.67	0.58	7.00	0.00	6.56	0.52
P3	7.00	0.00	6.75	2.38	5.75	2.50	6.50	1.25	7.00	0.00	5.36	1.12	5.18	1.53	5.85	1.35	6.25	0.50	6.00	0.82	5.00	2.16	5.75	1.36
P4	5.67	0.58	4.00	0.00	3.67	0.57	4.44	1.01	7.00	0.00	2.58	1.31	2.58	1.56	4.06	2.36	3.67	0.58	2.67	1.15	1.33	0.58	2.56	1.24
P5	7.00	0.00	5.67	1.73	5.00	1.73	5.89	1.45	7.00	0.00	4.50	1.08	4.30	1.64	5.27	1.66	4.67	0.58	5.00	1.00	4.00	1.00	4.56	0.88
P6	5.67	0.58	5.33	1.00	4.33	0.58	5.11	0.78	7.00	0.00	4.10	0.99	3.70	1.34	4.93	1.77	6.33	0.58	6.33	1.15	5.67	2.31	6.11	1.36
P7	7.00	0.00	6.50	0.00	7.00	0.00	6.83	0.41	7.00	0.00	4.50	0.84	4.17	0.75	5.22	1.45	6.50	0.71	7.00	0.00	5.50	2.12	6.33	1.21
P8	5.75	0.50	5.75	0.96	4.00	0.82	5.17	1.03	6.75	0.87	4.36	1.03	3.27	1.10	4.80	1.78	3.75	0.50	5.00	0.82	4.25	0.96	4.33	0.88

Note. Metric 1 and 3 data was based on 4 sessions for group 1 (P1-P4) and 4 sessions for group 2 (P5-P8). Metric 2 exercise engagement data was based on 13 sessions for group 1 and 12 sessions for group 2. Metric 2 BCT and peer engagement data was based on 14 sessions for group 1 and 11 sessions for group 2.

Table 4

Percent of Participants Enacting the BCTs and Mean Enactment Scores Post-Intervention

	Control (*n*=10)		Intervention (*n*=8)	
Behaviour change technique	%	*M* (*SD*)	%	*M* (*SD*)
Values identification	60.0	2.60 (1.78)	100.0	3.50 (0.93)
Goal setting	100.0	3.10 (0.74)	100.0	3.63 (0.92)
Action planning	80.0	2.50 (1.08)	87.5	3.63 (1.30)
Coping planning	70.0	2.00 (1.05)	87.5	3.38 (1.60)
Physical restructuring	40.0	2.10 (1.52)	75.0	2.88 (1.46)
Self-monitoring	60.0	2.60 (1.50)	62.5	2.63 (1.41)
Social restructuring	10.0	1.20 (0.63)	75.0	2.75 (1.58)
Resource findings	20.0	1.40 (0.84)	87.5	2.63 (1.30)
Self-belief	70.0	2.10 (1.20)	100.0	4.00 (0.93)
Overall	56.7	2.18 (1.28)	86.1	3.11 (1.32)

Note. Enacting a BCT was defined as using a BCT at least bi-weekly (i.e. score greater than 1/5, where 1 = no enactment; Hankonen et al., 2017).

Table 5

Total Number of Responses and Conversations Initiated by Session and by Topic and Number of Instances of Peer Support by Session and by Type

	Responses to specialist				Responses to peers				Conversations Initiated				Peer Support			
Session	BCT	COPD	Other	Total	BCT	COPD	Other	Total	BCT	COPD	Other	Total	E	I	A	Total
2	24	0	8	32	3	0	0	1	0	0	1	1	0	0	3	3
4†	17	6	7	30	7	8	1	16	0	2	2	4	2	11	4	17
5	21	0	5	26	2	1	8	11	0	1	1	2	0	0	2	2
7†	23	0	9	32	6	0	4	10	0	0	1	1	0	2	0	2
9	21	1	6	28	1	0	1	2	0	0	0	0	0	1	0	1
11†	19	0	8	27	13	0	5	18	0	0	0	1	4	6	1	11
14	18	0	5	23	1	0	0	1	0	0	0	0	0	0	1	1
16†	15	4	13	32	4	1	18	23	0	1	0	0	1	2	4	6

Note. Sessions 2, 4, 9, and 11 correspond to group 1 and sessions 5, 7, 14, and 16 correspond to group 2. † Denotes review sessions.

E = emotional support; I = informational support; A = appraisal support.

Table 6

Mean Responses and Conversations Initiated by Participant and Topic and Mean Instances of Peer Support by Participant and Type

	Responses to specialist				Responses to peers				Conversations Initiated				Peer Support			
Participant	BCT	COPD	Other	Total	BCT	COPD	Other	Total	BCT	COPD	Other	Total	E	I	A	Total
P1	2.00	1.00	2.50	5.50	3.00	0.50	0.00	3.50	0.00	0.50	0.00	0.50	1.00	1.50	0.50	3.00
P2	13.00	1.00	2.30	16.30	4.67	1.00	1.33	7.00	0.00	0.00	0.00	0.00	3.00	0.67	2.33	6.00
P3	7.50	0.25	2.75	10.50	0.75	1.00	0.75	2.50	0.00	0.25	0.00	0.25	0.50	1.25	0.00	1.75
P4	2.66	0.33	2.00	5.00	0.33	0.00	0.33	0.67	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33
P5	4.67	0.67	3.00	8.33	0.67	0.00	2.00	2.67	0.00	0.33	0.00	0.33	0.00	0.00	0.33	0.33
P6	10.33	0.00	2.67	13.00	1.67	0.00	1.67	3.33	0.00	0.33	0.67	1.00	0.67	0.00	0.00	0.67
P7	7.00	1.00	3.50	11.50	2.00	0.50	4.00	6.50	0.00	0.00	0.00	0.00	0.00	1.00	2.00	3.00
P8	4.50	0.00	2.00	6.50	0.50	0.25	2.75	3.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50

Note. E = emotional support; I = informational support; A = appraisal support.

Figure 1

Intervention Protocol

Autonomy	Competence	Relatedness
Certified Kinesiologist		
Acknowledge and support perspectives	Adapt exercises to individuals' needs/capabilities	Act in a warm and caring way and avoid judgment or blame
Provide a rationale for suggestions	Connects exercises to daily and social activities	Express empathy
Provide choice	Demonstration of behaviour	
	Instruction on how to perform a behavior	
	Provide positive feedback	
	Task climate	
	Verbal persuasion about past capability	
Behaviour change specialist		
Acknowledge and support perspectives	Assist in clarifying outcome expectations	Act in a warm and caring way and avoid judgment or blame
Involve adults in every decision related to their physical activity	Assist in identifying barriers	Express empathy
Provide a rationale for suggestions	Focus on past success	Encourage social support seeking
Provide choice	Instruction on how to perform a behavior	Group co-operation
	Normalize feelings, behaviours, and experiences	Paraphrasing/Reflective listening
	Provide positive feedback	Staying silent
	Review behaviour goals	Use open-ended questions
	Task climate	
	Verbal persuasion about past capability	

Note. The need-supportive intervention behaviours were adapted from Michalovic et al. (2021c), and informed by Gillison et al. (2019), Hardcastle et al. (2017), and Rocchi et al. (2021).

Figure 2

Overview of the Data Collection Process to Assess Delivery Fidelity of, and Participant Engagement with, the Behavioural Intervention (Primary Objective)

Week	B	1	2	3	4	5	6	7	8	P
Metric 1 – Intervention Participants										
Treatment Integrity										
Perceived need support (HCCQ)[1]		❶	❶	❷	❷	❶	❶	❷	❷	
Participant Engagement										
Self-reported engagement during the sessions		❶	❶	❷	❷	❶	❶	❷	❷	
Self-reported engagement outside the sessions (BCT enactment)	✓									✓
Self-reported engagement outside the sessions (Peer contact)		❶	❶	❷	❷	❶	❶	❷	❷	✓
Metric 2 – Intervention Providers										
Treatment Integrity										
Self-reported intervention behaviour use		✓	✓	✓	✓	✓	✓	✓	✓	
Self-reported intervention behaviour quality		✓	✓	✓	✓	✓	✓	✓	✓	
Self-reported adherence to BCT checklist		✓	✓	✓	✓	✓	✓	✓	✓	
Engagement										
Perceived participant engagement during the sessions		✓	✓	✓	✓	✓	✓	✓	✓	
Attendance		✓	✓	✓	✓	✓	✓	✓	✓	
Metric 3 – Independent Evaluators										
Treatment Integrity										
Intervention behaviour use (minute-by-minute)		❶	❶	❷	❷	❶	❶	❷	❷	
Intervention behaviour quality		❶	❶	❷	❷	❶	❶	❷	❷	
Adherence to BCT checklist		❶	❶	❷	❷	❶	❶	❷	❷	
Participant Engagement										
Perceived participant engagement during the sessions		❶	❶	❷	❷	❶	❶	❷	❷	
Exercise attempts		❶	❶	❷	❷	❶	❶	❷	❷	
Responses to behaviour change specialist and peers (minute-by-minute)		❶	❶	❷	❷	❶	❶	❷	❷	
Conversations initiated (minute-by-minute)		❶	❶	❷	❷	❶	❶	❷	❷	
Instances of peer support (minute-by-minute)		❶	❶	❷	❷	❶	❶	❷	❷	

Note. The number 1 icons in the figure indicate that data was collected from/for group 1. The number 2 icons indicate that data was collected from/for group 2. The checkmark icons indicate that data was collected from/for both groups 1 and 2.

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Appendix A

Intervention Behaviours Training Manual

Intervention Components	BCT/IS	Description	Examples
Autonomy Support			
Acknowledge and support adult's perspectives, feelings, and values	IS 2	Take time to understand the participant's perspective and recognise their challenges.	"I can understand why you feel intimidated by this exercise/movement".
Involve adults in every decision related to their physical activity	IS 1	Behaviour change specialist asks the adult for his/her thoughts/opinions during the peer support sessions. Consider the participant's history (e.g., family/work commitments).	"How many days of the week would you like to exercise?" "What specific exercise would you like to do?"
Provide a rationale for suggestions	IS 3	Explain to the adult the rationale behind advice and/or choices.	"If you engage your abdominals you are less likely to feel pain in your lower back."
Provide choice	IS 1	Participants are given choices and options.	"You could use weights or resistance bands for this next exercise." "Would you like to start with the upper body exercises or the lower body exercises?"
Competence Support			
Adapt exercises to individuals' needs	N/A†	Kinesiologist modifies exercises based on participant's capabilities and limitations/injuries.	"You can perform this next exercise seated to start and as you progress it can be performed standing".
Assist in clarifying outcome expectations*	IS 9	Behaviour change specialist discusses the outcomes of physical activity with the participants including how they feel it may positively or negatively affect health and quality of life.	"Studies have shown physical activity may increase X and Y." "What do you expect to achieve by becoming more physically active?"

Assist in identifying and barriers	IS 14	Behaviour change specialist works with the participants to identify barriers	"Is there anything you can think of that might prevent you from achieving your exercise goal?"
Connects exercises to daily and social activities	N/A†	Kinesiologist explains to the participants how the exercises prescribes are related to everyday activities (e.g. bathing, using transportation, etc).	“The farmer’s walk mimics carrying groceries so that you can get stronger at this task”.
Demonstration of behaviour	BCT 6.1	Kinesiologist provide a sample of the performance of the exercises prescribed either directly or indirectly (i.e. using film, pictures, etc.).	“On page 20 of your intervention booklet, you can see how a triceps dip is performed using a chair with arms”
Instruction on how to perform a behavior	BCT 4.1	Advise or agree on how to perform the behavior (includes ‘Skills training’)	“When you walk on an incline, make sure to pace yourself, take small steps, and use pursed lip breathing.”
Normalize feelings, behaviours, and experiences	BCT 6.2	Behaviour change specialist draws attention to others’ performance of a behaviour to allow comparison with the person’s own performance.	"Most people experience muscle pain when performing new exercises. This pain will decrease as you exercise more often".
Provide positive feedback	BCT 2.2	Monitor and provide informative or evaluative feedback on performance of behaviour (form, frequency, duration, intensity). Reward the adults for trying, and stress that a failed try does not mean they are incapable	"Great job exercising this week! Although it was not 3x a week as you had originally planned, it is still a great achievement that you were able to practice the exercises".
Review behaviour goals	BCT 1.5	Behaviour change specialist reviews behaviour goals jointly with the participant and considers modifying goals or behaviour change strategy in light of achievement. This may lead to re-setting the same goal, a small change in that goal or setting a new goal instead of (or in addition to) the first.	“You achieved your exercise goal last week. What do you think about increasing the duration/intensity/frequency of your exercise next week?”

Task climate	IS 10	Facilitation focuses on completing the process of the task, matched against one's own standards, rather than the outcomes of the task.	"Do not worry if you did not meet your goal of walking 3 km in under 30 minutes. What matters is that you found the time to walk this week."
Verbal persuasion about past capability	BCT 15.1	Tell the adult they can successfully perform the wanted behaviour, arguing against self-doubts and asserting that they can and will succeed.	"You mentioned that you used to exercise often. If you start slow you will be able to work yourself back up to that level of exercise."
Relatedness Support			
Act in a warm and caring way and avoid judgment or blame*	IS 9	Be respectful of the adult and work to understand them instead of passing judgment.	N/A
Express empathy*	IS 9	Show adults that you understand their emotions pertaining to the issue being discussed	"That must be very frustrating". "I hear what you are saying". "That sounds like a difficult experience".
Encourage social support seeking	IS 17	Advise on or discuss possible sources of social support (e.g. from friends, relatives, colleagues) or give non contingent praise or reward for physical activity. This includes general, practical, and emotional support.	General: Advise the participant to find someone who will encourage them to continue being active. Practical: Advise the participant to ask their partner to put their walker beside the bed so that the participant can get up by themselves. Emotional: Advise the participant to ask a friend or partner to exercise with them.
Group co-operation	IS 18	Practitioner establishes interdependence within a group, or encourages cooperative peer-to-peer activities.	"Does anyone else share a similar experience or have any suggestions for Barbara?"
Paraphrasing/ Reflective listening*	IS 9	After listening to the adult, summarize your perception of the main points.	"So what I am hearing is that…" or "It sounds like…".
Staying Silent*	IS 9	Allow the adult to complete sentences and finish speaking before following up with further questions.	N/A

Use open-ended questions*	IS 9	"Tell me"/"What"/"How" are useful terms when asking questions as they allow the adult to elaborate on his/her story	"What kind of things are you doing to alleviate the pain at the moment?"

Notes. The intervention behaviours were adapted from Michalovic et al. (2021c). Intervention strategies (IS) were informed by Gillison et al. (2019) and the behaviour change techniques (BCTs) were informed by Michie et al. (2011). * denotes motivational interviewing principles informed by Hardcastle et al. (2017) and Rocchi et al. (2021). † denotes intervention behaviours informed by Michalovic et al. (2021b).

Appendix B

Metric 1 Questionnaires

Figure B1

Modified, 6-Item Health Care Climate Questionnaire

Please answer the questions below regarding your relationship with your kinesiologist and behaviour change specialist. Your responses will be kept confidential, so your kinesiologist and behaviour change specialist will not know your responses. Please be honest and candid. Choose your answers using the scale below.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neutral	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

*The following six questions are regarding your relationship with your **kinesiologist**.*

1. I feel that my kinesiologist has provided me choices and options about my physical activity.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. I feel my physical activity counsellor understands how I see things with respect to my physical activity.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. My kinesiologist conveys confidence in my ability to make changes regarding my physical activity.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. My kinesiologist encourages me to ask questions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. My kinesiologist listens to how I would like to do things regarding my physical activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. My kinesiologist tries to understand how I see my physical activity before suggesting any changes.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

*The following six questions are regarding your relationship with your **behaviour change specialist**.*

1. I feel that my behaviour chance specialist has provided me choices and options about my physical activity.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. I feel my behaviour chance specialist understands how I see things with respect to my physical activity.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. My behaviour chance specialist conveys confidence in my ability to make changes regarding my physical activity.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. My behaviour chance specialist encourages me to ask questions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. My behaviour chance specialist listens to how I would like to do things regarding my physical activity	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. My behaviour chance specialist tries to understand how I see my physical activity before suggesting any changes.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Figure B2

Participant Engagement During the Intervention Sessions

Please answer the following 3 questions about the extent to which you took part in today's session.

To an Extremely Small Extent	To a Very Small Extent	To a Small Extent	To a Moderate Extent	To a Large Extent	To a Very Large Extent	To an Extremely Large Extent
1	2	3	4	5	6	7

1. To what extent did you take part in the exercises taught?	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. To what extent did you take part in the conversation surrounding the BCT taught or reviewed?	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. To what extent did you take part in conversations with other group members?	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Figure B3

Participant Engagement Outside of the Intervention Sessions

How often have you reached out to another participant within your exercise group outside of the exercise sessions in the past week?

Not once	About once	1-2	About every second day	Daily
1	2	3	4	5

Figure B4

BCT Enactment

During the last 2 weeks, have you done the following?

Not once	About once in 2 weeks	1-2 times per week	About every second day	Daily
1	2	3	4	5

Goal setting: outlining what you want to do and setting a goal defined in terms of the behavior you want to achieve. Example: Set a daily walking goal of 3 kilometres.	**1**	**2**	**3**	**4**	**5**
Action planning: creating a detailed outline of performance of your target behaviour (must include at least one of context, frequency, duration and intensity). Example: Planning to. Swim at 9am on Mondays, Wednesdays, and Fridays.	**1**	**2**	**3**	**4**	**5**
Coping planning: creating specific plans to overcome barriers/obstacles that you think you may encounter when performing your behaviour. Example: Identify barriers preventing you from starting a new exercise regime (e.g., lack of motivation), and discuss ways in which you could help overcome them (e.g., going to the gym with a buddy).	**1**	**2**	**3**	**4**	**5**
Physical restructuring: changing your physical environment/ space to better meet your target behaviour. Example: Reorganize living room so that there is space for exercise and a yoga mat.	**1**	**2**	**3**	**4**	**5**
Self-monitoring: monitoring and recording thoughts, feelings, behaviours, and/or outcomes. Example: recording in a diary how many steps you take every day.	**1**	**2**	**3**	**4**	**5**
Values identification: taking note of the behaviours you are currently participating in and determine how much they align with your values and identity.	**1**	**2**	**3**	**4**	**5**
Social restructuring: changing your social environment and support system to better meet your target behaviour and create barriers to unwanted behaviours. Example: identifying supportive people who help you achieve your activity goals.	**1**	**2**	**3**	**4**	**5**
Resource findings: developing skills that help you find resources (online/ in-person) that can provide information regarding your target behaviour. Example: Learning how to conduct a web search for physical activity programs in your neighbourhood.	**1**	**2**	**3**	**4**	**5**
Self-belief: using your own past experiences, visualization, and self-talk to shape your thoughts and opinions on the performance of your target behaviour. Example: Imagining yourself performing an exercise successfully.	**1**	**2**	**3**	**4**	**5**

Figure B5

Participant Sociability

Below are two characteristics that may or may not apply to you. Please indicate the extent to which you agree or disagree with each statement.

Disagree strongly	Disagree a little	Neutral; no opinion	Agree a little	Agree strongly
1	2	3	4	5

I am someone who...

1. Tends to be quiet.
2. Is outgoing, sociable.

Figure B6

Participant Motivations to Participate in This Research Study

Please rate your agreement with each statement below from 1 (Strongly Disagree) to 10 (Strongly Agree).

1. I signed up because it is an interesting study and research question.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2. I signed up because this study might be able to help future individuals in my situation.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
3. I signed up because it would be helpful to have advice and guidance on exercise.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
4. I signed up because of the compensation (money) for participation.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Appendix C

Metric 2 Questionnaires

Figure C1

Post-Session Evaluation – Kinesiologist

Which of the following intervention behaviours were used in today's session?

Note that it is not expected that you use all intervention behaviours every session. Please be as honest as possible with your responses. The more accurate the data, the better it can be used to inform study outcomes and future iterations of the program. Descriptions and examples of each intervention behaviour below can be found in the training manual.

- ❑ Acknowledge and support perspectives
- ❑ Provide a rationale for suggestions
- ❑ Provide choice
- ❑ Adapt exercises to individuals' needs/capabilities
- ❑ Connects exercises to daily and social activities
- ❑ Demonstration of behaviour
- ❑ Instruction on how to perform a behaviour
- ❑ Provide positive feedback
- ❑ Task climate
- ❑ Verbal persuasion about past capability
- ❑ Act in a warm and caring way and avoid judgment or blame
- ❑ Express empathy

How would you rate your overall performance delivering the intervention components during this session?

Poor									**Excellent**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

To what extent did each participant take part in the exercises taught? (1-7)

To an Extremely Small Extent	**To a Very Small Extent**	**To a Small Extent**	**To a Moderate Extent**	**To a Large Extent**	**To a Very Large Extent**	**To an Extremely Large Extent**
1	2	3	4	5	6	7

Participant 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Participant 2…	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**

Figure C2

Post-Session Evaluation – Behaviour Change Specialist

Which of the following intervention behaviours were used in today's session?

Note that it is not expected that you use all intervention behaviours every session. Please be as honest as possible with your responses. The more accurate the data, the better it can be used to inform study outcomes and future iterations of the program. Descriptions and examples of each intervention behaviour can be found in the training manual.

- ❑ Acknowledge and support perspectives
- ❑ Involve adults in every decision related to their physical activity
- ❑ Provide a rationale for suggestions
- ❑ Provide choice
- ❑ Assist in clarifying outcome expectations
- ❑ Assist in identifying barriers
- ❑ Focus on past success
- ❑ Instruction on how to perform a behavior
- ❑ Normalize feelings, behaviours, and experiences
- ❑ Provide positive feedback
- ❑ Review behaviour goals
- ❑ Task climate
- ❑ Verbal persuasion about past capability
- ❑ Act in a warm and caring way and avoid judgment or blame
- ❑ Express empathy
- ❑ Encourage social support seeking
- ❑ Group co-operation
- ❑ Paraphrasing/Reflective listening
- ❑ Staying silent
- ❑ Use open-ended questions

How would you rate your overall performance delivering the intervention components during this session?

Poor									**Excellent**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Please fill out the appropriate section by placing a checkbox next to each element that was delivered.

Session 1: Values identification elements
[ ] a. Overview values
[ ] b. Overview benefits of value identification
[ ] c. Review how working in alignment of your values help individuals meet their goals
[ ] d. Explain self-affirmation
[ ] e. Discuss values that align with physical activity/health
[ ] f. Discuss values that align with other aspects of their lives
[ ] g. Overview activity
[ ] h. Discuss ranked values
[ ] i. Discuss top values and how they relate to physical activity
[ ] j. Discuss how identifying top values can relate back to their goals and planning

Session 2: Goal setting elements
[ ] a. Review goal types
[ ] b. Describe SMART goal components
[ ] c. Purpose of goal setting
[ ] d. Benefits of goal setting
[ ] e. Overview of learning goals
[ ] f. Overview of process goals
[ ] g. Overview of outcome goals
[ ] h. Explain activity
[ ] i. Provide goal examples for each type of goal
[ ] j. Provide SMART goal example
[ ] k. Ask participants to set own goals
[ ] l. Review and help improve participants goals

Session 3: Values identification reflection elements
[ ] a. Review/summarize values identification
[ ] b. Discuss the use of values identification in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 4: Goal setting reflection elements
[ ] a. Review/summarize goal setting
[ ] b. Discuss the use of goal setting in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 5: Action planning and coping planning elements
[ ] a. Overview action planning components
[ ] b. Overview coping planning components
[ ] c. Explain benefits of action planning
[ ] d. Explain benefits of coping planning
[ ] e. Provide example of action planning
[ ] f. Provide example of coping planning
[ ] g. Review activity
[ ] h. Explain how to create an action plan
[ ] i. Ask participants to create action plans
[ ] j. Review and help improve participants' plans
[ ] k. Explain how to create a coping plan
[ ] l. Ask participants to create coping plans
[ ] m. Review and help improve participants' plans

Session 6: Physical restructuring elements
[ ] a. Overview of physical restructuring
[ ] b. Overview benefits of physical restructuring
[ ] c. Discuss environments currently using and what barriers prevent participation
[ ] d. Explore ideas around potential environments
[ ] e. Explain activity
[ ] f. Overview ideas of physical restructuring and discuss how they can be implemented

Session 7: Action planning and coping planning reflection elements
[ ] a. Review/summarize action planning and coping planning
[ ] b. Discuss the use of action and coping planning in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 8: Physical restructuring reflection elements
[ ] a. Review/summarize physical restructuring
[ ] b. Discuss the use of physical restructuring in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 9: Self-monitoring elements
[ ] a. Explain self-monitoring
[ ] b. Overview benefits of self-monitoring
[ ] c. Provide examples of how to self-monitor
[ ] d. Explain intentions phase of physical activity
[ ] e. Explain action phase of physical activity
[ ] f. Explain maintenance phase of physical activity
[ ] g. Review participants' goals with phases of physical activity
[ ] h. Explain types of self-monitoring
[ ] i. Help participants identify self-monitoring that matches their goal
[ ] j. Overview self-monitoring tools
[ ] k. Review two examples of self-monitoring

Session 10: Social restructuring elements
[ ] a. Overview of social restructuring
[ ] b. Overview benefits of social restructuring
[ ] c. Discuss current social environment and what barriers prevent participation
[ ] d. Review instrumental support
[ ] e. Review emotional support
[ ] f. Review informational support
[ ] g. Explore potential social support barriers
[ ] h. Brainstorm potential supporters
[ ] i. Discuss action plan for asking for support

Session 11: Self-monitoring reflection elements
[ ] a. Review/summarize self-monitoring
[ ] b. Discuss the use of self-monitoring in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 12: Social restructuring reflection elements
[ ] a. Review/summarize social restructuring
[ ] b. Discuss the use of social restructuring in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 13: Resource finding elements
[ ] a. Overview types of resources
[ ] b. Explain good versus bad resources
[ ] c. Discuss participants they find resources
[ ] d. Discuss participants they find resources lacking
[ ] e. Overview quality criteria
[ ] f. Explore resources that are often used by participants
[ ] g. Encourage them to share resources to group and explain likes and dislikes

Session 14: Self-belief elements
[ ] a. Overview self-belief
[ ] b. Describe how self-belief relates to physical activity experiences
[ ] c. Overview self-efficacy
[ ] d. Discuss visualization and how it can be used
[ ] e. Discuss reflection on past experiences and what can be learned from them
[ ] f. Explain how to use self-talk
[ ] g. Discuss types of self-talk
[ ] h. Discuss past successful experiences
[ ] i. Help identify cues to increase self-efficacy toward behaviours

Session 15: Resource finding elements
[ ] a. Review/summarize social restructuring
[ ] b. Discuss the use of social restructuring in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

Session 16: Self-belief elements
[ ] a. Review/summarize social restructuring
[ ] b. Discuss the use of social restructuring in participants' daily life
[ ] c. Use one or more prompts from the intervention booklet

To what extent did each participant take part in the conversation surrounding the BCT taught or reviewed? (1-7)

To an Extremely Small Extent	To a Very Small Extent	To a Small Extent	To a Moderate Extent	To a Large Extent	To a Very Large Extent	To an Extremely Large Extent
1	2	3	4	5	6	7

Participant 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Participant 2…	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**

To what extent did each participant take part in conversations with other group members?

To an Extremely Small Extent	To a Very Small Extent	To a Small Extent	To a Moderate Extent	To a Large Extent	To a Very Large Extent	To an Extremely Large Extent
1	2	3	4	5	6	7

Participant 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Participant 2….	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**

Appendix D

Independent Evaluator Protocol

Independent evaluators will assess sessions 2, 4, 9, and 11 for Group 1 and sessions 5, 7, 14, and 16 for Group 2.

Steps to take throughout each exercise session:

1. Determine whether or not each intervention behaviour in the intervention protocol was delivered by the certified kinesiologist (0= no, 1=yes) minute-by-minute.
    a. Note. Behaviours should be recorded when they are *initiated.* Therefore, if a behaviour is initiated in minute one, but carried over into minute two, only code it once in minute one.
2. Monitor whether each participant attempts each exercise prescribed. If a participant does not attempt an exercise, document whether it was due to (1) physical limitation, (2) out of breath, (3) disengaged, or (4) other.

Steps to take after each exercise session:

3. Rate the certified kinesiologist's overall performance delivering the intervention behaviours during the session on a scale of 1-10.

Poor									**Excellent**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**N/A**

4. To what extent did each participant take part in the exercises taught?

To an extremely small extent	**To a very small extent**	**To a small extent**	**To a moderate extent**	**To a large extent**	**To a very large extent**	**To an extremely large extent**	**No answer**
1	**2**	**3**	**4**	**5**	**6**	**7**	

Participant 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Participant 2…	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**

Steps to take throughout each peer support session:

1. Determine whether or not each intervention behaviour in the intervention protocol was delivered by the behaviour change specialist (0= no, 1=yes) minute-by-minute.
    a. Note. Behaviours should be recorded when they are *initiated.* Therefore, if a behaviour is initiated in minute one, but carries over into minute two, only code it once in minute one.
2. Determine whether or not each element of the BCT worksheet was delivered by the behaviour change specialist (0= no, 1=yes).

3. Record participant responses to the behaviour change specialist and to peers minute-by-minute. For each response, record whether it was related to (1) behaviour change, (2) Living with COPD, or (3) Other.
4. Record conversations initiated by each participant minute-by-minute. For each conversation, record whether it was related to (1) behaviour change (2) Living with COPD, or (3) Other.
5. Record instances of emotional, appraisal, and informational support from each participant minute-by-minute.

Steps to take after each peer support session:

6. Rate the certified behaviour change specialist's overall performance delivering the intervention components during the session on a scale of 1-10.

Poor									**Excellent**	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**N/A**

7. **To what extent did each participant take part in the conversation surrounding the BCT taught or reviewed?**

To an extremely small extent	**To a very small extent**	**To a small extent**	**To a moderate extent**	**To a large extent**	**To a very large extent**	**To an extremely large extent**	**No answer**
1	**2**	**3**	**4**	**5**	**6**	**7**	

Participant 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Participant 2…	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**

8. To what extent did each participant take part in conversations with other group members?

To an extremely small extent	**To a very small extent**	**To a small extent**	**To a moderate extent**	**To a large extent**	**To a very large extent**	**To an extremely large extent**	**No answer**
1	**2**	**3**	**4**	**5**	**6**	**7**	

Participant 1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Participant 2…	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**

Appendix E

Engagement Likert Scale Rubrics

To what extent did each participant take part in the exercises taught?

To an extremely small extent	To a very small extent	To a small extent	To a moderate extent	To a large extent	To a very large extent	To an extremely large extent	No answer
1	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Present but does not attempt the majority of the exercises	Attempts more than half of the exercises	Attempts all exercises	Answers some of the kinesiologist's qus + 1/3 of *	Answers most of the kinesiologist's qus + 1/3 of *	Answers most of the kinesiologist's qus + 2/3 of *	Answers all of the kinesiologist's questions + 2/3 of *	Not present or technical difficulties

***** Asks questions; asks for feedback / clarification; asks for an adaptation

To what extent did each participant take part in the conversation surrounding the BCT taught or reviewed?

To an extremely small extent	To a very small extent	To a small extent	To a moderate extent	To a large extent	To a very large extent	To an extremely large extent	No answer
1	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Does not contribute, but is present throughout	Contributes to the conversation at least once	Contributes to the conversation at least once + some signs of active listening (non-verbal only)	Contributes to the conversation at least twice + some signs of active listening (mainly non-verbal, some verbal)	Contributes to the conversation at least three times + frequent signs of active listening (verbal & non-verbal) + instance of reflexive listening	Contributes to the conversation at least four times + frequent signs of active listening (verbal & non-verbal) + some reflexive listening	Contributes to the conversation at least five times + frequent signs of active listening (verbal & non-verbal) + frequent reflexive listening	Not present or technical difficulties

To what extent did each participant take part in conversations with other group members?

To an extremely small extent	To a very small extent	To a small extent	To a moderate extent	To a large extent	To a very large extent	To an extremely large extent	No answer
1	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Does not contribute, but is present throughout	Instances of non-verbal communication (e.g. smiling, nodding, laughing)	Frequent non-verbal communication (e.g. smiling, nodding, laughing)	Responds to peer at least once + frequent active listening + instances of reflexive listening	Responds to peer at least twice + frequent of active listening + instances of reflexive listening	Responds to peer at least 3 times + frequent active listening + instances of reflexive listening	Responds to peer at least 4 times + frequent active listening + frequent reflexive listening	Not present or technical difficulties

Appendix F

Control Arm Measures

Figure F1

Treatment Integrity Checklists

Checklist for Week 1: The (virtual) home visit
❑ Overview of program explained. ❑ Exercise prescription completed. ❑ Borg scale explained (scale found in home diary). ❑ Home diary given and explained. ❑ Exercise goals (week 1) page completed. ❑ Exercise diary (week 1) first column completed. ❑ Excel sheet filled in. ❑ Weekly appointment time set with participant.
Checklist for Week 2: The first phone call
❑ Focus of the phone call was agreed upon. ❑ Exercise experiences from the previous week have been comprehensively discussed. ❑ Reflective statements were used. ❑ DARN statements were used. ❑ Exercise goals for the following week have been set with the participant (and goals page filled out in diary). ❑ Exercise prescription has been updated in the diary (as needed). ❑ Excel sheet filled in. ❑ Participant is available for the phone call the following week.
Checklist for Weeks 3-7: Weekly phone calls
❑ Exercise experiences from the previous week have been comprehensively discussed. ❑ Reflective statements were used. ❑ DARN statements were used. ❑ Exercise goals for the following week have been set with the participant (and goals page filled out in diary). ❑ Exercise prescription has been updated in the diary (progression when appropriate). ❑ Excel sheet filled in. ❑ Participant is available for the phone call the following week.
Check list for Week 8: The final phone call
❑ Exercise experiences from the previous week have been comprehensively discussed. ❑ Reflective statements were used. ❑ DARN statements were used. ❑ Exercise goals for the following week have been set with the participant (and goals page filled out in diary). ❑ Exercise prescription has been updated in the diary (progression if appropriate). ❑ Maintenance options offered. ❑ Excel sheet filled in. ❑ A follow up video call for the post-program assessment has been scheduled.

Figure F2

Treatment Differentiation Checklist

Treatment differentiation checklist for Weeks 1-8

While the intervention behaviour protocol from the video program is not meant to be followed in the phone program, we understand that there is likely to be some overlap. **Please place a checkmark next to any behaviours that were used during your phone call session.** Descriptions and examples of each behaviour can be found in the video program training manual.

- ❑ Acknowledge and support perspectives
- ❑ Provide a rationale for suggestions
- ❑ Provide choice
- ❑ Adapt exercises to individuals' needs/capabilities
- ❑ Connects exercises to daily and social activities
- ❑ Demonstration of behaviour
- ❑ Focus on past success
- ❑ Instruction on how to perform a behavior
- ❑ Provide positive feedback
- ❑ Task climate
- ❑ Verbal persuasion about past capability
- ❑ Act in a warm and caring way and avoid judgment or blame
- ❑ Express empathy

Figure F3

Week 1 Exercise Diary Page

Week 1 – My Exercise Diary

Day **Date**	**Monday** / /	**Tuesday** / /	**Wednesday** / /	**Thursday** / /	**Friday** / /	**Saturday** / /	**Sunday** / /
Shortness of breath?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
Exacerbation?	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
If you answer 'yes', please follow the instructions on page 5.							
My endurance exercises Type:_____ Duration: (goal)_____ Steps/distance: (goal)_____ Breathing score: (goal)_____ Leg score: (goal)_____							
My strengthening exercise 1. 2. 3. 4. 5.							
Comments							

Appendix G

Examples of Peer Support From Intervention Participants

Emotional	Appraisal	Informational
• P2 explains that they could not dance the entire time. P1 says "but you got up and you tried!" • P1 empathizes with P3 about feeling guilty for not exercising by stating that this it must be difficult and miserable to feel guilty. • P2 says that they are very impressed with what P1 accomplished (i.e. losing 200 pounds). • P3 tells P1 that they their story was "very nice".	• P1 agreeing with P3 that they have experienced a lot of failure and disappointment when it comes to setting goals. • P1 agreeing with P3 that short goals are easy, but achieving long term goals is very difficult. • P2 talks about dancing and P1 chimes in "I love dancing". • P1 agreeing with P3 that any exercise is good exercise, doesn't matter if you completed what you set out to do or not. • P4 agreeing with P2 that stacking wood takes one's breath away. • P4 agreeing with P2 that breathlessness makes everything more difficult. • P1 telling P3 that he has no reason to feel guilty because he is doing his best. "You worked out, you walked the dogs once. That's a good accomplishment right there". • P1 agreeing with P3 that the program went by too fast. • P3 agreeing with P1 that music could help bring more enjoyment to exercising	• P2 tells the group about a man who has his own dancing show on WABC every Saturday night. • P2 says that they want to be able to dance for an hour, but says it's really unattainable and laughs. P3 explains that that could be a long-term goal (i.e. outcome goal). • P3 tells the group that if you breathe properly, you can exercise longer. • P3 explaining that if you breathe properly from the beginning of a bout of exertion (e.g. going up a hill) you will be able to pace yourself and succeed. • P1 discussing when to breathe in and when to breathe out during exercise. • P3 explaining how it is good to breathe through the nose since breathing through the mouth can lead to coughing. • P4 explains to P3 how to access the intervention booklet • P1 tells P3 about the importance of bending one's knees when raking to avoid hurting one's back. P1 also discussed this new kind of rake that helps protect the back. • P1 provides some information to P3 about nutrition and instead of thinking of it as "dieting" think of it as changing your eating habits. • P1 provides suggestions on how to diet. One suggestion was to reduce portion sizes before making substitutions because it is easier. P1 learned this information from a nutritionist and lost around 200 pounds. • P7 demonstrating and explaining pursed lip breathing.