ANGLIA RUSKIN UNIVERSITY

FACULTY OF MEDICAL SCIENCES

PHYSICAL ACTIVITY, HEALTH STATUS AND HOSPITAL ADMISSION IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE FOLLOWING PULMONARY REHABILITATION

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A thesis in partial fulfilment of the requirements of Anglia Ruskin University for the degree of Doctor of Philosophy (PhD)

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DEDICATION AND ACKNOWLEDGEMENTS

I dedicate this work to my parents Mr Igbekele Charles and Mrs Margaret Meshe (May they rest in peace) and my siblings who have supported, encouraged and inspired me in accomplishing my goals in life.

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ABSTRACT

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Background: Despite the several benefits of post-rehabilitation Community-based Exercise Programmes (CEPs) to people with COPD, it is unclear whether these patients objectively improve their levels of daily physical activity (PA) and whether this is associated with improvement in other clinical outcomes. **Methods:** A mixed-methods sequential explanatory study design was applied. Daily PA (accelerometers, model AM300), health status (Saint George's Respiratory Questionnaire, SGRQ), exercise capacity (6MWD testing), pulmonary functional, FEV_1 (spirometry) and number of hospital admission (self-reporting) were measured at time points 1 (start of study) and 2 (after 3 months) of a CEP in 26 participants with COPD (mean [±SD] age, 73±7 years; FEV_1, 64±19% predicted). Participants' views of the benefits, barriers and enablers of participation were also explored. **Results:** Levels of daily PA improved moderately (42 minutes/day on moderate-intensity PA) but not significantly. Health status, 6MWD and FEV_1 improved while hospital admission reduced significantly after 3 months (all $p< 0.05$). Daily PA correlated positively with 6MWD ($r = 0.40$, $p=0.046$) and negatively with health status ($r= -0.52$, $p=0.006$) and number of hospital admission ($r= -0.394$, $p<0.05$). Changes in levels of daily PA correlated positively with changes in 6MWD ($r= 0.31$, $p= 0.048$) and negatively with changes in health status ($r= -0.65$, $p= 0.0001$). Only health status significantly predicted levels of daily PA (Beta= -0.47, t= -2.85, $p=0.009$, $R^2_{adjusted}= 0.38$). These results were enabled by six factors; ease of access to PA intervention, convenient programme components, being retired, feeling safe, social support and seasons. Four barriers to activity participation were identified; poor physical health, family commitments, transport difficulties and other commitments. **Conclusion:** Moderate improvement in levels of daily PA produced by a CEP is associated with improvements in clinical outcomes in people with COPD. Strengthening enablers of adherence to the programme is important to achieving the goals of COPD management.

Key words: Chronic obstructive pulmonary disease; physical activity; exercise; improvement; post-rehabilitation; barriers; facilitators.

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LIST OF ABBREVIATION/NOTATION

Abbreviation	In full
COPD	Chronic Obstructive Pulmonary Disease
PA	Physical Activity
PAM	Physical Activity Monitor
AM300	Activity Monitor, model 300 (PAM BV Doorwerth, the Netherlands)
6MWD	Six-Minutes Walking Distance (a measure of exercise capacity)
HRQoL	Health-Related Quality of Life
QOL	Quality of Life
SGRQ	Saint George's Respiratory Disease Questionnaire
SHAQ	Self-Reported Hospital Admission Questionnaire
CEP	Community-based Exercise Programme
PR	Pulmonary Rehabilitation
PRP	Pulmonary Rehabilitation Programme
REPs	Registered Exercise Professionals
FVC	Forced Vital Capacity
FEV_1	Forced expiratory volume in one second
GOLD	Global Initiative for Chronic Obstructive Lung Disease
BTS	British Thoraxic Society
ATS	American Thoraxic Society
ERS	European Respiratory Society
ACSM	American College of Sports Medicine
WHO	World Health Organisation
NHS	National Health Service
NICE	The National Institute for Health and Care Excellence
BLF	British Lung Foundation
SD	Standard deviation
MCIDs	Minimally Clinically Important Differences

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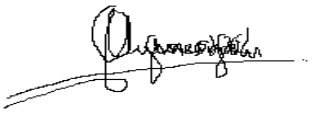
"I declare that this thesis was composed by myself and that all data were collected and analysed by myself, with supervision by academic staff. Neither the thesis nor the original work therein has been submitted to this or any other institution for a higher degree"

Signature: 

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CHAPTER ONE

INTRODUCTION AND OUTLINE OF THE THESIS

1.0 Introduction

This study investigated the relationship of physical activity (PA) with measures of health status and hospital admission in people with chronic obstructive pulmonary disease (COPD) following pulmonary rehabilitation (PR). This introductory chapter presents the general background, rationale, importance and research questions of the study as well as its contribution to the field of PA research in people with COPD. The chapter ends with a brief outline of the entire thesis.

PA is an important health indicator (World Health Organisation, WHO, 2014a) and its robustly documented health benefits in the general population (Warburton, Nicol and Brendin, 2006; Nelson, et al., 2007; Lee, et al., 2012) have supported its recommendation for healthy individuals of different age groups (WHO, 2010; 2013; National Health Service, NHS, 2013). Despite the PA recommendations for health, several factors have significantly influenced the health of people globally and resulted in unhealthy environments and behaviours, especially increase in sedentary lifestyle which has huge health concerns. For example, physical inactivity is currently the fourth leading mortality predictor, accounting for 6% of deaths globally (WHO, 2013a) and over 25% of the burden of the burden of non-communicable diseases (NCDs) such as colon cancer, breast cancer, ischaemic heart disease and diabetes (WHO, 2009). Promoting increase levels of PA participation is an important priority for the management of NCDs and part of the global effort to reduce the burden of physical inactivity.

A significantly higher proportion of people are still physically inactive in the general population (Dumith, et al., 2011). In their investigation of the prevalence of physical inactivity among 300,000 people (aged ≥ 15 years) from 76 countries, Dumith, et al. (2011) reported that 17.4% (95% CI 15.1–19.7) of the global population were physically inactive, necessitating research into factors responsible for the prevalence of inactivity in healthy adults. Age has been identified as a major risk factor. Troiano, et al. (2008) and Hallal, et al. (2012), observed that level of PA declines with increasing age in healthy individuals. Although level of PA declines with increasing age, experience of chronic diseases were found

to further reduce levels of PA in healthy individuals (Garcia-Aymerich, et al., 2004; Troiano, et al., 2008). For example, COPD, a disease common among older adults (Vestbo, et al., 2013) significantly reduced activity participation. People with COPD are less active in daily life than people of a similar age without the disease (Pitta, et al., 2005a; Hernandes, et al., 2009; Arne, et al., 2009; Troosters, et al., 2010).

COPD is one of the world's most common respiratory health problems characterised by remodelled and narrowed airways leading to airflow obstruction and laborious breathing. The main risk factor for COPD is exposure to harmful substances, predominantly cigarette smoking (Vestbo, et al., 2013). Three major clinical symptoms of COPD include chronic cough, sputum production and dyspnoea (shortness of breath) (Vestbo, et al., 2013; Kessler, et al., 2011; Vandevoorde, et al., 2007). The disease is associated with significant chronic morbidity and mortality as well as social and economic burdens (WHO, 2013a; Gibson, et al., 2013). Currently, COPD ranks as the fourth leading cause of death worldwide (WHO, 2017) accounting for 3.2 million deaths in 2015. Murray and Lopez (1997) predicted that COPD will be the third leading cause of death by 2020.

COPD primarily affects the lungs but has considerable systemic consequences (Fabbri, et al., 2008; Vestbo, et al., 2013). For example, it is associated with fatigue and skeletal muscle wasting (Seymour, et al., 2010) which have been linked to reduced levels of PA (Wust, et al., 2008; Barnes and Celli, 2009). The levels of recommended PA are significantly lower in people with COPD than in people of similar age without COPD (Pitta, et al., 2005a) and those with other chronic conditions, e.g. diabetes mellitus and rheumatoid arthritis (Arne, et al., 2009). People with COPD also spent less time on walking compared with people of similar age without COPD (Hernandes, et al., 2009; Vorrink, et al., 2011) and walk slower (Pitta, et al., 2005a). The extent of airflow limitation (COPD severity, classified as GOLD stages I, II, II, IV) appears to be related with levels of PA, with one study (Watz, et al., 2009a) reporting reduced levels of PA from GOLD Stage II and reduced time spent in moderate activity from GOLD Stage III. A more recent study found that, overall, people with COPD tend to decrease their levels of PA before the disease becomes severe (Gouzi, et al., 2011; Shrikrishna, et al., 2012; van Remoortel, et al., 2013a). In general, they are unable to perform PA that meets the current levels recommended for health (WHO, 2010). This reduced level of PA in this population has significant implications which are summarised below.

1.1 Implications of physical inactivity in COPD

Physical inactivity is considered a key clinical factor associated with high morbidity and mortality in several chronic diseases including COPD (Geneau, et al., 2010; Vestbo, et al., 2013). 6% of deaths worldwide are attributed to physical inactivity, making it the fourth primary risk factor for death (WHO, 2010). There is some evidence to suggest that a decrease in levels of PA is associated with adverse health outcomes such as decline in pulmonary function and health status and increased number of hospital admission and readmission. Some population-based studies have reported that levels of PA are inversely related with the degree of pulmonary function deterioration (Jakes, et al., 2002; Pelkonen, et al., 2003; Garcia-Aymerich, et al., 2007; 2008). Nevertheless, the relationship reported between reduced levels of PA and rapid pulmonary function decline was not consistent in these studies, possibly due to selection bias, not controlling for potential confounders and not considering changes in levels of PA during participants' follow-up.

A lower level of PA is associated with reduced health status and higher number of hospital admission. For example, a reduction of activity levels (classified as very low) and by ≥30 meters in six minutes walking distance (6MWD) has been correlated with reduced health status and increased risk for hospital admission (Garcia-Aymerich, et al., 2003; 2006). When 173 people with COPD participated in a 5-8 years longitudinal study, the time to first hospital admission due to COPD was shorter in participants who were less physically active compared to more physically active participants (Garcia-Rio, et al., 2012). Another study (Pitta, et al., 2006a) reported that people with COPD are particularly inactive during and after discharge from hospital. In the same study, inactivity after discharge from hospital was shown to correlate with readmission within the following year.

Levels of PA have been demonstrated as the major predictor of self-rated general health and HRQoL in people with respiratory problems such as COPD. One prospective study reported that people with moderate to high levels of PA had an enhanced HRQoL than those who maintained low levels of PA (Esteban, et al., 2010). Furthermore, a cross-sectional survey of participants with COPD (n=1,500) found that the likelihood of experiencing improved self-rated general health increased about 2.4–7.7-fold and the probability of having psychological distress reduced by approximately 50% in participants who maintained higher PA levels (Arne, et al., 2011). Generally, more physically active people with COPD experience better functional status measured by respiratory function test, expiratory muscle strength, exercise

capacity, maximal oxygen uptake and reduced systemic inflammation, compared with those who were less physically active (Garcia-Aymerich, et al., 2009). The adverse health outcomes associated with reduced levels of PA make increasing activity levels an important goal of COPD management (Vestbo, et al., 2013). The next section highlights the different interventions for managing COPD, particularly those for improving levels of PA.

1.2 Current interventions for improving physical activity in COPD

No definitive cure has been established for COPD. In general, patients are managed with several pharmacologic and non-pharmacologic therapies (Vestbo, et al., 2013). This section focuses only on the strategies for improving levels of PA.

1.2.1 Medications

While it has been clearly shown that bronchodilators, medications that increase the size of the airways, improve patients' lung function, health status and experiences of breathlessness at rest and during exertional activity (Westwood, et al., 2011; Tashkin and Cooper, 2004; Boni, et al., 2002), limited number of studies (n=4) have reported on the influence of medications on levels of PA (Kesten, et al., 2008; O'Donnell, et al., 2011; Hataji, et al., 2013; Troosters, et al., 2014). In two of the four studies, bronchodilators positively improved patients' levels of PA (Kesten, et al., 2008; Hataji, et al., 2013). While one of the two studies (Hataji, et al., 2013) was a non-randomised open-label clinical study (with no placebo group and no blinding) of 150μg of inhaled indacaterol in 23 patients, the other (Kesten, et al., 2008) was a randomized, double-blind, parallel-group, placebo-controlled trial. In contrast, two other randomised, placebo-controlled studies (O'Donnell, et al., 2011; Troosters, et al., 2014) did not observe any significant difference in levels of PA in participants with COPD following the use of a long-acting bronchodilator. Due to these inconsistencies, it remains presently unclear whether pharmacological therapies that are capable of improving patients' lung function, health status and exercise capacity will also positively improve or prevent decline in their levels of PA over time.

1.2.2 Oxygen therapy

Similar to the impact of pharmacological therapies, ambulatory oxygen therapy increases exercise capacity in COPD patients with low plasma concentration of oxygen (Bradley, et al., 2007). Whether or not oxygen therapy influences levels of PA remains unknown. When Garcia-Aymerich, et al. (2004) assessed levels and determinants of PA practice in people

with severe COPD, they found that long-term oxygen therapy was independently associated with a low level of PA. This finding agrees with that reported by Sandland, et al. (2005). Hence, it can be assumed that the use of oxygen therapy to increase levels of daily PA is unnecessary. Results from a more recent study of the impact of ambulatory oxygen therapy on patterns of PA in people with COPD reinforced this assumption (Casaburi, et al., 2012). The authors reported that the oxygen therapy did not improve participants' levels of PA measured with activity monitors over a 6-month period. Furthermore, findings from the study conducted by Nonoyama, et al. (2007) supported using oxygen therapy only by people with COPD who meet the criteria for mortality reduction with the intervention.

1.2.3 Behavioural change modifications and self-regulation

It has been robustly demonstrated that people with high exercise tolerance have increase levels of PA (Pitta, et al., 2005b; 2008; Garcia-Rio, et al., 2009; Watz, et al., 2009; Waschki, et al., 2012; van Gestel, et al., 2012). However, increasing exercise tolerance alone may not be adequate enough to increase levels of PA in daily life, particularly self-directed leisure time PA (Coronado, et al., 2003; Steele, et al., 2003a; Sewell, et al., 2005; Egan, et al., 2012). The acknowledgement of the problems associated with patients' ability to maintain their regular exercise habits has resulted in understanding some of the behavioural factors related to participation in daily PA as well as the development of strategies targeting the identified factors.

Some of the strategies that can potentially modify patients' PA behaviours include counselling and self-monitoring of levels of PA using activity monitors (Moy, et al., 2012; de Blok, et al., 2006; Nguyen, et al., 2009). Nevertheless, the evidence in support of these interventions is weak because some of the studies recruited small numbers of participants (de Blok, et al., 2006), while others did not have any control groups (Moy, et al., 2012; Nguyen, et al., 2009). Studies with higher sample sizes and follow-up for a longer duration will be needed to produce more robust evidence.

Some components that are required to make behavioural interventions effective have previously been reviewed and summarised (Conn, et al., 2008; Greaves, et al., 2011). These included, but are not limited to, strengthening support from social network, supporting people to solve problems, set goals, develop action plans, prevent relapse, be self-motivated and improve self esteem and belief. Motivational interviewing techniques was also suggested as a

strategy to effectively collaborate and communicate with people in order to achieve desired behavioural changes (Greaves, et al., 2011).

1.2.4 Pulmonary Rehabilitation (PR)

PR is defined as a *"comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education, and behavior change, designed to improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors"* (Spruit, et al., 2013, p. e14). PR has become the cornerstone of COPD management (Vestbo, et al., 2013). The components of PR vary widely but a comprehensive programme includes supervised exercise training, self-management education, nutritional counselling, psychological and social support (Yohannes and Connolly 2004; Desveaux, et al., 2014a). The main objectives of PR are to ensure a reduction in symptoms, improvement in quality of life (QOL) and levels of PA in daily life (Vestbo, et al 2013). To accomplish these goals, PR covers several non-respiratory problems such as exercise de-conditioning, social isolation, depression, skeletal muscle wasting weakness and weight loss that may not be treated by existing medications for COPD. The effects of PR on COPD severity and patients' response to this intervention have featured in COPD research in the last three decades.

It is difficult to accurately assess the severity of COPD and how patients respond to PR. Spirometry results (Forced Expiratory Volume in 1 second, FEV1, and Forced Vital Capacity, FVC) are the traditional measures used, but these have been shown to correlate poorly with vital clinical features of the disease, particularly HRQoL, QOL and survival (Domingo-Salvany, et al., 2002). Besides, the systemic effects of COPD, for example weight loss, muscle weakness and reduced PA (Barnes and Celli, 2009) are only poorly related to lung function. Therefore, FEV1 remains a key outcome. Other clinical outcomes are currently included in the overall assessment of COPD severity and/or response to pharmacological and non-pharmacological interventions. Examples of these outcomes include measurement of functional outcomes, such as dyspnoea indexes and exercise tolerance tests and globally recommended clinical outcomes, such as disease specific HRQOL and assessment of frequency and severity of acute exacerbations (sudden worsening of COPD symptoms that typically lasts for several days) which may lead to hospital admission or increase health service use (Gross, 2005; Vestbo, et al., 2013).

PR clearly improves exercise capacity, reduces dyspnoea and improves health status in people living with COPD (Egan, et al., 2012; Ries, et al., 2007; Verrill, et al., 2005). A combination of behavioural change interventions and those capable of improving exercise capacity can potentially increase levels of PA in patients with COPD. In spite of this rationale, the studies that investigated the impact of PR on levels of PA have reported inconsistent results. For example, four studies (Walker, et al., 2008; Sewell, et al., 2005; Mercken, et al., 2005; Pitta, et al., 2008) have demonstrated that PR increased levels of PA, while six studies (Coronado, et al., 2003; Steele, et al., 2003a; 2008; Dallas, et al., 2009; Mador, et al., 2011; Egan, et al., 2012) observed no improvement in participants' levels of PA after participating in PR programmes, even though there was a concomitant improvement in exercise capacity and health status. When Cindy, et al. (2012) performed a systematic review and meta-analysis of studies that investigated the impact of exercise training, which is a key component of PR (Desveaux, et al., 2014a), they found a significant relationship (with small effect size) between exercise training and increased levels of PA.

1.3 Rationale for this study

PR programmes are clinically effective and cost-effective interventions for improving exercise capacity and health status, reducing symptoms, duration of hospital stay and frequency of re-admissions for people with COPD (Egan, et al., 2012; Ries, et al., 2007; Verrill, et al., 2005; Seymour, et al., 2010; Holland, et al., 2017). They have also been shown to reduce mortality due to their modifying effects on prognostic indicators such as levels of daily activity, exercise tolerance, HRQoL and dyspnoea (Bowen, et al., 2000; Egan, et al., 2012; Verrill, et al., 2005). An earlier review of six trials including 230 patients (Puhan, et al., 2005) found that PR was associated with an -11.1 points (95% CI= -17.1 to -5.2) improvement in SGRQ's total score and reduced risk for hospital admissions (RR= 0.26; 95% CI= 0.12–0.54) and mortality (RR= 0.45; 95% CI= 0.22–0.91). A more recent study of the effects of a PR programme delivered after patients were treated for COPD exacerbations, found a decrease in hospital re-admissions of 26% (p=0.02) with cost effectiveness demonstrated (Seymour, et al., 2010). The robust evidence from these studies has provided a strong support for the use of PR programmes in a variety of settings, including the community, as well as making the case for service commissioning in the UK (The National Institute for Health and Care Excellence, NICE, 2006; 2010).

Benefits from PR appear to be short-lived. The improvements in outcomes, which were mostly observed after short-courses (4-12 weeks) of PR diminish significantly anytime from 1-24 months after programme completion (Egan, et al., 2012; Heppner, et al., 2006; Karapolat, et al., 2007; Holland, et al., 2017). Consequently, the latest clinical guidelines of the Global Initiative for Chronic Obstructive Lung Disease, GOLD (Vestbo, et al., 2013) now advocate regular exercise and activity for improving and sustaining initial benefits from PR. In accordance with these guidelines, health professionals refer graduates of PR programmes to home and/or community-based Exercise Programmes (CEPs) to maximize their functional ability (Hogg, Grant and Fiddler, 2012; Lewis and Cramp, 2010).

The effectiveness of post-PR CEPs has become an area of interest in the management of patients with COPD. In their review of studies that investigated the medium and long-term benefits of the post-PR CEP, Beauchamp, et al. (2013) found that, at 6 and 12 months following participation in PRPs, there was no difference between post-PR CEPs and usual care for HRQoL (SMD, -0.07; 95% CI, -0.29-0.14; P=0.50) and (SMD, -0.15; 95% CI, -0.42-0.13; P=0.30) respectively. However, a significant difference in exercise capacity (SMD, -0.20; 95% CI, -0.39 to -0.01) was reported at 6 month, but this was not sustained at 12 months (SMD, -0.09; 95% CI, -0.29-0.11). In this review, the effectiveness of CEPs was reported, but whether or not CEPs influence levels of PA remains to be investigated. There were also no reports of statistical measures of association between levels of PA and clinical outcomes such as HRQoL and number of hospital admission. Hence, the purpose of this investigation is to examine whether CEPs increase patients' levels of daily PA as well as determine whether participants' levels of PA are associated with clinical outcomes.

At the start of the present project there existed no data regarding (a) the influence of CEPs on levels of free living PA (b) the relationship between levels of free living PA and measures of health status and hospital admissions in people with COPD attending CEP following PR. Therefore, the clinical implications of a post-PR change in levels of daily PA are unclear in this patient population. In addition, participants' views of the benefits of post-PR CEPs are less routinely assessed. Further research seems necessary to contribute to knowledge in these areas. The importance, aims, and research questions of this study are discussed as follows.

1.4 The focus of the study

The study setting was an ongoing community exercise programme (CEP). The CEP presents an opportunity for participants to exercise and be active after completing an 8-week hospital based pulmonary rehabilitation programme (PRP). Inactivity alone can reduce muscle strength and other body functions and outcomes (Troosters, et al., 2013; Wascki, et al., 2015). It takes a very short time (a few weeks) for levels of PA to decrease in people with COPD. Levels of daily PA measured by energy expenditure, decreased by about 7,572 kcal/week in a study by Wascki, et al (2015). This level of decline is paralleled by deterioration in clinical outcomes such as health status and pulmonary function. In addition, prolonged period of physical inactivity is associated with a progression of skeletal muscle wasting and exercise intolerance (Wascki, et al., 2015). Hence, patients' improvement in outcomes may also occur due to reversing inactivity (considered in section 2.8).

Participants were referred to the programme from the PRP. The major goal of post-PR CEPs is to sustain or maintain benefits of initial PR (Vestbo, et al., 2013). However, for benefits to be maintained it is crucial for improvements in outcomes to first reach a plateau- a point where a participant receives optimal level and cannot improve anymore- in order to prevent rapid decline. It has been demonstrated that deterioration or diminution of benefits of initial PR occurs rapidly (in the first month after rehabilitation), even in COPD patients that are very well motivated (Karapolat, et al., 2007). It is, therefore, essential for patients to improve outcomes until they reach a plateau. This can potentially reduce rapid decline in benefits. Supporting patients to improve outcome until they reach a plateau poses a question on whether or not they have the capacity to improve these outcomes above and beyond the level they achieved immediately after a short period of the initial PRP.

The patients with COPD in the studies reviewed by Beauchamp, et al. (2013) further improved their 6MWD after 6 months of participating in post-rehabilitation CEPs. As it is now known that 6MWD correlates with outcomes such as muscle weakness, levels of daily PA, health status and number of hospital admission (Shrikrishna, et al., 2012; Tsiligianni, et al., 2011; Spruit, et al., 2012), it can be argued that, from a physiological point of view, if participants attending post-PR CEPs improve their 6MWD above and beyond that achieved immediately after a short period of PRP, there is capacity for them to also improve other clinical outcomes. In addition, it is possible for them to improve until they reach a plateau.

This appeared to be the case when 6MWD and HRQoL did not improve significantly at 12 months following PR (Beauchamp, et al., 2013).

This study, therefore, focused on investigating whether or not participating in a post-PR CEP is associated with improvement in clinical outcomes (levels of daily PA, health status, pulmonary function, exercise capacity and number of hospital admission) which were mostly not assessed by Beauchamp, et al. (2013). These outcomes were measured at two time points- start of the study (Time Point 1) and 3 months after participating in the CEP (Time Point 2). A consideration of the main goal of COPD (to improve daily PA) informed the researcher's decision to consider levels of daily PA as the primary or dependent outcome of the study. As a result, the study investigated: (a) whether the CEP improved participants' levels of daily activity and other outcomes and (b) the clinical implications of a change in levels of daily PA i.e. to know whether a change in levels of daily activity is associated with changes in other clinical outcomes.

Previous studies of the effectiveness of post-rehabilitation exercise programmes studied people beginning the programmes (Beauchamp, et al., 2013). It is worth mentioning that 17 of the participants in this study had been attending the CEP for some time before the commencement of the study (see Figure 21, p.188). 10 participants had been attending for 1-3 years, 7 for 4 years while 9 recently enrolled. This may raise doubt regarding why measured outcomes were expected to improve over the 3 months of the study. The rationale for recruiting both existing and consecutive participants was the observation (from participants' exercise recording sheets) that those who had been attending the class for >1 years had not been attending regularly compared to newly referred/enrolled participants (<1 year). Attending a long rehabilitation programme is an independent predictor of low adherence (Sabit, et al., 2008). This observation was one of the rationales for the qualitative part of the study that explored barriers and facilitators of adherence. There is evidence that diminution of benefits of pulmonary rehabilitation occurs rapidly and with tendency to return to baseline values (from the 4 weeks after rehabilitation) in people with COPD who do not enter CEPs (Verrill, et al., 2005; Heppner, et al., 2006; Karapolat, et al., 2007; Egan, et al., 2012). Irregular attendance and subsequent drop out from a rehabilitation programme was associated with 18% reduction in FEV_1, dyspnoea and 6MWD scores (Cote and Celli, 2005). By interpretation, benefits would have diminished, at least to some extent, in participants who do not attend regularly. Hence, their levels of daily PA and other measured outcomes were

expected to improve over the 3 months of the study. In addition, arguably the PA monitors and outcome measurements were interventions; hence improvements in outcomes may have been due to reactivity- a change in participants' behaviour resulting from data collecting procedures (Nelson and Hayes, 1981; Rachele, et a., 2012). However, reactivity was minimised as described in section 5.4.3 (p.136-137).

1.5 Importance of the study

Establishing the post-PR relationship between free living PA and clinical outcomes such as health status, exercise capacity, pulmonary function and hospital admission will be of public health significance. Any identified association may help improve understanding about the likelihood of poor health status and hospital admission given a person's current PA levels in the post-rehabilitation phase of COPD management.

The qualitative component of this study explored the effectiveness of a CEP from participants' perspectives as well as barriers and facilitators that may influence the observed relationship between outcomes. It also identified distinctive issues that were not captured by objective instruments for measuring activity and other clinical outcomes. This study potentially has practical implications for rehabilitation professionals.

1.6 Research questions

1.6.1 Primary Research questions

(a) Does participation in a Community-based Exercise Programme improve clinical outcomes in people with COPD following pulmonary rehabilitation?

(b) Is there a relationship between free living daily PA and measures of health status and hospital admission in people with COPD following pulmonary rehabilitation and participation in a community-based Exercise Programme?

(c) Can any of the clinical variables such as health status, pulmonary function, exercise capacity and number of hospital admission predict levels of daily PA following pulmonary rehabilitation?

1.6.2 Secondary Research questions

(a) What are participants' views of the benefits of a community-based exercise programme to which they were referred after completing initial pulmonary rehabilitation?

(b) What helps people with COPD to be able to attend the weekly exercise classes and what makes it more difficult for them to attend?

To answer these questions three separate studies, with distinct aims were performed (see Figure 1)

1.7 Contribution to knowledge

In a discussion of the future research agenda relating to the significance of promoting, improving and evaluating levels of PA in people with COPD, Watz, et al. (2014) identified four important areas for future research studies:

(i) Enhancing the benefits of therapeutic interventions for increasing activity levels

(ii) Understanding how rehabilitation specialists can help people with COPD translate the benefits of an intervention (e.g. improvements in outcomes such as breathlessness, exercise capacity, and self-management) into being more physically active in daily life.

(iii) Standardising objective methods of measuring PA and guidance on how this should be done.

(iv) Exploring participants' experiences of PA participation.

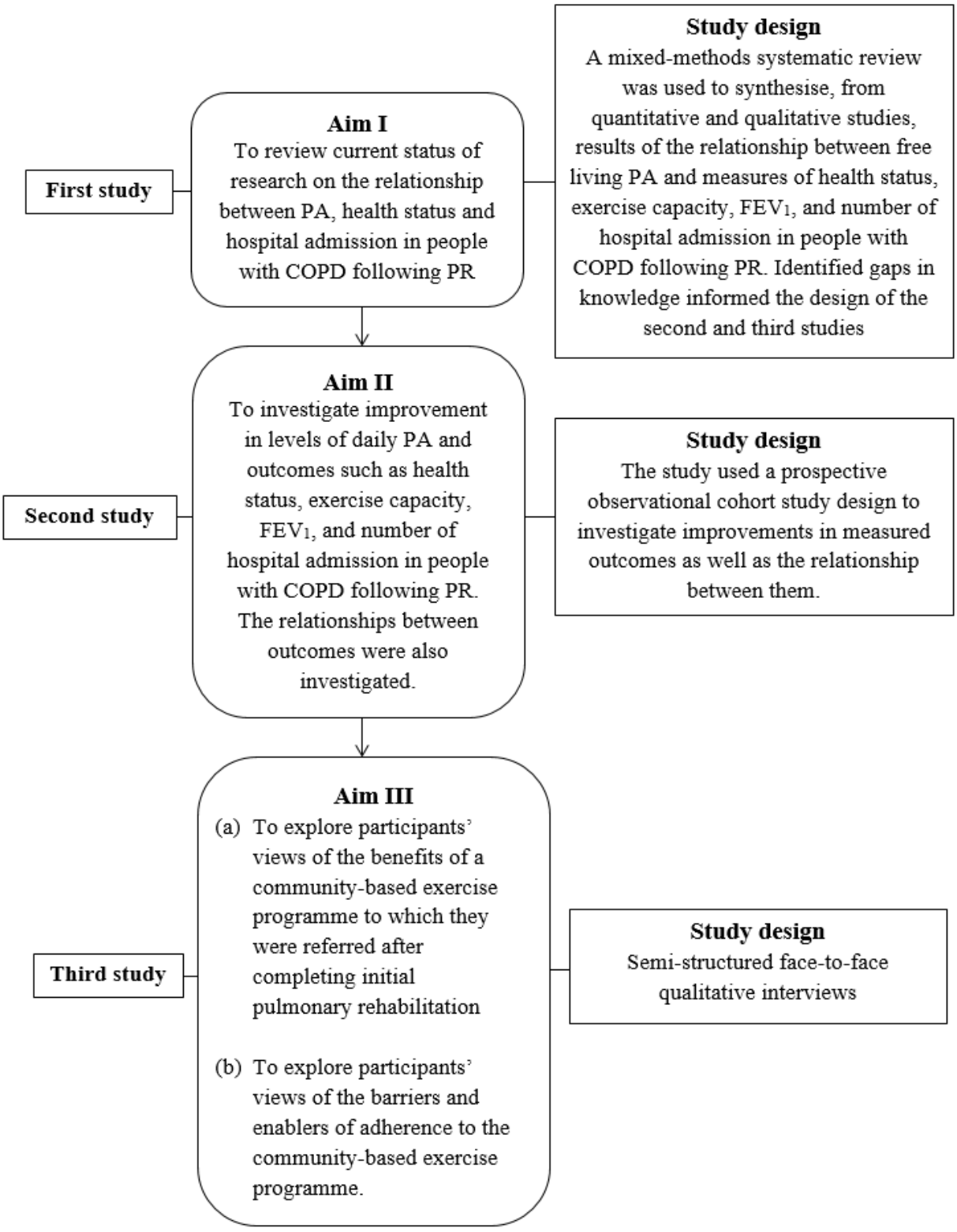
This study contributes to the field by investigating the benefits of a non-pharmacological intervention (CEP) that aim to increase participants' levels of daily PA and other outcomes in people with COPD following PR. It advances our knowledge on the impact of a post-PR CEP on objectively and subjectively measured clinical outcomes such as free living daily PA, health status, exercise capacity, pulmonary function and hospital admission. An insight into the relationship of daily PA with clinical outcomes was improved. There is much scope for

additional studies on the relationship between daily PA and relevant clinical outcomes, with a priority on using larger sample size, longer follow-up period and accounting for confounding variables.

Lastly, this study contributes to the field by identifying a distinct cycle of PA in the post-rehabilitation phase of COPD management. A model of two mutually exclusive cycles of PA which are linked by PR was proposed. Addressing the facilitators and barriers to activity participation in the the post-rehabilitation phase suggests that the mutual-exclusivity of both cycles can help foster higher levels of daily PA. The data and conclusions may help rehabilitation professionals and social supporters know how to make rehabilitation programmes more long-lasting, help people with COPD become more physically active and improve well-being following PR.

Further studies of sedentary behaviours of people with COPD and those exploring why they engage in sedentary behaviours in the post-rehabilitation phase are warranted to provide further information for designing future CEPs. In addition, additional studies are required to fully understand whether or not the two cycles of physical activity and inactivity are mutually exclusive. A discussion of the entire outline of this thesis is presented in the next section while the next chapter is dedicated to the study's literature review.

Figure 1: Flow chart of thesis outlining the aims of the studies



1.8 Outline of this thesis

This thesis is presented in nine chapters.

Chapter one- this introductory chapter will present the general background, rationale for the need of the study, importance and research questions of the study as well as its contribution to the field of PA research in people with COPD post-PR.

Chapter two- reviews existing literature relevant to the study; COPD and PA. It highlights the meaning, epidemiology and aetiology, pathophysiology, diagnosis and classification of severity, clinical symptoms and the systemic effects of COPD. Particular attention will be given to the constructs of PA and the international consensus documents on recommended levels of PA and its measurement in relation to the general population and in people with COPD. PA guidelines and applications in COPD will be discussed. Physical inactivity, its mechanism, measurement and implications in people with COPD will also be outlined. In addition, the chapter presents a discussion of the current empirical knowledge on correlates of PA in people with COPD and concludes that the relationship of PA with clinical outcomes exists pre-PR. Given the robust evidence of the benefits of PR and need for interventions to increase benefits over a long period, the case for additional research to explore relationships post-PR will be presented.

Chapter three- presents a published mixed-methods systematic review article (Meshe et al 2017) that outlines the relationship between free living PA and relevant clinical outcomes (health status, exercise capacity, FEV1, dyspnoea and hospital admission) post-PR. It acknowledges that the observed post-PR associations between outcomes were largely based on PA measured by PA questionnaires and 6MWD tests. Therefore, objective measurement of free living PA and its relationship with clinical outcomes in the post-rehabilitation phase are required along with participants' views to contribute new knowledge.

Chapter four- details the theoretical and conceptual framework for the study. The conceptual model will be developed based on dominant concepts and findings from empirical studies. It concludes with a statement of the different hypotheses that will be used to address the research questions.

Chapter five- provides an overview of the pragmatic philosophical paradigm underpinning the mixed-methods study design (prospective observational cohort study plus qualitative interviews) that will be used to explore the benefits of the CEP as well as the post-PR relationship of objectively measured free living PA with clinical outcomes in 26 participants with COPD. The chapter also details the rationale for the study design along with all components of the study; participants, recruitment process, sample size, methods of data collection and analyses in both phases of the study and ethical issues.

Chapter six- presents the findings from the quantitative phase of this study. The chapter has two sections. The first section highlights the context to which findings can be applied. The second section presents findings from the analyses of quantitative data. It reports on referrals, dropouts from programme, participants' recruitment and characteristics. It also reports on results of all statistical analyses of the relationships between participants' free living daily PA and clinical outcomes.

Chapters seven- This chapter presents the findings from the qualitative phase of the study. It will report on the main themes that will emerge from the semi-structured, face-to-face interviews. The chapter concludes with the integration of quantitative and qualitative findings which provides insights into how participants' characteristics and attitudes may influenced their experiences of benefits of the programme and also explains the reasons for participants' moderate levels of daily activities.

Chapter eight- discusses the key findings of the quantitative and qualitative phases of the study and critically analyses each of the findings specific to the research questions.

Chapter nine presents a discussion of the implications of findings for practice, the strengths and limitations of the study, and recommendations for future research.

1.9 Summary

The general background to this study has been outlined in this chapter. It has highlighted the rationale, importance and research questions of the study. The short-term benefits of pulmonary rehabilitation were identified as the justification for patients' referral to CEPs, while the need to understand the relationship between PA and clinical outcomes along with patients' views in the post-rehabilitation phase necessitated this present study. The study's

contributions to the field of PA research in patients with COPD were also summarised. The chaptering of this thesis has also been summarized. The next chapter is dedicated to the literature review of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides an overview of the literature relating to COPD and PA. Considering the copious amounts of literature related to COPD and PA, discussing all existing literature is beyond the scope of this study. Nevertheless, the literature review was organised to form a coherent flow and address the main points relevant to the study.

The meaning, epidemiology and aetiology, pathophysiology, diagnosis and classification of severity, clinical symptoms and systemic effects of COPD are outlined to help understand participants' diagnosis and position the study. This is followed by a discussion about PA, international consensus documents on recommended levels of PA and its measurement in relation to the general population and in people with COPD. PA guidelines and applications in COPD are discussed. Physical inactivity and its implications in people with COPD will also be summarised. The correlates of PA in people with COPD are included to identify the clinical outcomes that are linked with PA in the literature. The chapter concludes that the relationship existed pre-PR and justifies the need for additional research to explore relationships post-PR.

2.1 Chronic obstructive pulmonary disease (COPD)

2.1.1 Definition of COPD

COPD is defined as a respiratory condition in which the airways are abnormally and characteristically narrowed so much so that airflow is obstructed and breathing becomes very difficult (Vestbo, et al., 2013). The airflow obstruction is often connected with the inflammation of tissues of the airways and lungs in response to harmful particles, especially tobacco smoke (ATS 1999). Although the disease can be prevented and its symptoms can be treated, the obstruction to airflow usually progresses slowly and is mostly irreversible (Vestbo, et al., 2013). COPD is thought to be a combination of bronchitis (an inflammation of the mucous membrane in the lung's bronchial passage), asthma and emphysema (a condition in which the air sacs of the lungs are damaged and enlarged causing impaired respiratory function) (Fischer, Pavlisko and Voynow, 2011). Although COPD primarily affects the lungs,

it produces substantial systemic consequences such as fatigue and cachexia (general physical wasting with loss of weight and skeletal muscle mass) and physical inactivity.

COPD is diagnosed based on the presence of previous exposure to risk factors, a family history of the disease and two key symptoms; breathlessness and chronic cough with sputum production (Vestbo, et al., 2013, see section 2.5 for symptoms of COPD). The extent or severity of airflow obstruction can be assessed by post bronchodilator spirometry and classified based on GOLD guideline (Vestbo, et al., 2013) (Table 1). According to Vestbo, et al. (2013), the severity of COPD is defined by the extent of airflow obstruction which is assessed by measuring decline in forced expiratory volume in 1 second (FEV_1). The guideline uses the measured forced FEV1 as percentage (%) of the predicted FEV1 to diagnose and classify patients with COPD.

Table 1: Clinical guidelines for definition and gradation of COPD severity

Post-bronchodilator FEV1/FVC	FEV_1 % predicted	GOLD Stage	Severity of airflow obstruction
<0.70	≥80%	GOLD I	Mild
<0.70	50-79%	GOLD II	Moderate
<0.70	30-49%	GOLD III	Severe
<0.70	<30	GOLD IV	Very severe*

*OR FEV1 < 50% and respiratory failure (defined as arterial partial pressure of oxygen <8.0 kPa [60 mm Hg] with or without arterial partial pressure of carbondioxide >6.7 kPa [50 mm Hg] while breathing air at sea level) (Vestbo et. al., 2013).

Source: Vestbo, et al. (2013)

2.2 Epidemiology and burden of COPD

COPD is a huge public health challenge as it is associated with significant chronic morbidity, mortality and increasing social and economic impact on society. The current pooled global prevalence of COPD is 11.7% in adults aged ≥40 years (95% CI= 8.4%–15.0%) (Adeloye, et al., 2015). This is higher than the pooled global prevalence of 9.2% (95% CI= 7.2%–11.0%) reported in 2006 by Halbert, et al. (2006) and represents a 69% increase in the number of people living with the disease between 1990 and 2010.

According to the European Health Interview Survey, the mean prevalence of COPD in the WHO EURO region is 3.1% among people aged at least 15 years in 17 European Union (EU)

member states (Eurpean Commission, 2014). In the UK, approximately 3 million people are living with COPD and about 67% of this population are not aware they are living with the disease (National Institute for Health and Clinical Excellence, NICE, 2011). According to the data obtained from the Quality and Outcomes Framework (QOF), the prevalence of diagnosed COPD in England is 1.6%, an equivalence of approximately 819,524 people (NICE, 2011). The same data showed clear variation in COPD prevalence across different strategic health authorities, ranging from 0.9% in London to 2.3% in the North east. Like in other countries (Schimhofer, et al., 2007) the observed prevalence of COPD in the UK is also influenced by age. The prevalence of diagnosed COPD for people aged between 45–54 years is <1% increasing to >5% for people aged ≥65 years (NICE, 2011). It is worth noting that the percentage increase in COPD cases is lowest in Europe region (22.5%) compared to other WHO regions (Adeloye, et al., 2015). This may be due to the decrease in prevalence of smoking as a result of legal regulations and intensive public health interventions in Europe.

Often, results of the burden of a health problem analyses are expressed as number of Disability-Adjusted Life Years, DALYs, lost due to the disease or injury. One DALY corresponds to the loss of one year of life free of the disease; hence the DALY unit of measurement incorporates both the loss of years of life, because of death and the loss of QOL, because of the disability (Saracci, 2010). The DALYs for COPD is the amount of time (measured in years) lost due to untimely deaths and the time (years) that people lived with disabilities. COPD ranked as the 12th disease with the most DALYs globally in 1990 and it is projected that it will rank as the 7th leading cause of DALYs lost globally by 2030 (Mathers and Loncar 2006).

In the UK, 1 in 8 (130,000) acute medical admissions in adults is due to COPD (British Lung Foundation, BLF, 2006) making it the second largest cause of emergency admission. COPD accounts for a million ‘bed days’ in the hospitals each year. The NHS spends approximately £491,652,000 and £490,348,000 as direct and indirect costs of managing COPD in the UK every year (Britton 2003; NICE, 2011). The estimated mean direct and indirect annual costs of COPD per patient are £81,942 and £81,966 respectively, totalling £163,908 per patient every year. A significant amount (54%) of the direct costs was spent on secondary care, as a result of inpatient hospitalisation, leaving 46% spent on follow-up of patient, care of exacerbations, comorbidities and prescriptions for medication.

COPD has a negative impact on work productivity. 50% of people with COPD are less than 65 years old (Buist, et al., 2007). This suggests that the disease affects people in the productive part of their lives. Annually, in England, approximately 24 million working days are lost to COPD, amounting to £2.7 billion loss in work productivity (DoH, 2010). It is important to mention that it is difficult to estimate the true direct cost of COPD because the disease is often under-presented and under-diagnosed and excludes cost of home care to the society. Notably, most estimates of direct costs of care (Loddenkemper, Gibson and Sibille, 2003; Britton, 2003; NICE, 2011) do not include the economic value of the care given by family members and friends of people with COPD.

Currently, COPD ranks as the fourth leading cause of death worldwide and it was responsible for an estimated 3.2 million deaths in 2015 (WHO, 2017). Two global reports of the burden attributable to ten major risk factors (tobacco, alcohol, illicit drugs, occupation, air pollution, poor water supply, sanitation, and personal and domestic hygiene, hypertension, physical inactivity, malnutrition, and unsafe sex) estimated that COPD, which was the sixth and fourth primary cause of death in 1990 and 2010 respectively, will rank as the third primary cause of death in 2020 (Murray and Lopez, 1997; Chapman, et al., 2006). On average, 15 per cent of people with COPD admitted to hospital in the UK die within three months and, although estimates vary, it is thought that 25% of patients die within a year (British Lung Foundation, BLF, 2006). Within the framework of the National COPD Audit conducted by Price, et al. (2006), 7.4% deaths were reported in a cohort of 7,529 patients in hospital admission due to exacerbations and older patients with severe symptoms of the disease (GOLD stage II) had increased risk of death. For discharged patients the readmission rate within 3 months is 31.4% and mortality rate, 3 months after hospital discharge, is 15.5%. According to a recent report published by the BLF (2017), 29,776 and 30,858 people died from COPD in 2012 and 2015 respectively in the UK. The data on age-standardised mortality rate (per million of population) puts the UK among the top 15 countries for COPD mortality worldwide (BLF, 2017).

There is a plethora of risk factors that increase the risk of death in people with COPD. The presence of one or more co-morbidities independently predicted higher death rates in a study by Mannino, et al. (2008). Other risk factors associated with higher death rates in people with COPD include: long-term use of oral corticosteroids (RR= 5.07; 95% CI=2.03-12.64), older age (RR= 1.07; 95% CI= 1.01-1.12), higher carbon (IV) oxide arterial tension, $PaCO_2$

(RR=1.17; 95% CI= 1.01-1.38) (Groenewegen, Schols and Wouters, 2003), ≥3 acute COPD exacerbations requiring hospital admission (HR= 4.13; 95% CI=1.80-9.41) (Soler-Cataluna, et al., 2005), disease severity, GOLD stage IV (HR=1.81; 95% CI= 1.02–3.24), ≥2 previous hospital admissions (HR= 1.22; 95% CI= 0.79–1.90) (Gudmundsson, et al., 2006), PA limitation (OR= 2.62; 95% CI= 1.43-4.78; p<0.001), depression (OR= 3.6; 95% CI= 1.5-8.65; p<0.004), marital status (OR= 3.12; 95% CI= 1.73-5.63) and low body mass index, BMI (Almagro, et al., 2002). Nevertheless, mortality rates have been shown to be reduced by some factors such as smoking cessation (Anthonisen, et al., 2005), use of oxygen therapy (O'Reilly and Bailey, 2007) and availability of more respirologists and improved standard of care (Price, et al., 2006).

Besides the substantial burden of COPD on society, there is a considerable impact on individuals with the disease. People with COPD are physically less active (Pitta, et al., 2005a) and have a high morbidity. COPD is an activity limiting disease. People living with it experience different activity limitations which impact negatively on their QOL. COPD associated morbidity worsened by the presence of other chronic conditions which are often associated with the disease. An estimated 67% of patients with COPD are diagnosed with one or two chronic comorbid conditions such as ischaemic heart disease, heart failure, osteoporosis, normocytic anaemia, lung cancer, depression and diabetes (Barnes and celli's (2009). Mapel, et al. (2000) identified an average of 3.7 comorbid conditions in people with COPD compared with 1.7 in controls. A more recent study (Terzano, et al., 2010) found that, among 288 patients with COPD, the most frequently diagnosed comorbidities include hypertension (64.2%), kidney failure (26.3%), diabetes mellitus (25.3%) and cardiac diseases (22.1%). In an earlier study (Barr, et al., 2009), hypertension was also identified as the most common comorbidity (55%) among 1,003 people with COPD. Others included hypercholesterolaemia (52%), depression (37%), cataracts (31%) and osteoporosis (28%). These comorbidities potentiate COPD morbidity, increases healthcare utilization, cost of care and mortality as well as complicate the management of the disease (Simon-Tuval, et al., 2011; Vestbo, et al., 2013).

2.3 Aetiology of COPD

Tobacco smoking remains the main risk factor for COPD (Vestbo, et al., 2013). However, there is consistent evidence that non-smokers may also develop the disease. In an earlier study (Lundback, et al., 2003), only 15-20% of all smoking participants and about 50% of

elderly smokers (age >75 years) developed COPD. Among people with similar smoking history not all were observed to have COPD (Eduard, Pearce, and Douwes, 2009). This suggests a likely genetic (individual) susceptibility to tobacco smoke and that age plays an influential role. Environmental exposure to tobacco smoke (ETS, also known as passive smoking or second-hand smoke exposure) and prenatal exposure to tobacco smoke have also been reported to increase the risk of COPD (Eisner, et al., 2006; Salvi and Barnes 2009; Postma, Bush and van den Berge, 2015).

Besides tobacco smoke, occupational inhalation of various particles such as organic and inorganic dusts, chemicals, vapours and fumes as well as indoor and outdoor air pollutants also increase the risk of COPD (Hnizdo, et al., 2002; Blanc, et al., 2009; Hu, et al., 2010; Kurmi, et al., 2013).

Deficiency of an enzyme known as Alpha 1-antitrypsin (AAT) is recognised as the major genetic risk factor for COPD. Stoller and Aboussouan (2005) observed that between 1-3% of people with COPD are deficient of AAT and that active smoker with low plasma levels of this enzyme are at increased risk of developing emphysema. Other genes associated with COPD development have also been identified e.g. transforming growth factor (TGF)-β, tumour necrosis factor α and microsomal epoxide hydrolase 1 ((Morty, Konigshoff and Eickelber, 2009; Zhang, et al., 2011; Mehrotra, et al., 2010). Nevertheless, Vestbo, et al (2013) acknowledged that findings from genetic association studies are inconsistent and therefore, no other genes could be identified with certainty yet.

Living in socially and economically poor conditions considerably influences the risk of COPD. Poor people have higher risk of developing COPD than their rich counterparts (Yin, et al., 2011). Poverty is considered a broad outcome measure that encompasses several factors (such as malnutrition, crowding, inhalation of air pollutants, smoking habits, poor education, living in rural area, childhood exposure to respiratory infections and poor access to health services) that subsequently increase the risk of COPD (Svanes, et al., 2010; Eisner, et al., 2011; Yin, et al., 2011). However, no study has identified the exact components of poverty that, over time, contribute to the reported COPD occurrence.

Asthma has been identified as a risk factor for COPD occurrence, although this has not been fully established. In an earlier cross-sectional study, 30% of patients with asthma were

diagnosed with COPD (Soriano, et al., 2003). This result was corroborated by Silva, et al. (2004) who found that asthmatic adults had a 12-fold increased risk of developing COPD over time than non-asthmatic adults after adjusting for tobacco smoking. A longitudinal study of asthmatic patients found that about 20% of the participants developed irreversible airflow obstruction (Vonk, et al., 2003). In a lung health population-based survey of Europeans (de Marco, et al., 2011), bronchial hyperactivity was identified as the second leading risk factor for COPD after exposure to tobacco smoking and it accounted for 15% of people with COPD in the general population. Although reduced respiratory function is common in people with asthma and COPD, both diseases are still considered separate because the pathological presentation of chronic airflow limitation in asthmatic non-smokers is different from that of non-asthmatic smokers (Fabbri, et al., 2003). Nevertheless, it is still difficult to differentiate asthma from COPD on the basis of clinical presentations. Although bronchial hyperactivity has not been identified as an independent predictor of asthma, it independently predicted COPD occurrence (de Marco, et al., 2011) and significantly increased the risk of reduced FEV_1 in people with mild COPD (Brutsche, et al., 2006).

Other risk factors for COPD include age, sex and hormones (Buist, et al., 2007; Carey, et al., 2007; Macsali, et al., 2012) and exposures to respiratory infections during childhood could adversely modify people's pulmonary function in later life (Galobardes, et al., 2008; de Marco, et al., 2011). Childhood exposures what is referred to as "childhood disadvantage factors" significantly increased the risk of lung function impairment and COPD development in early adulthood. Svanes, et al. (2010) demonstrated that the effects of these factors were equivalent to that produced by active tobacco smoking. Repeated experiences of viral and bacterial infections in adulthood also contribute to decline in respiratory function (De Serres, et al., 2009).

The aetiology of COPD has been linked with major risk factors which are mostly environmental and genetic, as well as other factors that predispose people to the disease. The pathological processes by which inhaled exposures remodel and cause airflow obstruction are considered further as follows.

2.4 Airway remodelling and airflow obstruction

The pathological processes by which inhaled chronic irritants such as tobacco smoke and other noxious gases, vapours and fumes exert their effects on respiratory tissues are in favour of an inflammatory response of the respiratory tract (Gan, et al., 2004). The mechanisms of this inflammatory process in both smokers and nonsmokers have not been clearly explained. Oxidative stress (OS) is now known to have an influence in the pathogenesis of COPD. Jones (2006) defined OS as a continual imbalance in the synthesis of reactive oxygen and the body's ability to detoxify its toxic effects. High concentrations of some biomarkers of OS- hydrogen peroxide and 8-isoprostane- were identified in the sputum, exhaled breath condensate and serum of people with COPD (Montuschi, et al., 2000; Kostikas, et al., 2003), suggesting there is increased OS in their lungs. Tobacco smoke and other chronic irritants contain oxidants and also activate the production of additional oxidants from inflammatory cells such as macrophages and neutrophils (types of white blood cells that are part of the body's immune system).

When Fischer, Pavlisko and Voynow (2011) reviewed studies of biomarkers and genetic variations of OS and their association with COPD pathogenesis, they reported a decline in the synthesis of antioxidants (substances that prevent this oxidation process) in people with COPD. They also reported the presence of high concentration of proteinases (enzymes that catalyse the hydrolytic breakdown of proteins into amino acids). Fischer and Colleagues (2011) suggested that OS and increased concentration of proteinases modify lung inflammation and cause the pathological features observed in patient's lungs. In a laboratory study, the inflammatory changes in the airways of mice caused by exposure to tobacco smoke for 20 weeks were only partially reversed 2 months after smoking cessation (Braber, et al., 2010). This suggests that the inflammatory changes in airways of humans caused by long-time exposure to tobacco smoke will also not be completely reversible even after modifying smoking habit.

Histological analyses of lung tissue biopsies obtained from people with COPD showed the presence of increased number of different inflammatory cells in different parts of the lungs. For example, higher concentration of cytotoxic cells, lymphocytes (small white blood cells) and neutrophils were found in their upper airways and sputum (Gan, et al., 2004; Tzanakis, et al., 2004). Similarly, the presence of tobacco smoke triggers the production and mobilization

of different immune cells especially macrophages and epithelial cells of the airways (Chung and Adcock, 2008). Di Stefano, et al. (2009) explained that these cells synergistically contribute to the synthesis of other substances such as mediators, cytokines and enzymes that play active roles in amplifying and sustaining the inflammatory response as well as interact with structural cells, lung tissues and pulmonary blood vessels. This repeated injury and repair results in structural remodelling or narrowing of the airway lumen, loss of cilia (small hair-like structures lining airways surfaces) function and reduced elasticity of smooth muscles cells (Chung and Adcock, 2008; Soltani, et al., 2010).

There is now a better understanding of how the pathological processes in COPD result in the physiological deformities and clinical symptoms presented in people with COPD. For instance, inflamed and narrowed airways and destruction of lung tissues due to emphysema are responsible for the mucus hyper-secretion, airflow obstruction, air trapping and other symptoms (Soltani, et al., 2010). The prolonged airflow obstruction in COPD is due to a mixture of airways disease (referred to as chronic bronchitis) and emphysema.

Emphysema is a condition in which the tiny air sacs of the lungs (alveoli) are damaged and inflamed, causing hyperinflation and impaired gas-exchange (Viegi, et al., 2007). The damage of the lung tissues causes the small airways to collapse during expiration, making it difficult for the lungs to empty. This leads to air becoming trapped in the alveoli (minute air sacs of the lungs which permit enable quick exchanges of gases) and subsequent chest hyperinflation. The blood pressure may increase in the pulmonary artery, cor pulmonale (enlargement of the right ventricle of the heart) and other cardiovascular conditions may develop (Terzano, et al., 2010; Fischer, Pavlisko and Voynow, 2011).

Chronic bronchitis, on the other hand, is a condition in which the bronchi and bronchioles are progressively and recurrently being inflamed (Viegi, et al., 2007). Its clinical features include mucus hypersecretion leading to persistent productive cough and dyspnoea (breathlessness). It progressively worsens over time. Bronchitis is mainly caused by toxic particles in cigarette smoke or other pollutants. It is said to be chronic when the coughing and sputum production lasts for at least three months in two consecutive years (Viegi, et al., 2007; Vestbo, et al 2013). Due to inflammation and thickening of the bronchial walls, people with chronic bronchitis may develop chronic bronchial obstruction and, hence COPD. Although this unusual inflammation of the lungs in response to the presence of inhaled particles and gases,

especially tobacco smoke, is accepted to be the overall mechanism in COPD (Hogg and Timens, 2009), the individual contribution of each of these two pathological processes has not been fully established in vivo and are thought to vary from patient to patient (Vestbo et al 2013). The chronic inflammation of the lungs, caused by activities of immune cells and oxidative stress (Fischer, Pavlisko and Voynow, 2011), damages the parenchymal cells of the lungs. As a result, the alveoli lose their attachments to the walls of the small airways. The lung also loses its elastic recoil ability; thus, causing the airway to remain opened during expiration. This structural reshaping (narrowing) of the airways limits airflow during respiration.

It is important to note that although most COPD definitions emphasized the terms emphysema and chronic bronchitis, care needs to be taken to avoid confusion. For example, emphysema has been observed to be only one of the many changes affecting the structure of the normal small airways (Matsuoka, et al., 2010), it will be incorrect to mention that emphysema is the only structural abnormality in patients with COPD. Chronic bronchitis often refers to presence of cough and over secretion of mucus from main or larger airways (bronchi). This may also be confusing as it appears to exclude secretion of mucus from other smaller and smaller airways (bronchioles). In addition, people without COPD (those with normal spirometry) have been shown to experience chronic bronchitis (Eduard, Pearce and Douwes, 2009). Nevertheless, it remains clinically important in COPD because it may occur before or after airflow obstruction develops. It has also been linked with the development and progression of airflow obstruction.

The pathological processes in COPD have also been observed in people with asthma. Asthma is a common chronic inflammatory disease caused by inflammation of eosinophil (a type of disease-fighting white blood cell containing granules that are easily stained by eosin, a red fluorescent dye) in peripheral airways which affects the sensitivity of nerve endings in the airways so they become easily irritated (WHO, 2014). Asthma is characterized by variable and recurring symptoms, including cough, wheeze, dyspnoea and bronchospasm. In an attack, the lining of the passages swell causing the airways to narrow and reducing the flow of air in and out of the lungs. The airway obstruction in asthma however is reversible (NICE, 2011). Asthma is clinically classified according to the frequency of symptoms, FEV_1, and peak expiratory flow rate. Asthma usually affects all ages but often begins in childhood. As noted

earlier, asthma increases the risk of developing COPD in smokers compared to nonsmokers (Silva, et al., 2004; de Marco, et al., 2011).

2.5 Clinical symptoms and features of COPD

The natural history of COPD is characterized by three major symptoms; chronic cough, excessive sputum production and dyspnoea (Agusti, et al., 2010; Vestbo, et al., 2013). People with COPD may also present with other symptoms such as wheezing (laborious or whistle breathing), rhinorrhoea (persistent watery mucus discharge from the nose), chest tightness, fatigue, weight loss and anorexia (loss of appetite for food) (Vandevoorde, et al., 2007), but these are not regarded as COPD specific symptoms. Their severities over time vary from one patient to another and are often underreported.

Dyspnoea is the most important symptom of COPD. Typically, it is chronic, progressive and often the main reason people seek treatment for the disease (Vestbo, et al., 2013). People with severe COPD identified dyspnoea as the worse symptom they experience (Kessler, et al., 2011). In those with mild COPD, exercise reduced the experience of breathlessness, but when the disease has become more severe, people usually become more breathless even on minimal physical exertion (Guenette, Webb and O'Donnell, 2012). Although persistent cough and sputum production may be the earliest symptoms in COPD occurrence (Vandevoorde, et al., 2007), they are also common in young smokers without COPD and will normally not make people to initially seek medical care. In a cross-sectional analysis of data obtained from 433 people with COPD (Burgel, et al., 2009) persistent cough and sputum production were linked with repeated COPD exacerbations, including severe exacerbations that can result in hospital admission. The chronic cough and sputum production are important features of chronic bronchitis, but not necessarily linked with airflow obstruction (Eduard, Pearce and Douwes, 2009).

Other clinical features that characterise COPD include airflow obstruction and air trapping, gas exchange abnormalities leading to hypoxaemia (abnormally low concentration of oxygen in the circulating blood) and hypercapnia (abnormally high concentration of carbon (IV) oxide in the circulating blood), toughness of airway wall and pulmonary hypertension have also been reported (Hardin, et al., 2011; Vestbo, et al., 2013). The symptoms of COPD are, most often than not, underreported by patients and underdiagnosed by physicians especially during the early stages of the disease.

2.5.1 Symptom exacerbations

Although there is currently no widely accepted definition of what constitutes an exacerbation, Wedzicha and Seemungal (2007) defined exacerbation as a worsening of one or more COPD symptoms for a period of ≥24 hours. Patients with COPD often experience exacerbations of respiratory symptoms (Burgel, et al., 2009) which Wedzicha and Seemungal (2007) explained to be initiated by infections caused by viruses and bacteria or presence of chronic irritants (pollutants). The presence of viral particle and bacterial pathogens in the airways stimulates inflammatory response of the respiratory tract. When respiratory symptoms exacerbate, the lung hyper-inflate and gases are trapped. This leads to reduced expiratory flow which, in turn, increases the experience of breathlessness and worsens ventilation-perfusion abnormalities, which can cause hypoxaemia (Wedzicha and Seemungal, 2007). Other diseases such as pneumonia, thromboembolism (obstruction of blood vessels by blood clot) and congestive heart failure can also imitate or worsen the exacerbation of respiratory symptoms in people with COPD (Vestbo, et al., 2013). The susceptibility to exacerbation varies in different people with the disease. Those with frequent exacerbations have more severe airway obstruction, poor health status (Jones, et al., 2011), increase risk of hospital admission (Burgel, et al., 2009; Terzano, et al., 2010) and high mortality (Garcia-Aymerich, et al., 2010) than those who have irregular exacerbations.

2.6 Differences between COPD and Asthma

COPD and asthma have several different clinical outcomes despite their similar pathophysiological pathways and symptoms. As a result of the high prevalence of respiratory diseases, people with different diseases may present with similar clinical symptoms. The distinction between COPD and asthma is important to prevent misdiagnoses, underestimation of burden of the disease as well as in determining suitable treatment measures especially in the early stages of the disease.

The experience of slowly progressive respiratory symptoms by young and older adults is a strong indication of COPD. In any case, such individuals might likewise have asthma. It has been reported that people whose symptoms begin after the age of 35 years are more likely to be asthmatic, especially if they do not have a chronic exposure to tobacco smoking and if the symptoms vary in severity. Serial peak flow monitoring showing 20% or higher daytime variability of symptoms may aid in differentiating between COPD and asthma. In accordance

with NICE and GOLD guidelines, further differential diagnostic test is not needed where clinical presentations and spirometry show the presence of COPD (NICE, 2010; Vestbo, et al., 2013). If there is any uncertainty, reversibility testing is recommended (a large response, >400ml, to bronchodilator e.g. salbutamol, terbutaline and ipratropium bromide) or a large response (>400ml) to 30mg prednisolone administered daily and orally for 14 days (NICE, 2010). Alternatively, a reassessment of spirometry and clinical response can be done after a 30-day administration of a bronchodilator. Because bronchodilator reversibility testing is, as of yet, not a 'gold-standard' differential test, the British Thoracic Society, BTS (2005) recommends considering people's clinical history when interpreting test results. According to NICE (2010), if there is significant improvement in people's experiences of symptoms after medication use, the diagnosis of COPD should be reconsidered. More so, an individual is not considered to have COPD if his/her FEV_1 and FEV_1/FVC test results reverse to normal values after using any medication. Other features that differentiate asthma and COPD are summarised in Table 2.

Table 2: Clinical features differentiating COPD and Asthma

Clinical features differentiating COPD and Asthma		
	COPD	**Asthma**
Smoker or ex-smoker	Nearly all	Possibly
Symptoms under age 35	Rare	Often
Chronic productive cough	Common	Uncommon
Breathlessness	Persistent and progressive	Variable
Night-time waking with breathlessness and/or wheeze	Uncommon	Common
Significant diurnal or day-to-day variability of symptoms	Uncommon	Common

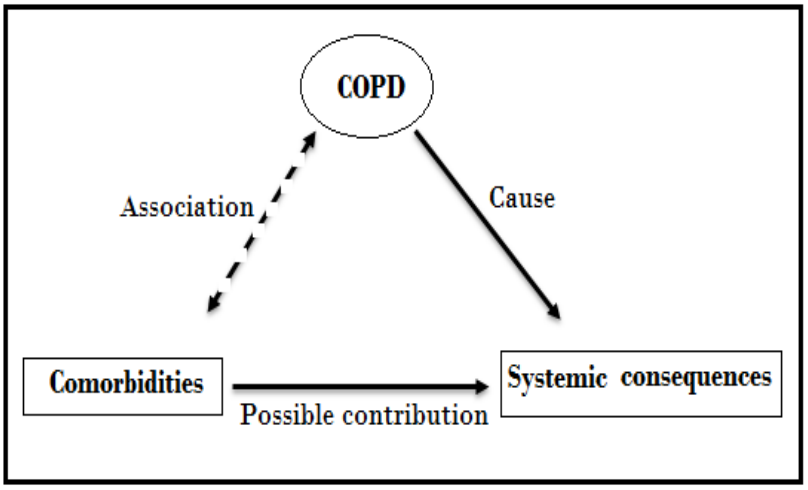
Source: NICE (2010) and BTS (2005)

2.7 The Systemic effects of COPD

The ATS and GOLD guidelines' definitions of COPD (Vestbo, et al., 2013) and Fabbri, et al. (2008) recognised that although COPD primarily affects the lungs, it substantially affects other systems of the body. People with COPD have increasingly been reported to have other comorbid conditions that worsen their QoL, increased health care utilisation and reduced survival (Mapel, et al., 2000; Terzano, et al., 2010 Simon-Tuval, et al., 2011). However, it is difficult to differentiate between comorbidities and systemic consequences of COPD due to

lack of any consensus definition. In this context, co-morbidities are defined as diseases that occur together with COPD, probably due to exposure to similar risk factors. On the other hand, systemic consequences are direct effects of COPD. Decramer, et al. (2008) suggested a causal link between COPD and its effects, but Wust, et al. (2008) were of the view that a systemic feature such as fatigue and muscle wasting which limit PA, could be a comorbid condition due to exposure to similar risk factor (tobacco smoking). On the other hand Seymour, et al. (2010) observed that fatigue and muscle wasting are direct consequence of COPD. In addition, Decramer, et al. (2008) further explained that the presence of comorbidities in COPD can contribute to systemic consequence in COPD (Figure 2).

Figure 2: Interrelationships between COPD, systemic consequences, and co-morbidities



Source: Decramer, et al. (2008)

The relationships between systemic consequences or co-morbidities and COPD appear complex and not clearly understood. Because of this, it is difficult to predict whether or not an individual will develop one or more co-morbidities in his/her COPD life course. Chronic systemic inflammation has been suggested as a possible mechanism for these associations Barnes and Celli, 2009). Nevertheless, the origin of systemic inflammations and its connection with respiratory inflammation are unknown. One hypothesis, advanced by Barnes and Celli (2009), holds that inflammatory mediators translocate (spill over) from the airways to blood circulation. This translocation hypothesis is supported by the fact that the concentration of cytokines increases during pulmonary inflammation and spill over into

systemic circulation. This is thought to further increase the levels of acute-phase proteins, leading to skeletal muscle atrophy, cachexia (general physical wasting with loss of weight and muscle mass), initiation and worsening of comorbid conditions, and acceleration of lung cancer. Alternatively, systemic inflammation may cause several inflammatory diseases, including COPD. Yet another possibility is that a comorbid condition produces systemic inflammation that affects the lungs (Barnes and Celli, 2009).

Although this attractive translocation or spill over hypothesis is supported by some researchers (Moermans, et al., 2011), it has not been widely accepted by others because they did not observe any significant relationship between inflammatory mediators in sputum and peripheral blood (Singh, et al., 2010), thus, suggesting that the inflammatory processes in the local and systemic compartment are regulated in a different way. Further links between COPD and co-morbidities may be due to shared risk factors or hereditary predisposition. Additional study is required to elucidate these relationships in order to avoid misclassifying patients with COPD.

Skeletal muscle wasting and activity limitation are among the systemic consequences identified by Barnes and Celli (2009) in people with COPD. The mechanisms underlying their occurrence remain to be explained. The translocation of cytokines into systemic circulation is thought to cause systemic inflammatory effects, exacerbation of cardiovascular diseases and skeletal muscle wasting. High levels of interleukin-6 (IL-6) and tumour necrosis factor-α (TNF-α) are found in the serum of people with severe COPD (Barnes and Celli, 2009). A possible link between IL-6 and TNF-α and cachexia has been reported by some researchers (Jackman and Kandarian, 2004; Haddad, et al., 2005). Cachexia has significant adverse functional consequences, notably limitation in PA participation (Jackman and Kandarian, 2004). Physical inactivity is considered a key clinical factor that is associated with morbidity and mortality in several chronic diseases including COPD (Geneau, et al., 2010; WHO, 2009) and it accounts for 6% of deaths worldwide, making it the fourth primary risk factor for death worldwide (WHO 2009). Physical inactivity is a major mortality predictor in people with COPD (Garcia-Aymerich, et al., 2006; Waschki, et al., 2011; Garcia-Rio, et al., 2012). Increasing levels of PA is currently an important goal of COPD management (Vestbo, et al., 2013).

This thesis focuses on objectively measuring free living daily PA and its relationship with clinical outcomes (health status, pulmonary function, exercise capacity and hospital

admission) in people with COPD attending a community-based exercise programme (CEP) following PR. The next section considers the meaning of PA, its measurement, importance, recommended guidelines and mechanism and implications of inactivity in people with COPD.

2.8 Physical Activity (PA)

Caspersen, Powell and Christenson (1985) defined PA as *"any bodily movement produced by skeletal muscles that requires energy expenditure"*. Because PA is a reflection of what an individual actually does it differs from functional capacity which is an indicator of what an individual is able to do. Hence, PA also has a behavioural component and remains a core health indicator (WHO, 2014a). The health benefits of PA are well documented (Warburton, Nicol and Brendin, 2006; Nelson, et al., 2007; Wen, et al., 2011, Lee, et al., 2012). WHO (2008; 2009; 2010) have repeatedly reported that engaging in frequent PA reduces risk of many Non-Communicable Diseases (NCDs), notably type II diabetes, cancers, hypertension, COPD and mental health problems (depression). In addition, as PA is an important determinant of energy expenditure, it can be concluded that it is essential for energy balance and recommended for people wishing to lose weight. The robust evidence of the health benefits of PA has supported the development of its framework and recommendations for healthy individuals of different age groups (WHO, 2010; NHS, 2013).

Population-ageing, rapid urbanization and globalization have significantly influenced the health of people globally and resulted in unhealthy environments and behaviours. Sedentary lifestyle has increased in many countries and this raises serious concerns for the general health of people and the burden of NCDs. For example, approximately 50% of the total global burden of disease is attributable to NCDs. NCDs currently accounts for 6 out of every 10 deaths (WHO, 2008). Physical inactivity is responsible for 21–25% of the burden of breast and colon cancers, 27% of diabetes and 30% of the burden of ischaemic heart disease and currently the fourth leading mortality predictor, responsible for 6% of death worldwide (WHO, 2009). In recent years, physical inactivity has increasingly been recognised following results from a study (Wen, et al., 2011) which found that it significantly predicted poor health and other adverse health outcomes. To reduce the burden of physical inactivity and increase the potential benefits of PA, it has become important to provide opportunities for people to be encouraged and motivated to become more physically active. This appears to be the rationale for the different levels of PA recommended by the WHO for all age groups (WHO, 2010).

2.8.1 Recommended levels of PA for health in adulthood

A global dietary and PA guidelines that was intended to guide national PA policies was endorsed by the World Health Assembly in 2004 (WHO, 2004). In 2010, the WHO recommended different levels of PA for health in all age groups (WHO, 2010). The recommended PA levels for adults (18-64 years) and those aged >65 years are shown in Table 3. These guidelines are relevant to all healthy adults unless there is a contraindication for exercise due to underlying medical issues, in which case, the guideline suggested taking precautions and seeking medical advice prior to making effort to comply with recommended levels of activity.

The recommended guidelines now constitute the framework for the development, review and update of PA guidelines in several countries including the UK (NHS, 2013). For example, the recommended dose or level of PA for adults (18-65) in the UK is a mix of 150 minutes (2 hours and 30 minutes) of moderate-intensity aerobic activity in bouts of 10 minutes or more every week and muscle-strengthening activities on ≥2 days per week or 75 minutes of vigorous-intensity aerobic activity every week and muscle-strengthening activities on ≥2 days a week (NHS, 2013). Alternatively, they can engage in an equivalent mix of moderate- and vigorous-intensity aerobic activity every week (e.g. two 30-minute runs plus 30 minutes of fast walking) and muscle-strengthening activities on ≥2 days a week (NHS, 2013).

Despite the current levels of PA recommendations and global efforts to promote PA, physical inactivity is still prevalent in the general population. In their investigation of the prevalence of physical inactivity among 300,000 people (aged ≥ 15 years) from 76 countries, Dumith, et al. (2011) noted that "the crude worldwide prevalence of physical inactivity was 21.4% (95% CI 18.4–24.3)". After adjusting for the total population of each country, the researchers found that 17.4% (95% CI 15.1–19.7) of the global population were physically inactive.

Table 3: WHO guidelines on levels of physical activity for health in adults

18-64 years old	65 years old and above
For adults of this age group, physical activity includes recreational or leisure-time physical activity, transportation (e.g. walking or cycling), occupational (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities. In order to improve cardiorespiratory and muscular fitness, bone health and reduce the risk of NCDs and depression the following are recommended:	For adults of this age group, physical activity includes recreational or leisure-time physical activity, transportation (e.g. walking or cycling), occupational (if the person is still engaged in work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities. In order to improve cardiorespiratory and muscular fitness, bone and functional health, and reduce the risk of NCDs, depression and cognitive decline, the following are recommended:
1. Adults aged 18–64 years should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week, or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate and vigorous-intensity activity. 2. Aerobic activity should be performed in bouts of at least 10 minutes duration. 3. For additional health benefits, adults of this age group should increase their moderate intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. 4. Muscle-strengthening activities involving major muscle groups should be performed 2 or more days a week.	1. Adults aged 65 years and above should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week, or do at least 75 minutes of vigorous intensity aerobic physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity. 2. Aerobic activity should be performed in bouts of at least 10 minutes duration. 3. For additional health benefits, adults of this age group should increase their moderate intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. 4. Adults of this age group with poor mobility should perform physical activity to enhance balance and prevent falls on 3 or more days per week. 5. Muscle-strengthening activities involving major muscle groups should be performed on 2 or more days a week. 6. When older adults cannot do the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow.

Source: WHO (2010)

Several factors are responsible for the global prevalence in physical inactivity in healthy adults. Dumith, et al. (2011) reported a positive correlation between Human Development Index (HDI) (a composite statistic of life expectancy, education, and income per capita indicators) and the global prevalence of physical inactivity (rho = 0.27). Geographical location and gender were also reported as important correlates of global prevalence of physical inactivity, with inactivity being higher among women (mean = 23.7%, 95% CI 20.4–27.1) than men (mean = 18.9%, 95% CI 16.2–21.7), lower proportion of people living in developing countries (18.7%) being physically inactive (18.7%) compared to 27.8% of physically inactive people living in developed countries (Dumith, et al., 2011). Age is also a predictor of physical inactivity. Troiano, et al. (2008) and Hallal, et al. (2012), observed that levels of PA decline with increasing age in healthy individuals. Although levels of PA decline with increasing age in healthy individuals (Troiano, et al., 2008), the experience of chronic diseases further reduce activity participation. For example, people with COPD are less active in daily life than people of a similar age without COPD (Pitta, et al., 2005a; Hernandes, et al., 2009; Arne, et al., 2009; Troosters, et al., 2010).

As noted earlier (section 2.7), COPD primarily affects the lungs and produces substantial systemic consequences such as fatigue and skeletal muscle wasting which are associated with reduced levels of PA. Researchers have observed lower levels of PA in people with COPD. When Arne, et al. (2009) compared levels of recommended PA in healthy individuals and people with different chronic conditions, they found that significantly lesser number of those with COPD performed the recommended PA levels compared with healthy individuals and people with rheumatoid arthritis and diabetes mellitus. A comparative study of older adults with COPD and age-matched individuals (Pitta, et al., 2005a) found that people with COPD were less active in daily life by 37 minutes/day in walking time, 104 minutes/day in standing time, and 36m in exercise capacity (6MWD). Their sitting and lying times were higher by 68 minutes/day and 58 minutes/day respectively in the same study. Other studies have also reported that people with COPD spent significantly lesser time walking compared with people of similar age without COPD (Hernandes, et al., 2009; Vorrink, et al., 2011). The results of these studies seem to be consistent regardless of their settings, cultural background of participants, geographical location and methods used to assess levels of PA. Furthermore, the intensity of body movement in those with COPD is lower compared with people of similar age without COPD. Pitta, et al. (2005a) reported that the movement intensity of people with COPD is 0.6 meter/second^2 lesser than that of people of similar age without

COPD. This suggests that people with COPD move or walk slower than those without the disease.

The stage of COPD severity (GOLD stages I, II, II, IV) at which people experience difficulty or limitations in performing PA has not been well established. One study (Watz, et al., 2009) found that the number of steps taken per day was reduced from GOLD Stage II while time spent in moderate activity and steps per day were both reduced from GOLD Stage III. People who are oxygen-dependent (an indicator of severe COPD) were observed to be less active (by 30% activity count) than those who are not oxygen dependent (Sandland, et al., 2005). This suggests that the observed decline in participants' PA levels reflects their disease severity. Overall, findings from more recent studies indicate that people tend to decrease their levels of PA before COPD becomes severe (Gouzi, et al., 2011; Shrikrishna, et al., 2012; van Remoortel, et al., 2013a). Consequently, most people with COPD are unable to perform PA that meet the current levels recommended for healthy individuals (WHO 2010). For instance, of the total number of participants (n=177, mean FEV1 % predicted=52%) in a study only 26% (n=46) completed at least 30 consecutive minutes of moderate-intensity PA on at least 5 days. This proportion of participants increased to 50% (n=88) when the 30 minutes moderate-intensity activity was completed in bouts of 10 minutes each (Donaire-Gonzalez, et al., 2013). These results were corroborated by a study published by van Remoortel, et al. (2013b) which found that the time (minutes) spent on moderate-intensity PA per day reduced by 50% in people with COPD compared with people of similar age without COPD. Further reduction in time was observed when the activity was completed in bouts of at least 10 minutes (van Remoortel, et al., 2013b). These findings appear to underscore the need for a different PA guideline for people with COPD.

2.8.2 Physical activity guidelines and applications in COPD

The extent to which the recommended PA for health in adulthood (WHO, 2010) apply to people with COPD is currently unknown. COPD limits people's ability to meet the required levels of PA. Nonetheless, PA is still recommended for people with COPD, but there is currently no PA guideline for this population probably due to limited COPD-specific evidence. In 2006, the ATS and the ERS supported the continual use of PR for people with COPD and emphasised that it should not be taken as a "last ditch" intervention for those with severe symptoms, but should be an integral component of clinical management of chronic respiratory diseases, to address functional and/or psychological impairments (Nici, et al.,

2006). Although there is limited evidence other than studies of PR (Ries, et al., 2007; Vestbo, et al., 2013) in support of COPD-specific PA recommendations, Nici, et al. (2006) emphasised the significance of PA and improvement of activity participation as one of the goals of PR programmes. The current international guidelines for COPD management (Vestbo, et al., 2013) recommended regular daily PA for every person with the disease, but recommended dose (level) and intensity of such activity have not been defined.

In the absence of COPD-specific PA guidelines, WHO (2010) advised inactive adults and/or adults with disease limitations to undertake as much level of activity as their health allows and it was argued that they will have added health benefits if they move from the category of "no activity" to "some levels" of activity. To this end, the PA guidelines for healthy adults appear to have been adjusted to suit people with COPD based on their exercise capacity and limitations. Levels of PA recommendations for people with COPD have now been published by the American College of Sports Medicine, ACSM (ACSM, 2013). The ACSM now recommends light to moderate level of PA (30 minutes a day, on most, if not all days of the week) which they found beneficial for improving QOL. Although engaging in regular PA and exercise cannot reverse the physiological and structural deficits in COPD, it can reduce disability associated with the condition by improving physical endurance and strength, as well as breathing efficiency and tolerance, especially in people with severely impaired airways. Persons with COPD who follow an individualised progressive exercise programme can often increase their functional capacity by 70% to 80% after six weeks of training (ACSM, 2013).

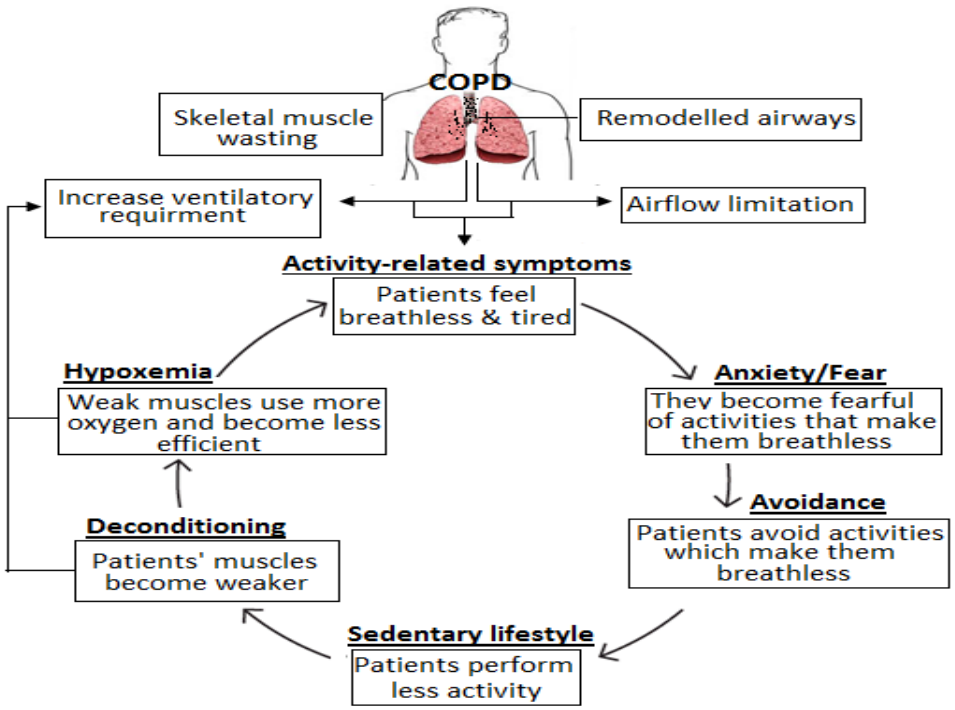
2.8.3 Physical inactivity

Physical inactivity is increasingly been recognised following the results from a study (Wen, et al., 2011) which found that reduced amount or level of PA significantly predicted poor health and other adverse health outcomes. Basically, physical inactivity refers to inadequate levels of PA. It is generally used to describe any level of PA that is lower than the required or optimal threshold (Hallal, et al., 2012). In general, healthy individuals are described as physically inactive if they do not meet the recommended level of daily or weekly PA (WHO, 2010; Hallal, et al., 2012) (see Table 3). This is also applicable to people with COPD. The mechanism by which physical inactivity occurs in patients with COPD has been inadequately reported in COPD literature. The current knowledge on this is summarised below.

2.8.4 The mechanism of physical inactivity in COPD

The mechanism underlying inactivity in people with COPD is not well established. Because inactivity is one of the systemic effects of COPD, one of the theories of its occurrence is the systemic inflammatory process expounded by Barnes and Celli (2009) (section 2.7). The vicious cycle of physical inactivity model (Troosters, et al., 2013; see Figure 3) is also a widely accepted theory about why people with COPD may become inactive. According to this theory, the remodelled airways and skeletal muscle wasting described by some researchers (Chung and Adcock 2008, Soltani, et al., 2010) limit airflow and increase the ventilatory requirements during any exertional activity. This results in PA-associated symptoms such as breathlessness and fatigue. These symptoms make exercise an unpleasant experience for people and create fear of performing similar or other activities. They are, therefore, naturally inclined to avoid such activities and become more sedentary and depressed. This inactive lifestyle can lead to progressive decline in functional ability. Periods of inactivity may further reduce cardiovascular functions and decondition skeletal muscles as well as worsen people's physical state, increase frequency of breathlessness and further plunge them into more sedentary living, thus, creating a vicious circle of inactivity (Barnes and Celli, 2009; Troosters, et al., 2013).

Figure 3: The vicious cycle of physical inactivity in patients with COPD



Adapted from: Troosters, et al. (2013)

2.8.5 Measuring Physical activity in COPD

An assessment of PA performance is an important consideration in assessing health and health-related states in COPD (Vestbo, et al., 2013). Most studies assessing the level of PA have used different subjective and objective methods for measuring or quantifying PA. These include self-report questionnaires, sensors that detect movement- e.g. pedometers and/or accelerometers (Pitta, et al., 2006; Manini, et al., 2006; Ward, et al., 2005), and techniques that assess free-living energy expenditure e. g. doubly labelled water technique (Manini, et al., 2006). Each of these techniques has its strengths and inherent limitations.

2.8.5.1 Subjective instruments for measuring physical activity

Self-reported questionnaires and self-recording (patients' diaries) have been used to subjectively assess PA in daily life (Pitta, et al., 2005a; 2005b; Benzo, et al., 2009). These instruments are inexpensive and useful for assessing the participants' subjective impressions of their level of daily or weekly PA. The problem with them is that they rely on several factors such as participants' memory and ability to recall, characteristics of interviewers, structure or design of the questionnaires and participants' characteristics- cognition, age, sex, socioeconomic status and cultural backgrounds (Pitta, et al., 2006b). These variables may potentially influence the reliability of the results. For example, information on PA obtained via self-report is, most often than not, subject to recall bias (Ward, et al., 2005) and does not correlate well ($r = 0.14$; not significant) with objectively quantified PA (Steele, et al., 2000, Pitta, et al., 2005a). In addition, it is not possible to accurately estimate energy expenditure (Manini, et al., 2006) from self-reported PA data.

Some examples of fairly old, better-documented and validated subjective instruments that are often used for assessing PA include the Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ) or Minnesota Leisure Time Physical Activity Survey (MLTPAS) (Taylor, et al., 1978), the Baecke Physical Activity Questionnaire (Baecke, Burema and Frijters, 1982; Voorrips, et al., 1991), Follick's diary (Follick, ahern and Laser-Wolston, 1984), the Physical Activity Scale for the Elderly (PASE) (Washburn, et al., 1993), the Zutphen Physical Activity Questionnaire (ZPAQ) (Caspersen, et al., 1991) and Stanford Seven-Day Physical Activity Recall (PAR) questionnaire (Garfield, et al., 2012). Garfield and Colleagues (2012) evaluated the Stanford Seven-Day PAR questionnaire against objective tools (SenseWear armband accelerometer) and compared its validity with three other physical activity questionnaires (Baecke, PASE and Zutphen questionnaire). The

authors found that the Stanford tool was more reliable than the PASE, Zutphen or Baecke questionnaires. Nevertheless, all of the questionnaires yielded poor association between measured PA and questionnaire outcomes. Despite the emergence of more recent objective measuring instruments, some researchers continue to focus on improving and developing new subjective instruments. For example, Scheers, Philippaerts and Lefevre (2012) have developed a simple and time-saving web-based instrument, the Flemish physical activity computerized questionnaire (FPACQ). They compared estimates of physical (in)activity obtained with the FPACQ to those obtained from a combination of accelerometers (SenseWear Armband) and an electronic diary. Although they observed moderate associations, the results were significantly varied between methods. These have highlight the importance of developing and validating patient reported outcome tools to examine domains of PA that are essential to participants.

2.8.5.2 Objective instruments for measuring physical activity

One of the limitations of subjective instruments for measuring PA is their lack of sensitivity to detect overestimation or underestimation of level of PA by participants. For example, in two studies conducted by Lightman, et al. (1992) and Jakicic, et al. (1998), obese adults overestimated level of PA by about 30-50%. In another study (Conway, et al., 2002), adults with average BMI overestimated their levels of PA by about 8-30%. Pitta, et al. (2005b) found that people with COPD significantly overestimated time spent on PA by 22 minutes (P=0.04) and underestimated standing time by -45 minutes (P=0.04). For these reasons, objective instruments may provide precise assessment of level and characteristics of PA (e.g. time spent on activity, pattern and intensities and energy expended during activity). They can also quantify body movements performed over a period of time (Pitta, et al., 2006). In the last two decades, several studies have used pedometers (devices that measure steps), accelerometers (electronic devices that detects body movement) to objectively quantify habitual levels of PA (Hendelman, et al., 2000; Crouter, Churilla and Bassett, 2006a; 2006b; Pitta, et al., 2006b; Plasqui and Westerterp, 2007; Kwak, et al., 2007; Troiano, et al., 2008). The limitations associated with pedometers are that they can underestimate levels of PA, reduce walking pace in adult population (Dijkstra, et al., 2008) and do not provide information on time spent in different activities and pattern of PA (Benzo, 2009). They are further limited by their inability to accurately measure energy expenditure (Leenders, Sherman and Nagaraja, 2000; 2006). Despite these limitations, pedometers have been used to quantify PA in people with COPD (de Blok, et al., 2006; Hospes, et al., 2009).

Accelerometers are mostly worn on the arm or waist. They assess or quantify energy expenditure and other activity-related characteristics such as intensity of body movement and body posture based on measurements of body's acceleration during PA (Glaab, Vogelmeier and Buhl, 2010; Slootmaker, et al 2009; Vooijs, et al., 2014). While some researchers have used accelerometers to assess energy expended during PA (Crouter, et al., 2006a; 2006b), others used them to assess habitual PA and classify it into different level; sedentary, light, moderate, vigorous and very vigorous (Kwak, et al., 2007; Hendelman, et al., 2000). The increasing use of accelerometers in research led to the manufacture of accelerometers such as Actigraph (AG) and ActivPAL (AP) (Macfarlane, et al., 2006).

Limitations associated with using of accelerometers include cost, poor acceptance due to participants' preference of some models, sensitivity to artefacts, non-compliance and observation bias (Pitta, et al., 2006; Casaburi, 2007). Troiano and Colleagues (2008) reported that accelerometers can provide basic information about body movement in form of counts per minute (CPM). An important challenge posed by this method is that it is difficult to establish a link or derive key indicators such as energy expended (EE) in each activity or time taken to complete different intensities of PA (light, moderate and vigorous activity) from CPM. Furthermore, some researchers argued that accelerometers are associated with overestimation of light-intensity PA and underestimation of vigorous-intensity PA (King, et al., 2004; Schmidt, Freedson and Chasan-Taber, 2003). These challenges arise due to many reasons, one of which is related to the principles underlying their design. The functioning of accelerometers is based on biomechanical principles whereas effort and energy expenditure during PA are based on physiological and biomechanical principles. The role differing principles play in providing misleading results in research was explained by Cole, et al. (2000) when they observed that process of growth and development in children and teenagers distorted findings of their study. In spite of these limitations, Waschki and Colleagues (2012) recently demonstrated, in a multicentre study, that very high level of compliance and limited technical difficulties can be achieved with the use of accelerometers in people with COPD.

More recent studies (Patel, et al., 2007; Watz, et al., 2008, Harrison, et al., 2013) now use multisensor armbands (SenseWear Pro armbands) to measure both PA and energy expenditure. These devices incorporate biaxial accelerometers and some physiological indicators. While the biaxial accelerometer counts the number of steps taken daily, the

physiological indicators records the amount of energy required to complete the tasks. In these studies, SenseWear Pro armbands were used to provide a more accurate and repeatable evaluation of energy expenditure during PA (e.g. walking) at a slow to moderate pace.

2.8.6 Classifying levels of physical activity in people with COPD

In COPD research, participants' PA are measured and classified into different categories predominantly based on two criteria. First, PA levels are classified based on time spent on PA. For example, when Schnohr, Scharling and Jensen (2003) explored the relationship between changes in leisure-time PA and risk of death in 7,023 healthy men and women aged 20–79 years, they quantified and classified participants' levels of PA into four groups: 1 (very low): engaging in no PA during leisure time, mainly sitting during work, no jogging or cycling; 2 (low): engaging in light PA such as walking or biking for <2 hours/week; 3 (moderate): engaging in light PA for 2–4 hours/week; and 4 (high): engaging in light PA for >4 hours/week or in more vigorous activity for any frequency. A similar approach was applied by Garcia-Aymerich, et al. (2006) in their investigation of the impact of regular PA on hospital admission and mortality in patients with COPD. The recommended levels of PA for healthy adults and for people with COPD (discussed in sections 2.8.1 and 2.8.2) are also based on amount of time spent on activity. Second, participants' PA levels have also been classified into different groups; very inactive, sedentary, active and very active, based on energy expenditure. This approach was used by Watz, et al. (2008; 2009) when they investigated the effects of COPD on PA. They reported four classes of participants' PA levels based on the ratio of energy expended on PA and whole-night sleeping energy expenditure

It appears that the importance of classifying PA levels is to determine patterns and amount of activity as well as the unique characteristics of participants in each group. This is fundamental to identifying facilitators and barriers to activity participation as demonstrated by Soicher, et al. (2012). This may also be valuable for planning interventions to induce long-term behaviour change.

2.9 Factors influencing levels of physical activity in people with COPD

This section presents a discussion of the current literature on the relationships between clinical characteristics of people with COPD and their level of PA. The clinical features of people with COPD include disease severity (defined by GOLD Stages), symptom exacerbations, comorbid conditions, and behavioural factors, notably, smoking and

exercising (Vestbo, et al., 2013). Generally, an individual's PA depends on several factors such as biological, genetic, environmental, behavioural, social, cultural and national and local policies on PA (Bauman, et al., 2012). This section focuses on the factors that are reported in COPD literature.

2.9.1 Health status

There is robust evidence of an existing relationship between level of PA and different measurements of health status in people with COPD. Most of the studies found that participants with reduced health status (measured with disease-specific or generic tools) perform lower levels of PA (Waschki, et al., 2012; Garcia-Aymerich, et al., 2004; Esteban, et al., 2010). Esteban, et al. (2010) followed up 611 people with COPD for 5 years to determine whether changes in their regular levels of PA will have any influence on their health status. They found that, among the 391 survivors, maintaining a reduced level of PA was associated with a significant decline in health status, measured by both generic and disease-specific instruments.

Tsiligianni, et al. (2011) identified several determinants of health status in people with COPD. They reported the following determinants; socio-demographic factors, FEV_1 and disease severity, COPD symptoms, exacerbations, comorbidities, mental health problems (anxiety and depression), and exercise capacity. The relationship between these factors and people's levels of PA are discussed as follows.

2.9.2 Sociodemographic factors

Some of the several sociodemographic factors that have influenced level of PA include; age, gender, ethnicity, employment status, level of education, socioeconomic status, and place of abode. Generally, as noted earlier, levels of PA decline with increasing age in healthy individuals (Troiano, et al., 2008; Hallal, et al., 2012), the experience of chronic diseases further reduce levels of PA. Lower levels of activity are associated with lower socioeconomic status, lower level of education and non-Caucasian race among healthy adults (Marshall, et al., 2007; Parks, Jone and Brownson, 2003). However, it appears that this finding may be different in people with COPD, since Garcia-Aymerich, et al. (2004) found that lower levels of PA are independently associated with higher socioeconomic status (OR= 2.23, 95% CI= 1.24-4.02). Pitta, et al. (2009) corroborated this observation. In addition, Garcia-Aymerich, et al. (2004) also reported an independent associaton between lower levels of PA and female

sex (OR= 2.92, 95% CI= 1.11-7.70) and older age (OR=1.04, 95% CI= 1.01-1.07). Despite the reported associations, Garcia-Aymerich, et al. (2004) and Pitta, et al. (2009) did not clearly control for the influence of other factors such as geographical location, ethnicity and cultural background of participants. It could be that reliance on public transportation and walking among female participants with lower socioeconomic status accounts for the lower levels of PA observed in the studies. It is also important to acknowledge that the participants in both studies had severe COPD; hence the findings may not be true for those with mild or moderate COPD severity.

2.9.3 Pulmonary function and disease severity

There is a weak-to-moderate positive correlation between pulmonary function (FEV1, % predicted) and PA assessed by objective measuring instruments (Watz, et al, 2009; Pitta, et al., 2005a; 2008; Hernandes, et al., 2009; Waschki, et al., 2012). Generally, pulmonary function accounts for only a minimal amount of the difference in levels of PA in people with COPD. Pitta, et al. (2008) suggested that a direct measurement of Maximal Voluntary Ventilation (MVV) (the total volume of air exhaled during 12 seconds of rapid, deep breathing) may offer a better correlation with PA. The links between PA and other measures of pulmonary functions such as diffusion capacity and dynamic hyperinflation are not well documented. While Pitta, et al. (2005b), Walker, et al. (2008) and Langer, et al. (2012) reported weak-to-moderate positive associations between PA and diffusion capacity, Garcia-Aymerich, et al. (2009) found a strong and linear relationship. Garcia-Rio, et al. (2009) found that dynamic hyperinflation (measured in a laboratory setting during cardiovascular exercise test on a stationary cycle ergometer) significantly correlated inversely with participants' PA. Overall, increasing severity of pulmonary function deterioration is linked with lower levels (Watz, et al., 2009). Because the relationship is not very strong, measures of pulmonary function are not accurate enough to predict levels of PA in people with COPD.

2.9.4 Symptoms

COPD is characterized by three major symptoms: chronic cough, sputum production and dyspnoea (breathlessness) (Vestbo, et al., 2013). The experience of these symptoms significantly reduces health status (Burgel, et al., 2009). There is also a link between breathlessness and physical inactivity. The experience of breathlessness while performing any PA is known to be the major reason why people with COPD avoid regular PA and become trapped in the vicious cycle of physical inactivity described in section 2.8.4.

Participants in most qualitative studies have mentioned breathlessness on exertion as one of the barriers to regular exercise and PA participation (Katajisto, et al., 2012; Lewis and Cramp, 2010). Two studies (Watz, et al., 2009; Waschki, et al., 2012) have both found a significant association between higher dyspnoea scores (measured by the modified Medical Research Council, MRC, dyspnoea scale) and reduced levels of PA in people with COPD.

Two other commonly reported symptoms among people with COPD are fatigue and pain (Baghai-Ravary, et al., 2009; Lewis and Cramp, 2010; Bentsen, Rustoen and Miaskowski, 2011). When Wong, et al. (2010) investigated the link between fatigue and PA, they observed that high levels of subjectively measured fatigue (using Multidimensional Fatigue Inventory, MFI-20) were associated with reduced levels of PA. Higher levels of fatigue were also associated with reduced time spent outdoors in another study (Baghai-Ravary, et al., 2009). The association between pain symptoms and levels of PA in COPD has not been robustly reported. One comparative study of 47 people with COPD and 47 age- and gender-matched healthy individuals found that people with COPD had significantly greater pain-related fear of movement and reduced levels of PA and energy expenditure than healthy individuals (HajGhanbari, et al., 2012).

2.9.5 Exacerbations of COPD and hospital admission

Levels of PA are markedly reduced when people are admitted to hospital due to symptom exacerbations. Activity levels also reduce shortly after discharge from hospital due to the several weeks required for recovery. In addition, Pitta, et al. (2006) and Borges and Carvalho (2012) reported people with COPD perform lower levels of PA following recovery compared to the levels they performed prior to their hospital admissions. When people experience mild exacerbations (not requiring hospitalisation), they are very inclined to stay indoors and be sedentary to recover from exacerbations (Donaldson, et al., 2005). Besides, Donaldson, et al. (2005) also found that those who frequently experience exacerbations reduced the time they spent outdoors at a more rapid rate than those with infrequent exacerbations. Hence, people with frequent exacerbations are more likely to spend time indoors and become less physically active. This finding is consistent with that of Waschki, et al. (2012) who observed a significantly lower level of PA in particpants with more than one exacerbation.

Several prospective cohort studies have reported on the relationship between levels of regular PA and the number of times they were admitted or readmitted to hospital due to COPD

exacerbations (Garcia-Aymerich, et al., 2003; 2006; 2008; Pitta, et al., 2006b; Benzo, et al., 2010; Garcia-Rio et al., 2012). These studies consistently demonstrated, with statistical significance, that reduced levels of PA increased the risk of hospital admissions. Although all studies adjusted for the influence of confounding factors, only one of the studies adjusted for participants' prior COPD-related hospital admissions, which Almagro, et al. (2006) and Bahadori and FitzGerald (2007) found to be the main risk factor for hospital readmission. Importantly, in their review of studies that investigated the relationship between levels of PA and hospital admission, Watz, et al. (2014) noted that a relatively small amount of regular PA, equivalent to walking or cycling for 2 hours/week, is required to obtain a significant effect on COPD-related hospital admissions.

2.9.6 Comorbid conditions

COPD is associated with several chronic comorbid conditions which may independently influence levels of PA. Cardiac dysfunction was significantly associated with lower levels of PA in people with different severity of lung impairment (Watz, et al., 2008). However, in this study, other comorbidities such as malnutrition, high blood pressure, anaemia and depression were not linked with lower levels of PA. In a different study (Watz, et al., 2009b) in which the same participants were assessed, it was reported that those with COPD and metabolic syndrome had lower levels of PA compared with people with metabolic syndrome regardless of the severity of their lung impairment. Watz, et al. (2009b) did not state the exact component of metabolic syndrome that contributed to this observation. For example, obese participants with COPD have lower levels of PA compared with those who are underweight and/or normal weight (Monteiro, et al., 2012; Vozoris and O'Donnell, 2012). Similarly, diabetes is independently correlated with lower level of PA in people with severe COPD (Garcia-Aymerich, et al., 2004). According to van Remoortel, et al. (2014), the presence of comorbid conditions was more strongly associated with reduced PA compared with lung impairment in individuals who were newly diagnosed COPD.

Reduced skeletal muscle mass and strength is common in COPD (Barnes and Celli, 2009) and this has been shown to correlate positively with PA (Pitta, et al., 2005b; Waschki, et al., 2012; Shrikrishna, et al., 2012). Waschki, et al. (2012) demonstrated that quadriceps muscle strength was significantly associated with levels of PA and steps per day. By contrast, handgrip strength was not associated with levels of PA in other different study (Garcia-Aymerich, et al., 2009; Watz, et al., 2008).

Psychological conditions, notably anxiety and depression are commonly reported by people with COPD (Moussas, et al., 2008). Two studies have reported significant association between depression and PA (Iyer, et al., 2016; Nguyen, et al., 2013). In one study, participants who were very anxious were more physically active, whereas those who are more depressed tended to be less active (Nguyen, et al., 2013). Iyer, et al. (2016) demonstrated that depression independently predicted both short- and long-term readmissions for acute exacerbations which have previously been associated with lower levels of PA (Pitta, et al., 2006b; Borges and Carvalho, 2012).

2.9.7 Exercise capacity

Goldstein (1990) defined exercise capacity as the highest amount of physical effort an individual can sustain when completing a task. It reflects an individual's physical fitness, and is measured by different exercise tests such as the 6MWD and incremental shuttle walking tests. According to Caspersen, Powell and Christenson (1985), exercise capacity consists of a set of features that relates to peoples' ability to perform PA. For this reason, several studies in COPD have reported moderately positive associations between measures of exercise capacity and levels of PA that were quantified objectively (Pitta, et al 2005b; 2008; Garcia-Rio, et al., 2009; Waschki, et al., 2012). Two studies (Watz, et al., 2009; van Gestel, et al., 2012) investigated whether or not the 6MWD is able to predict or identify physically inactive people with COPD. Both studies found that 6MWD was moderately related with levels of PA, but did not reliably identify physically inactive patients.

2.9.8 Self-efficacy

Self-efficacy is "an individual's belief in his or her capability of performing a specific task in a specific situation" (Watz, et al., 2014, p.1526). It is a predictor of health behavior change and maintenance. In middle-aged and young-old adults, self-efficacy has both direct and indirect relationship with PA and this is influenced by other factors such as perceived ability to perform an activity, perceived barriers, expected outcomes, family support and self-care behaviors (Ayotte, Margaret and Hicks-Patrick, 2010; Kasikci and Alberto, 2007). In theory, people with higher levels of self-efficacy may be more physically active and people who are more physically active may have higher levels of self-efficacy. Nevertheless, when self-efficacy for walking was measured in people with COPD (using the Self-Efficacy Questionnaire – Walking, SEQ-W), it was not strongly associated with objectively assessed

PA (Belza, et al., 2001). In addition, in a recent study of 165 participants with COPD, DePew, et al. (2013) reported that self-efficacy (assessed with the General Self-Efficacy Scale, SES6) was not associated with PA.

2.9.9 Environmental factors

Weather and different climatic conditions such as variations in temperature and humidity have also been shown to influence levels of PA among people with COPD. Excessive heat or cold and/or high amounts of air pollutants have been reported as major triggers of acute exacerbations, increased coughing and sputum production and bronchoconstriction in COPD (Wedzicha and Seemungal, 2007; Gan, et al., 2004). These have also been reported as barriers to exercise and activity participation (O'Shea, Taylor and Paratz, 2007; Kosatsky, et al., 2009). As a result, seasonal differences in levels of daily PA have been reported by participants in a few studies (O'Shea, Taylor and Paratz, 2007; Sewell, et al., 2010; Lewis and Cramp, 2010; Langer, et al., 2012). Participants in these studies were more inclined to be physically less active during winter seasons. Living in an environment with high altitude may also influence levels of PA due to the link between high altitude and reduced exercise tolerance and concentration of oxygen in the blood at rest or while exercising (Kelly, et al., 2009). Living in a specific geographical area has not been reported to influence people's levels of PA independent of other factors. There were no statistically significant variation in levels of PA between people with different COPD severity living in Europe and America (Troosters, et al., 2010; Waschki, et al., 2012). Day of the week may also influenced levels or intensity of PA, with people inclining to be more intensely active during week days than during weekend (Watz, et al., 2009; Rabinovich, et al., 2013).

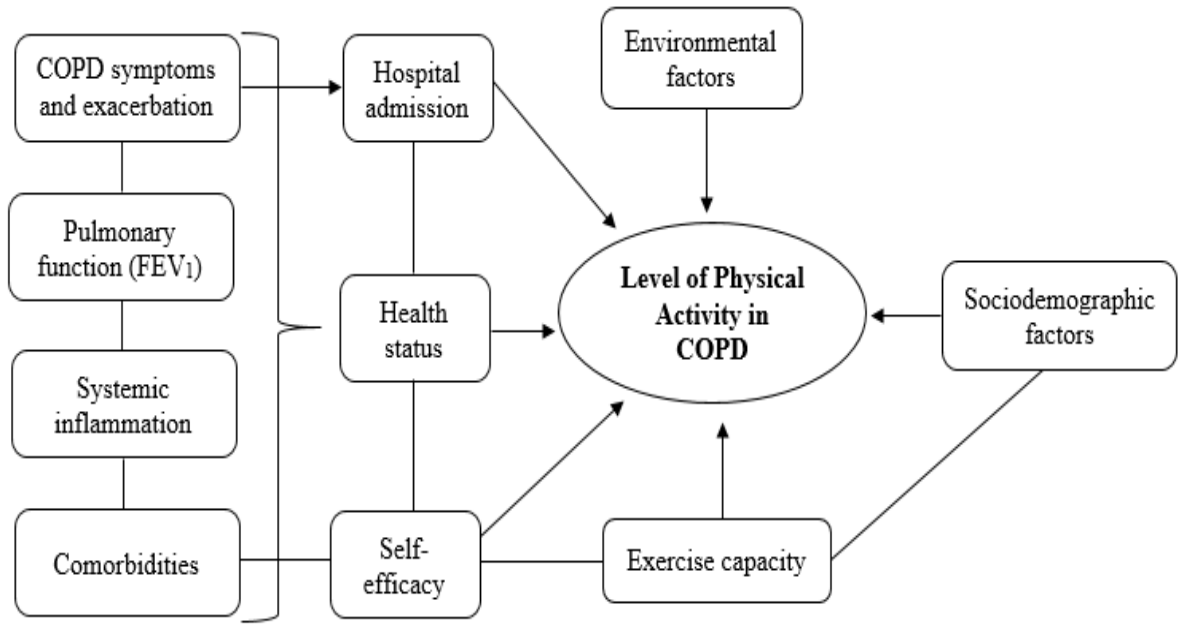
2.9.10 Systemic inflammation

There is a close relationship between systemic inflammation, immunity and levels of PA. Consistent participation in moderate-intensity PA is linked with reduced systemic inflammation in healthy individuals (Handschin and Spiegelman, 2008; Gleeson, 2007). Pedersen (2011) linked the likely mechanisms through which these findings occur to the the production and discharge of anti-inflammatory myokines when skeletal muscles contract. Four studies have demonstrated that higher levels of systemic inflammation is independently associated with lower levels of PA in people with COPD (Waschki, et al., 2012; Garcia-Aymerich, et al., 2009; Watz, et al., 2008; Moy, et al., 2014). However, Magnussen and Watz

(2009) noted that it remains unclear whether or not these associations can be explained by the anti-inflammatory mechanisms of regular PA.

In view of the empirical literature reviewed, a model of the correlates of levels of PA in people with COPD was developed. This is illustrated in Figure 4 and some of these factors were used to develop a conceptual framework for the study (see Chapter four). Without taking these into account, interventions for increasing level of PA on their own may be futile in sustaining long term benefits. It is important to note that it is not possible to conclusively agree on the directionality of the reported associations between levels of PA and the aforementioned factors (comorbidities, exercise capacity, sociodemographics, exacerbations, systemic inflammation) because most of the studies are of cross-sectional designs. Gimeno-Santos, et al. (2014) agrees with this view. In addition, because participants in the cited studies have not previously completed PR, the directionality and strength of the reported relationship may be different in people who have previously completed PR or those attending other post-PR exercise programmes. Future studies in this area are warranted.

Figure 4: Factors influencing levels of physical activity in patients with COPD



2.8.8 Future research agenda relating to physical activity in people with COPD

The implications of physical inactivity in people with COPD (see section 1.1) have made increasing PA levels an important goal in COPD management (Vestbo, et al., 2013; WHO, 2013). An overview of the current interventions for improving levels of PA in people with COPD was was presented in section 1.2). These included use of medications (Kesten, et al., 2008; O'Donnell, et al., 2011; Hataji, et al., 2013), ambulatory oxygen therapy (Casaburi, et al., 2012), behavioural change modifications and self-regulation (Moy, et al., 2012; de Blok, et al., 2006; Nguyen, et al., 2009; Conn, et al., 2008; Greaves, et al., 2011) and pulmonary rehabilitation (Vestbo, et al., 2013; Desveaux, et al., 2014a).

Previous studies on levels and determinants of PA in people with COPD was focused on measuring PA and its relationship with clinical outcomes prior to participation in PRPs (Jakes, et al., 2002; Pelkonen, et al., 2003; Garcia-Aymerich et al., 2003; 2006; 2007; 2008; Pitta, et al., 2006; Kesten, et al., 2008; Conn, et al., 2008; Greaves, et al., 2011; O'Donnell, et al., 2011; Casaburi, et al., 2012; Garcia-Rio, et al., 2012; Hataji, et al., 2013; Troosters, et al., 2014). Studies were also focused the effectiveness of PRPs (Egan, et al., 2012; Ries, et al., 2007; Verrill, et al., 2005; Puhan, et al., 2005; Heppner, et al., 2006; Karapolat, et al., 2007) and those of maintenance programmes following PR (Beauchamp, et al., 2013). Given the robust evidence of the benefits of PR and the need for interventions to maintain benefits over a long period, it remains presently unknown whether the relationship between PA and clinical outcomes observed pre-PR also apply post-PR. Researching the post-PR relationship between PA and clinical outcomes was recommended by a multidisciplinary Task Force of experts representing the ERS Scientific Group (Watz, et al., 2014). In their discussion of the future research agenda relating to the clinical importance of assessing and improving levels of PA in people with COPD (Watz, et al., 2014), they identified four important areas for future research (see section 1.7) and these provided a strong rationale for the present study.

2.10 Summary

This chapter has presented a discussion on the existing literature on COPD and PA. The epidemiology, pathophysiology, diagnosis and classification of severity, clinical symptoms and systemic effects of COPD were presented. The meaning of PA, its importance, subjective and objective measurement and recommended guidelines in people with COPD were highlighted. The mechanism of physical inactivity and its implications were also discussed.

The chapter concludes with a discussion of the current empirical knowledge on the several correlates of PA in people with COPD and provided the rationale for this research.

The gap in knowledge is identified as the lack of research into the extent of continued daily PA and its relationship with clinical outcomes for people with COPD who have completed an initial rehabilitation programme and attending CEPs. A complex mixed-methods systematic review was completed to establish the research questions outlined in section 1.5. Details of the mixed-methods systematic review are presented in the next chapter.

CHAPTER THREE

THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND HEALTH STATUS IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE FOLLOWING PULMONARY REHABILITATION

3.0 Introduction

The following journal article presents a mixed methods systematic review that synthesised, from quantitative and qualitative studies, results of the relationship between free living PA and measures of exercise capacity, health status and hospital admissions in people with COPD following PR. The review improved understanding on the current status of knowledge in this area and identified areas where new knowledge can be contributed. See Appendix 1 for the online supplement material related to this article.

3.1 Declaration by candidate

The candidate hereby certifies that:

- The extent of candidate's contribution to this published article is as follows:

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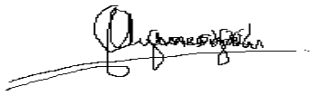
Meshe OF		22/04/2017

THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY AND HEALTH STATUS IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE FOLLOWING PULMONARY REHABILITATION

Meshe, O.F., Claydon, L.S., Bungay, H. and Andrew, S., 2017.
Disability and Rehabilitation, 39(8), pp.746-756

ABSTRACT

Aim: To investigate the relationship between physical activity (PA) and measures of health related quality of life (HRQoL) and hospital admissions in people with chronic obstructive pulmonary disease (COPD) following pulmonary rehabilitation (PR).

Method: CINAHL, Medline, PubMed, AMED, PsycINFO and Cochrane Library (database inception to June 2015) were searched. Relevant outcomes included relationships between PA and HRQoL, lung function (forced expiratory volume in 1 second, FEV_1) and/or hospital admission. 6 quantitative and 11 qualitative studies were included and Harden's method of data synthesis in a mixed-methods systematic review was applied.

Results: Six months following PR, increase activity levels was associated with improvement of 62m in 6MWD, 2.31 and 15.55 points increase in SGRQ and CRDQ total scores respectively, 1.3% FEV_1 and reduced dyspnoea. No study reported on hospital admission. Reported relationships were facilitated by healthcare professionals, social supporters, motivation and encouragement, reduced fear and seeing benefits and hindered by changing physical health, environment, lack of motivation, fear and social isolation.

Conclusion: The associations between increased levels of PA and quality of life, respiratory function and dyspnoea are largely based on 6MWD and PA questionnaires. Objective measurement of free living activity in exercise maintenance phase is required along with participants' views.

Key words: Chronic Obstructive Pulmonary Disease; exercise; health; barriers; facilitators and review.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition in which the airways are abnormally and characteristically narrowed so much so that airflow is limited and breathing becomes very difficult [1]. Currently, COPD ranks as the third leading cause of death worldwide [2]. The natural history of the disease is characterized by chronic cough, sputum production, reduced functional capacity and dyspnoea during physical activity (PA) leading to repeated symptom exacerbations and hospital admission [3]. PA is defined as "any bodily movement produced by skeletal muscles that requires energy expenditure" [4] and this includes free living physical activity undertaken in everyday functioning including occupational, sports and leisure activities [5].

Physical inactivity is considered a key clinical factor associated with high morbidity and mortality in COPD [6-8]. Physical inactivity remains the fourth leading risk factor for global mortality (6% of deaths globally) [9]. Specifically, a comparative study [10] of older adults with COPD and age-matched healthy individuals found that people with COPD were less active in daily life by 37 minutes/day in walking time, 104 minutes/day in standing time, 0.6 meter/second^2 in movement intensity during walking and 36m in six minutes walking distance (6MWD). Their sitting and lying times were higher by 68 minutes/day and 58 minutes/day respectively in the same study. A reduction of activity levels (classified as very low) and by ≥30 meters (in 6MWD) has been correlated with an increased risk of hospital admission [11,12]. Increasing activity levels is currently an important goal of COPD management [14] which could lead to improved long-term outcomes [8,10-12].

Pulmonary rehabilitation (PR) remains an integral non-pharmacological intervention for people living with COPD [13]. Supervised exercise training is the principal component of all pulmonary rehabilitation programmes followed by self-management education, psychological and social support [14,15]. Several studies have demonstrated that PR improves exercise capacity and activity participation as well as health status in people living with COPD [16-18]. In addition, PR also reduces mortality due to its modifying effects on prognostic indicators such as levels of daily activity, exercise tolerance, health related quality of life (HRQoL) and dyspnoea [7,16,18]. These improvements, which were mostly observed after short-courses (4-12 weeks) of hospital or community-based PR, diminish significantly 6-24

months after programme completion [18-20]. Clinical guidelines [9,13] now advocate exercise and activity in sustaining initial benefits from PR. In accordance with these guidelines, health professionals refer graduates of PR programmes to home and/or community-based exercise maintenance programmes to maximize their functional ability [14,15].

A previous review, that investigated the medium and long-term benefits of the post-PR exercise maintenance programmes [21], found that, at 6 and 12 months follow-up, there was no difference between post-PR exercise maintenance programmes and usual care for COPD-specific HRQoL (SMD, -0.07; 95% CI, -0.29-0.14; P=0.50) and (SMD, -0.15; 95% CI, -0.42-0.13; P=0.30) respectively. However, a significant difference in exercise capacity (SMD, -0.20; 95% CI, -0.39 to -0.01) was reported at 6 month, but this was not sustained at 12 months (SMD, -0.09; 95% CI, -0.29-0.11) [21]. In this review, the effectiveness of exercise maintenance programmes were reported, there were no reports of association between clinical outcomes in the post-PR life course of patients with COPD. Hence, the aim of this review was to synthesise, from quantitative and qualitative studies, the relationship between free living PA, measures of HRQoL and hospital admissions in people with COPD following PR. The quantitative aspect of this review investigated the relationship between PA and measures of HRQoL and hospital admission. The qualitative aspect explored the mediators of the observed relationships along with attitudes of patients to post-PR maintenance programme.

MATERIALS AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [22] and Harden's review process for data synthesis in a mixed method systematic review [23] were applied.

Search strategy

Two reviewers independently searched six electronic databases: CINAHL (1970-June 2015), Medline (1967-June 2015), PubMed (1982-June 2015), AMED (1986-June 2015), PsycINFO (1971-June 2015), and Cochrane Library (1999-June 2015). Details of the search strategy used in these databases are provided in online supplement 2 (tables 1 & 2). The search was limited to studies published in English language. Hand searching of the reference lists of identified studies was also performed.

Inclusion criteria

Studies were considered eligible for inclusion if they met the criteria (see table 1 and online supplement 3). Studies which evaluated exercise therapy during and after PR for people with COPD but did not include a measurement of free living physical activity were not included. Free living physical activity was defined as activity undertaken in everyday functioning and this include occupational, sports and leisure activities [5]. Studies which specifically measured activity limitation rather than participants' actual level or type of PA, were not included. Quantitative studies reporting improvements in relevant outcomes following PR but without statistical measures of associations were also excluded.

Table 1: Inclusion criteria

1	**Study design:**	Randomised controlled trials (RCTs), cohort, case–control, cross-sectional or qualitative studies
2	**Participants**	Adults (>18 years) living with clinical diagnosis of COPD according to the GOLD (2013) guideline which uses FEV_1 as percentage of the predicted normal FEV1 to define and classify patients with COPD (FEV1/FVC <0.7 and FEV1 ≥80%. FEV1 ≥80%=mild; FEV_1 50-79%=moderate; FEV_1 30-49%=severe; FEV_1 <30%=very severe)
3	**SMP:**	Studies were included if they reported results separately for each disease**; s**tudies were also included if they do not report results separately as long as they recruited ≥85% patients with COPD.
4	**Interventions:**	Participants had completed PR, participation in home and/or CEPs following PR.
5	**Outcomes:**	The primary outcome was PA measured objectively by accelerometers, pedometers, doubly labelled water (DLW), heart rate monitors and global positioning system (GPS) and/or subjectively by activity diaries, logs, questionnaires and interviews. Health status, functional/exercise capacity and health-care use (doctor visits, emergency visits, or length of stay) were the secondary outcomes
6	**Associations:**	The association between free living PA and clinical outcomes such as health status, health care utilisation, respiratory function, functional/exercise capacity were evaluated statistically
7	**Language of publication**	Published in the English language

COPD= chronic obstructive pulmonary disease; FEV_1= forced expiratory volume in one second; FVC= forced vital capacity; GOLD= Global Strategy for the Diagnosis, Management and Prevention of COPD; PR= pulmonary rehabilitation; CEPs= community-based exercise programmes; PA= physical activity; SMP= studies with mixed participants.

Review process

Titles and abstracts not fulfilling the inclusion criteria were excluded. Full texts of all remaining studies were retrieved and inclusion criteria applied. A search of the reference lists of all retrieved articles was also performed to identify additional studies. Two reviewers (OFM and LC) independently screened potential studies for final inclusion, and any discrepancies were discussed and resolved by consensus within the team.

Data extraction and methodological quality appraisal

Sets of two independent reviewers (OFM, LC, HB and SA) appraised the quality of included studies and extracted data into a standardized form (supplementary table 3). The quality of each quantitative study was assessed using a modified Downs and Black checklist (MDB) [24]. The MDB tool consists of 27 items that relate to study description, reporting, external validity, internal validity (bias and confounding) and power to detect a clinically important effect. Each item was score one point, resulting in a maximum score of 27 (see supplementary table 4). The quality of qualitative studies was assessed using the critical appraisal skill programme's (CASP) qualitative tool [25], which consists of 9 items that relate to key aspects of a qualitative study- aims appropriateness of study design, recruitment strategy, data collection, rigour, power relationship and ethical issues. Similarly, each item was score one point, resulting in a maximum score of 9 (see supplementary table 5). Any discrepancies between reviewers were resolved by discussion within the team until consensus was reach. Reviewers unanimously agreed to grade the quality of quantitative studies as poor, fair and good if they had MDB scores of <14, 15-19 and >20 respectively [24], while qualitative studies were graded as low, medium and high if their CASP score is between 0-3, 4-6 and 7-9 respectively [25].

Quantitative and Qualitative Data Analyses

A mixed-synthesis method [23,26], consisting of three stages, was applied in this review. Following data extraction, a synthesis and summary of the relationships between PA and COPD outcomes from quantitative studies was performed. Heterogeneity of statistical analyses for associations reported between PA and other outcomes in the included studies precluded meta-analysis of findings, therefore, evidence was synthesized narratively. When there is heterogeneity of statistical techniques, Hendrick et al [27] suggested reporting only the univariate analyses unless the study only reported results of the multivariate analyses. The

main consideration was statistical measurements of association at $p<0.05$, or reports of 95% confidence interval (CI) and ≤1 odds ratio (OR), risk ratio (RR) or correlation coefficient. In studies where longitudinal relationships between variables were assessed, statistical relationships were presented at reported time points.

Methods of qualitative data analysis in systematic reviews are still evolving and several techniques are available [28]. An approach similar to thematic synthesis [29] was used in this review. Quotes from respondents and statements from author's interpretations were repeatedly scrutinised in order to identify recurrent themes. Findings from each study were first described separately before searching for common themes. Themes that emerged from the findings were ordered and mapped according to the number of studies in which they were identified (see supplementary tables 6 & 7). The themes were then used to interrogate the quantitative findings to identify commonalities and differences. Themes were also explored for contextual differences which are discussed to include possible influences on the outcomes.

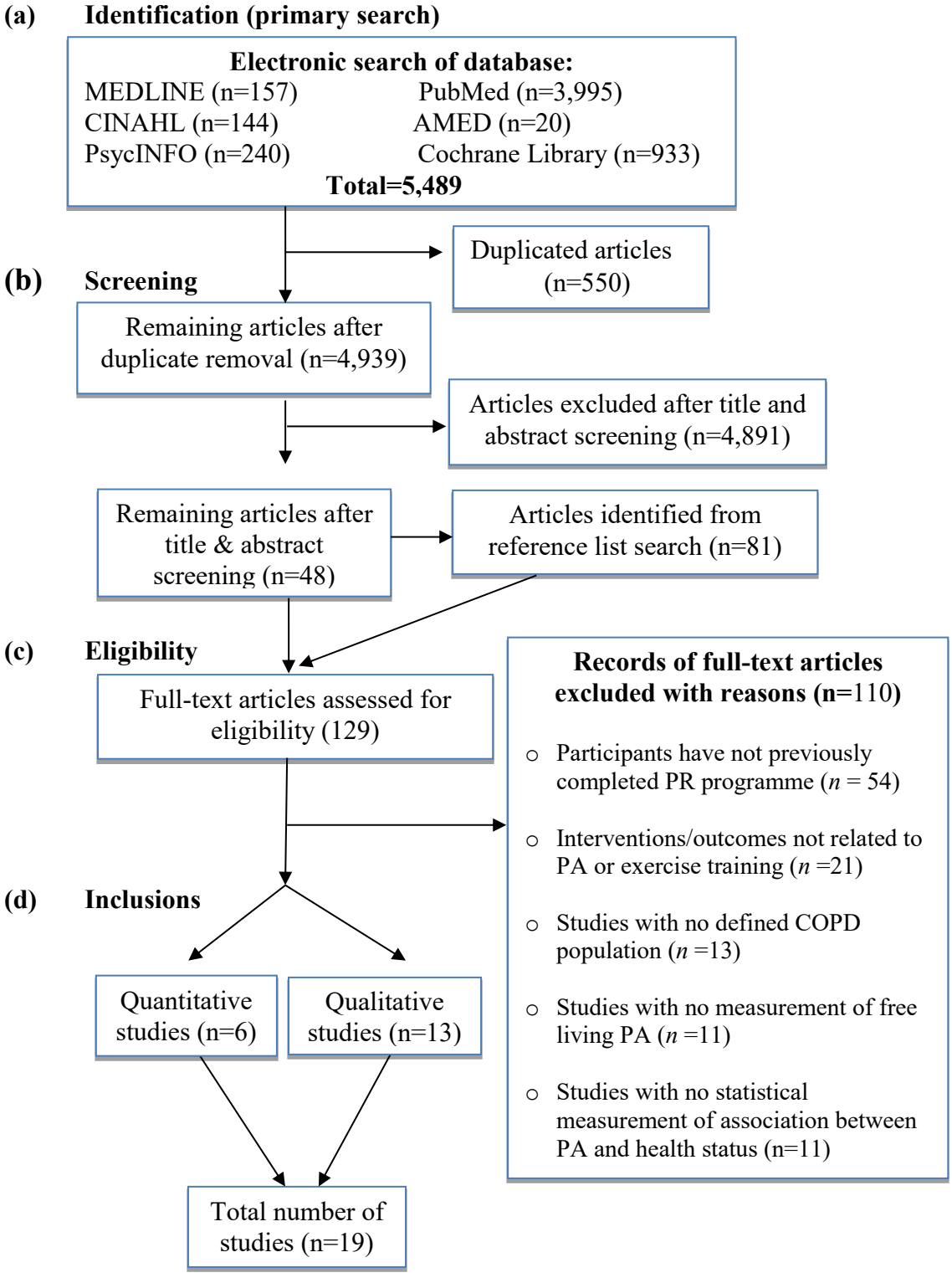
MAIN RESULTS

Included studies

The database search yielded **5,**489 articles of which 550 duplicates and 4,891 articles were removed based on title and/or abstract screening. A reference list hand searching of the 48 remaining identified 81 additional articles. Full-texts of these 129 articles were then assessed for eligibility of which 110 were further excluded. 19 studies- 6 quantitative [30-35] and 13 qualitative [36-48] (see Figure 1) met inclusion criteria.

Figure 1: The PRISMA's flow diagram for study selection

PR= pulmonary rehabilitation; PA= physical activity



Characteristics of included studies

The characteristics of included quantitative and qualitative studies are detailed in tables 2 and 3 respectively. The quantitative studies consist of one randomized controlled trial (RCT) [31], one non-randomized trial (nRT) [30] and four cohort studies [32-35]. The qualitative data collection and analyses strategies varied across studies. Ten studies employed one-to-one semi-structured interviews [36-38,41-43,45-48], the remaining three used focus group interviews [39,40,44].

Participants were community-dwelling elders, mean age 67.54±7.30 years, mean BMI 25.5±6 Kg/m^2 (data from 5 quantitative studies) [30,32-35], with mild to very severe COPD GOLD stages I-IV (mean FEV_1 47.05±16.36% predicted) and mostly retired. The total number of participants in the quantitative studies was 588 (332 men and 256 women) and 216 (134 men and 82 women) in the qualitative studies.

Quality assessment

Three quantitative studies [30,31,34] were rated as good (>20 score) and the other three studies [32,33,35] were rated as fair (15-19 score) on a 27-MDB quality scale. Two studies reported on randomization procedures [30,32], but none reported allocation concealment indicating possible selection bias. All studies had a high risk of performance bias as participants were not blind to the intervention. This is an inherent limitation of studies involving exercise training. Blinding of outcome assessors was also unclear in all studies. Potential for attrition bias was high in three studies [30-32] due to high dropout rates of 33%, 29% and 28% respectively. All studies reported the characteristics of participants lost to follow-up and accounted for the potential effects of attrition. Overall, quantitative studies had a fair quality rating- an average score of 20 on the MDB scale. It is notable that all qualitative studies explicitly or implicitly provided evidence of reflexivity. Overall, qualitative studies had a high quality rating- an average score of 8 on the CASP scale.

Table 2: Characteristics of included quantitative studies

First author [ref.], Country	MDB Quality score	Study design	Sample size and gender (M/F)	Age (years)	Loss to Follow-up	BMI (Kg/m^2)	COPD diagnosis (FEV_1 % predicted)
Bendstrup [32], Denmark	21 (Good)	RCT	24 (9M, 7F)	Mean (SD) 64(±3)	8	Not reported	49.76±16%
Cooke [33], Australia	19 (Fair)	One-group longitudinal pre-test post-test design	29 (18M, 11F)	Mean (SD) 71.7(8.45)	8	Median (IQR) 25.0 (22.3-30.3)	Median (IQR) 41% (30-56%)
Jones [34], UK	19 (Fair)	Prospective/cohort study	239 (136M, 103F)	Mean (SD) 70 (9)	0	Mean (SD) 27.5 (6.1)	Mean (SD) 48.1 (19.8)
Pitta [31], Belgium	21 (Good)	Longitudinal nRT	41 (31M, 10F)	66±8	12	25±6	45±16%
Skumlien [35], Norway	21 (Good)	Prospective parallel group study	40 (22M, 18F)	Min-Max. (45-75)	1	24.5 (8.5)	48 (17)
Soicher [36], Canada	19 (Fair)	Longitudinal observational study	215 (116M, 90F)	66±8	9	Underweight-Obese	44.4±13.0

Abbreviations: M= Male; F= Female; SD= standard deviation; BMI= body mass index; RCT= randomized control trial; nRT= non-randomized trial; IQR= inter-quartile range; FEV_1= forced expiratory volume in 1 second; MDB= modified Downs and Black quality scale

Table 3: Characteristics of included qualitative studies

First author [ref.], Country	CASP Quality Score	Main aim/objective of study	Main outcomes assessed	Study design & data analysis	Sample size (n) and Gender (M/F)	Age (years)	COPD diagnosis
Arnold [36], UK	7 (Medium)	To explore the patients' experiences of a hospital-based 7-week (2x/week) PRP	Facilitators and barriers to adherence	Qualitative study using SSI and GT	20 participants (9M, 11F)	45-85 years old (Mean age=66.45)	COPD GOLD I-III
Halding [37], Norway	8 (High)	To unpack and interpret descriptions of experiences of social relationships during a 12-week (once a week) PRP	Social relationships (belonging) during a 12- PRP	Qualitative study using interviews (IP) and CA	18 participants (13M, 5F)	52-81 years old	COPD GOLD I-III
Halding [38], Norway	8 (High)	To explore the experience of patients with COPD in terms of their transitions in health during and after PR a 12-week (once a week) PRP	Health transitions during and after a 12-week PRP	Qualitative interview (IP) and CA	18 participants (13M, 5F)	52-81 years old	COPD GOLD I-III
Hogg [39], UK	9 (High)	To explore patients' views and perceptions of an 8-week PRP & maintaining an active lifestyle following a course of PR	Value of PRP; ongoing exercise opportunities after PRP, facilitators and barriers	Qualitative study using focus groups (2) and GT	16 participants (9M, 7F)	Mean age (SD) 71 (10) in Group A 67 (11) in Group B	Moderate COPD.
Lewis [40], UK	8 (High)	To explore patients' attitudes to exercise & reasons for non-concordance with post-PR exercise maintenance	Facilitators and barriers to exercise (at home and gym)	Qualitative study using focus group and TA	6 participants (1M, 5F)	61-83 years old (Mean age=69.3)	COPD GOLD I-IV
Milne [41], Australia	8 (High)	To report the meaning of hope as described by patients with COPD involved in a home-based EMP	Hope after hospital-based PRP followed by home-based EMP	Qualitative interviews (IP) and TA	7 participants (5M, 2F)	57-81 years old	COPD (severity not reported)
Norweg [42], USA	6 (Medium)	To analyse participants' perceptions of a 6-week (2 hours/week) PRP which combined occupational therapy with physical therapy.	Value of the programme, facilitators and barriers	Qualitative study using SSI and TA	4 participants (1M, 3F)	69-80 Mean age=73 years	COPD GOLD I-IV
O'Shea [43], Australia	9 (High)	To explore the qualitative outcomes of a progressive resistance exercise (PRE) program	Value of the programme, facilitators and barriers	Qualitative study using SSI and TA	22 participants (8M, 14F)	51-79 years old Mean age (66.7±6.8)	COPD GOLD II-IV
Rogers [44], UK	8 (High)	To understand patient information needs and how best to meet them by exploring experiences of PLWCOPD following PR.	Support needs following PRP	Qualitative study using focus groups and template analysis	23 participants (14M, 9F)	Mean age (SD) 66.75 (10) years	COPD (severity not reported)

Wang [45], Taiwan	7 (Medium)	To explore patients' beliefs regarding regular exercise	Beliefs regarding exercise, facilitators and barriers	Qualitative study using one-to-one interviews & CA	31 participants (28M, 3F)	44-81 years old	COPD GOLD II-IV
Williams [46], UK	8 (High)	To explore how an 8-week PRP (1.5 hours, 2x/week) affect the experience of activity and breathlessness	Effects of PRP, perception of dyspnoea and post-PR activity	Qualitative study using SSI and GT	9 participants (6M, 3F)	54-84 years old	COPD GOLD II-IV
Stewart [47], The Netherlands	10 (High)	To explore determinants of behaviour change maintenance of a physically active lifestyle following PRP	Determinants of behaviour change, facilitators and barriers	Qualitative study using SSI and CA	22 participants (14M, 8F)	45-78 years old Mean age (SD) 63.5 (7.8) years	COPD GOLD I-IV
Zakrisson [48], Sweden	9 (High)	To describe the experiences of the usefulness of PRP one year after participation	Value of the programme, awareness of limitation, regaining control.	Qualitative study using SSI and CA	20 participants (13M, 7F)	62-78 years old Mean age (SD) 68 (4.1) years	COPD GOLD II-IV

Abbreviations: SSI= Semi-Structured Interviews; GT= Grounded Theory; IP= Interpretive Phenomenology; M= Male; F= Female; PA= Physical Activity; PRP= Pulmonary Rehabilitation Programme; CA= Content Analysis; TA= Thematic Analysis; EMP= Exercise Maintenance Programme; GOLD I-IV= COPD severity ranging from mild to very severe.

PR and post-PR exercise maintenance programmes

Participants in all studies attended 4-12 weeks PR programmes and continued in home or community-based exercise maintenance programmes. The structure and contents of the PR programmes- supervised exercise training, self-management education, psychological and social support- as well as delivery were consistent with national and international practice [14,15]. Most were administered in a hospital-based outpatient setting and were supervised by physiotherapists. There were 2-4 training sessions lasting 1-2 hours per week [30,31,34]. Two studies did not describe the PR programme [32,33]. The duration of PRP varied from 4-24 weeks [30,34,35]. Participants in all studies were encouraged to join community-based exercise maintenance programmes or continue to exercise at home.

Only four studies described the exercise maintenance programmes [30,32,34,35], which were mostly administered at home, with the exception of one study [35], in which participants were encouraged to join a community exercise facility. The home-based exercise sessions were generally unsupervised, except in one study where participants were supervised by regular telephone calls and home visits [32]. The frequency and duration of exercise training were reported in two studies and consisted of 30-45 minutes, three times/week for 12 months [35] and 24 sessions in 12 weeks [34]. In two studies [30,32], frequencies of home exercise training were not reported but their maintenance programmes lasted for six and twelve months respectively. The exercise maintenance programmes always included aerobic exercise (walking or cycling) and most studies [30,32,34,35] reported muscle resistance training.

Outcome measurements

Free living PA, exercise capacity, generic and COPD-specific health related quality of life (HRQoL) and hospital admissions were the outcomes of interest. Methods for assessing these outcomes varied across studies. Only one study [30] employed an objective measure of PA (activity monitors) to quantify pattern of time spent on activity and classify levels of activity into low, moderate and high. Another study [33] employed a common activity of daily living (continuous sit-to-stand activity). Five studies utilized self-reported PA questionnaires [30-32, 34,35]. Of the five different questionnaires used, only the Stanford 7-D-PARQ and PFSS have been validated as a measure of activity in patients with COPD [49,50]. Exercise capacity was mostly measured with the 6-min walk distance (6MWD) test [30-32,34,35], while COPD-specific HRQoL were mostly measured with the St. Georges'

Respiratory Questionnaire (SGRQ) [32-35] and Chronic Respiratory Disease Questionnaire (CRDQ) [30,31] which have previously been tested and validated for patients with COPD [51,52].

Associations between physical activity, health status and hospital admission

Supplementary tables 8,9,10 & 11 summarise the improvements in reported outcomes. At 3-6 months, there is a positive trend of improvements in free living activity and time spent in daily/week activities from six studies [30-35] (n=588). Due to heterogeneity in the measurement tools the average cannot be reported. The average improvement in 6MWD from five studies [30,31,33,34] (n=344) is 62 meters (m). There is a positive trend of improvements in dyspnoea, heterogeneous measurement tools precludes pooling of data. Average SGRQ total score from four studies [32-35] (n=523) improved by 2.31 points while CRDQ total score from two studies [30,31] (n=65) improved by 15.66 points. FEV_1 from three studies [30,31,34] (n=105) improved minimally by 1.3%.

Table 4 summarises the associations reported between free living PA exercise capacity, health status and dyspnoea. There were five main quantitative findings in this review. First, 5 out of 6 studies examined the relationship between PA and exercise capacity [30,31,33-35]. A highly significant association was found between change in FLPA sub-scores and exercise capacity, 6MWD ($r=0.636$, $p<0.01$) [31]. A change in time spent on FLPA was associated with 46m (95% CI= 20-72) improvement in 6MWD [34]. A reduction of -1.45s seconds in median time to complete 5STS time correlated significantly with change in exercise capacity ($r= -0.13$, $p<0.05$). A high PA level of 2.7h/week was associated with higher 6MWD [35]. Frequent exercise training correlated with increase exercise capacity ($r= 0.38$; $p=0.04$) [30]. The 5 studies reported positive relationship between activity and exercise capacity, indicating that as activity increases exercise capacity increases.

Second, 4 out of 6 studies examined the relationship between PA and HRQoL [31-34]. A significant association was observed between improvement in FLPA score and COPD-specific HRQoL scores ($r=0.376$, $p<0.01$) and generic HRQoL scores ($r=0.563$, $p<0.05$) [31]. Similarly, an improvement in 6MWD was also associated with lower COPD-specific HRQoL scores ($r= 0.430$, $p<0.05$) and generic HRQoL scores ($r= 0.414$, $p<0.05$) [31]. A significant association was also observed between higher self-efficacy score for PA and lower SGRQ total score ($r=0.930$, $p=0.002$) [32]. A reduction of -1.4s in median time to complete 5STS

activity was associated with lower SGRQ total score (r= 0.35, p<0.001) [33]. Improvements in ADL and 6MWD were associated with lower SGRQ total score after 12 weeks (OR= 0.285; 95% CI= 0.06-1.35; p=0.113) and 12 months (OR= 0.97; 95% CI= 0.23-4.61, p=0.972) [34]. The 4 studies reported positive relationship between activity and HRQoL, indicating that a higher level of activity was associated with better HRQoL.

Third, 4 out of 6 studies examined the relationship between activity and dyspnoea [30,32,33,35]. Changes in walking time in daily life of 7±35% at 3 months and 20±36% at 6 months correlated significantly (r= 0.43; p= 0.02) with reduced dyspnoea [30]. High level of activity (mean 2.7h/week) was associated with lower dyspnoea score [35]. A positive correlation was observed between self-efficacy and mean dyspnoea score (r= 0.680; p= 0.044) [32]. Time spent in completing 5STS activity was associated with lower dyspnoea score (r= 0.42; p=0.01) [33]. The 4 studies reported positive relationship between activity and dyspnoea, indicating that higher levels of activity were associated with reduced dyspnoea.

Fourth, 3 studies examined the relationship between activity and respiratory function (FEV1) [31,34,35]. Improvements in free living activity and 6MWD were positively associated with increase in FEV1 (r= 0.318, p<0.01; r= 0.008, p<0.05) [31]. Improvement in ADL score was associated with a 1.2 increase in FEV1 (95% CI= -2.4-4.8) [34]. High level of activity (mean 2.7h/week) was associated with increase in FEV1 [35]. Overall, the 3 studies reported positive relationship between activity and FEV1, indicating that higher levels of activity was associated with better FEV1. Finally, none of the 6 included studies reported on the association between activity and hospital admission.

Table 4: Findings from included quantitative studies

First author [ref.]	PA	Associated outcome examined	Statistical analysis of associations	OR, RR 95% CI or correlation coefficient (r)	Nature of relationship
Bendstrup [32]	Change in FLPA score	Exercise capacity (6MWD)	4^{th} order partial correlation	r= 0.636, p<0.01	Positive
Jones [34]	1.4s reduction in median 5STS time	Exercise capacity (ISWT)	Spearman rank correlation	r= -0.13 (p<0.05)	Positive
Skumlien [35]	Change in ADL time after PR/EMP	Exercise capacity (6MWD)	Mean (95% CI)	46m (95% CI= 20-72)	Positive
Pitta [31]	Walking time in daily life	Frequency of exercise/no of session	Pearson's correlation coefficient	r= 0.38; p=0.04)	Positive
Soicher [36]	PA levels after PR and EMP	Exercise capacity (6MWD)	Trajectory modelling, ANOVA, X^2, MDA, comparison of baseline features	Patients with high PA levels (mean 2.7h/week) had higher 6MWD.	Positive
Bendstrup [32]	Change in FLPA score	COPD-specific HRQoL scores	4^{th} order partial correlation	r=0.376 (p<0.01)	Positive
	Change in FLPA score	Generic HRQoL score	4^{th} order partial correlation	r=0.563 (p<0.05)	Positive
	Change in exercise capacity	COPD-specific HRQoL scores	4^{th} order partial correlation	r= 0.430 (p<0.05)	Positive
	Change in exercise capacity	Generic HRQoL score	4^{th} order partial correlation	r= 0.414 (p<0.05)	Positive
Cooke [33]	Cross-sectional self-efficacy for PA	SGRQ total score	Pearson's correlation coefficient	r=0.930 (p=0.002).	Positive
Jones [34]	Time spent in completing 5STS PA	SGRQ total score	Spearman rank correlation	r= 0.35 (p<0.001)	Positive
Skumlien [35]	Change in ADL & 6MWD after PR and EMP	SGRQ total score	Logistic regression performed with MCID	OR= 0.285 (95% CI= 0.06-1.35; p=0.113) after 12 weeks.	Positive
				OR= 0.97 (95% CI= 0.23-4.61, p=0.972) after 1 year.	Positive
Cooke [33]	Cross-sectional self-efficacy for PA	MRC dyspnoea score	Pearson's correlation co-efficient.	r=0.680 (p=0.044)	Negative
Pitta [31]	Change in walking time in daily life after PR and EMP	Changes in dyspnoea domain of CRDQ	Pearson's correlation coefficient	r= 0.43 (p= 0.02)	Positive
Soicher [36]	PA levels after PR and EMP	MRC dyspnoea score	Trajectory modelling, ANOVA, X^2, MDA, comparison of baseline features.	Patients with high PA levels (mean 2.7h/week) had lower dyspnoea score	Positive
Jones [34]	Time spent in completing 5STS PA	Age Dyspnoea Obstructive index	Spearman rank correlation	r= 0.42 (0.01)	Positive

Bendstrup [32]	Change in FLPA score Change in exercise capacity	FEV_1 % predicted FEV_1 % predicted	4^{th} order partial correlation 4^{th} order partial correlation	r= 0.318, (p<0.01) r= 0.008, (p<0.05)	Positive Positive
Skumlien [35]	Improvement in ADL after PR and EMP	FEV_1 % predicted	Mean (95% CI)	1.2 (95% CI= -2.4-4.8) at 12 weeks	Positive
Soicher [36]	PA levels after PR and EMP	FEV_1 % predicted	Trajectory modelling, ANOVA, Chi-square, MDA, comparison of baseline features	Patients with high PA levels (mean 2.7h/week) had lower FEV_1 % predicted	Positive
None	PA levels after PR and EMP	Hospital admission	None	None	N/A

Nature of relationship: Positive= as physical activity increases, outcome tends to increase; **Negative=** as physical activity increase, outcome tends to decrease.
Abbreviations: PA= Physical Activity; FLPA= Free living physical activity; PR=pulmonary rehabilitation; EMP=exercise maintenance programme; FEV_1= Forced Expiratory volume in 1 second; HRQoL= Health-Related Quality of life; CRDQ= Chronic Respiratory Diseases Questionnaire; 6MWD= Six-Minute Walking Distance; ADL= Activities of Daily Living; MRC-DS= Medical Research Council Dyspnoea Scale; SF-36= Medical SGRQ= St. Georges' Respiratory Questionnaire; STS= Sit-To-Stand; ISWT= Incremental Shuttle Working Test; ADO= Age Dyspnoea Obstructive index; MRA= multivariate regression analysis; ANOVA= analysis of variance

Qualitative (Patients' Reported) Outcomes

The qualitative outcomes of PR and exercise maintenance programmes are summarized in supplementary tables 6 and 7. Included studies varied in context, design, method of data collection and analysis, but were mostly similar in participants' characteristics. Included studies explicitly and implicitly examined barriers and promoters of adherence to PR and maintenance programmes, barriers and promoters of adherence to exercise and activity participation, perceived effects of PR, benefits of exercising, behavioural change and the post-rehabilitation support needs of people with COPD. Overall, the views of participants regarding perceived effects of PR and benefits of exercising appeared consistent. Views regarding barriers and facilitators were more varied. Participants also perceived the influence of social integration, professional and peer social group support and expressed their views of the type of support they need after completing pulmonary rehabilitation.

Social integration emerged as the most common theme. It provided an opportunity to learn, **s**hare knowledge, encourage mutual trust and support, increase self-confidence, motivation and improve quality of life [37,47]. Professional and peer social support further strengthens self-confidence and hope which persists despite COPD [39,41,47]. The main post-PR support needs of people with COPD were: reinforcement of knowledge of COPD and self-management skills, disseminating knowledge of COPD and its treatment to family, friends and the public, access to individualized counselling and staying connected with peers and health professionals [38,39,44,45,47].

Most of the studies focused mainly on the perceived effects of PR and benefits of exercising after PR [36-48] which fall into four categories: health, physical, social and psychological benefits. In order of frequency, the two most often identified indicators of improved health status were reduced breathlessness and increased control of breathlessness during activities. This played an important role in mediating the quantitative association between increased PA and improvement in dyspnoea as participants appeared to have performed more activities they avoided prior to PR due to fear of being breathless. Other indicators of improved health status included: increase education/knowledge of disease, self-care and coping skills, recovery after an exacerbation, loosening secretion, reduced experience of co-morbid conditions, mainly arthritis and change in perception of breathlessness. In order of frequency, the most often reported physical benefits were: increase exercise capacity, PA and regular

exercise, increase stamina and muscle strength, less fatigue and acknowledgement of post-PR limitations and abilities. Looking attractive was the least reported physical benefit. Participants linked these improvements with the rehabilitation programmes. Nevertheless, some participants in one study [45] stated that participating in PR did not help them maintain a regular exercise habit. Other participants reported that the perceived initial physical benefits declined 12 weeks after PR [43].

Positive psychological benefits were reported across studies. In order of frequency, the most frequently reported psychological benefits were: increased self-confidence, reduced fear of activity, improved self-esteem, desire and motivation for self-management and strengthened hope for the future. Despite perception of positive benefits some respondents did not perceive any benefit, while others reported adverse effects of PR and exercise maintenance programmes. Some participants in four studies reported no change in levels/experience of breathlessness [43,44,46,48] and two other studies observed no relationship with regular exercise [45,48]. The three negative effects reported by participants were: tiredness, discomfort [40,45,48] and frustrations with training equipment [43-45].

One study reported barriers and facilitators to attending a hospital-based PR programme [36], the remaining ten studies [37-48] reported facilitators and barriers limiting exercise and activity participation (supplementary table 6 & 7). In order of frequency, the five most often identified facilitators of adherence were: healthcare professionals, social supporters (family members, friends and companions), motivation and encouragement, reduced fear and seeing benefits (increased activity and reduced breathlessness). Other facilitators included: self-confidence, enjoyment of programme, goal setting, personal attributes, availability of exercise options, will power and fitting exercise into one's personal schedule. These enablers were only reported in the qualitative studies [37-46]. Barriers such as lack of social support, fatigue, frustration with exercise equipment, working, changing physical health (co-morbidities and acute exacerbations) and lack of motivation were cited in both qualitative and quantitative studies [31,33-36,41,47]. Three additional barriers- cost, change of contact details and lack of proximity- were cited in five quantitative studies [30-32,34,35]. Five other barriers- didactic nature of learning, environment (fumes, weather and competition in gyms), lack of available classes at suitable times, perception of overcoming the effort of living with COPD and safety issues were reported in six qualitative studies [36,39-41,43,45]. In order of

frequency, the five most often identified barriers were: changing physical health status, fear and anxiety, environment, lack of motivation and social isolation.

So in short it seems the positive relationships between increased activity, exercise capacity, breathlessness and HRQoL are also reported in the qualitative studies. It seems that facilitators of these positive relationships are healthcare professionals, social support, reduced fear and seeing the benefits (increased activity and decreased breathlessness) whereas barriers to the relationship are lack of social support, fear, co-morbidities and changing physical health/exacerbations.

DISCUSSION

The aim of this mixed-methods review was to synthesise, from quantitative and qualitative studies, results of the relationship between free living PA and measures of health status and hospital admissions in people with COPD following PR. Mediators of the reported relationships between these variables were also explored along with attitudes of patients to post-PR maintenance programme. Overall, there is a positive relationship with increased activity and improvements in a range of health outcomes. On average, approximately six months following PR and exercise maintenance, activity as measured by the 6MWD increased by 62m (compared to baseline- end of PR programme), HRQoL improved by 2.31 and 15.66 points measured by SGRQ and CRDQ respectively, dyspnoea reduced and FEV_1 improved minimally by 1.3%. No study reported on hospital admission, defined as a stay in a hospital for nursing care for at least overnight or other forms of health-care use such as doctor visits or emergency visits as a consequence of an exacerbation [11,12]. The patients linked participating in the joint PR and exercise maintenance programmes with improvements in exercise capacity and activity levels. Reported indicators of improved health status such as reduced breathlessness and increased control of breathlessness during activities agreed with the quantitative associations between activity, health status and dyspnoea. In addition, patients' perception of improved HRQoL was related to better understanding of COPD, coping skills, recovery after exacerbation, reduced experience of co-morbid conditions (mainly arthritis) and change in how they perceived breathlessness. Increase muscle strength, stamina, energy levels and less fatigue were associated with improved functional ability.

Previous cross-sectional study [10] has shown that the 6MWD in patients with COPD is lower by 36m compared to age-matched healthy older adults and by 16m at 12 months in a 5-

year longitudinal study of patients with severe airflow limitation (FEV_1 <50% predicted) [53]. A ≥30 meters reduction in 6MWD has been correlated with an increased risk of death (HR=1.93; 95% CI= 1.29–2.90; *P* = 0.001) [8]. This review shows an increase in patients' activity with PR/exercise maintenance programme of approximately 62m (in 6MWD) at 3-6 months. The clinical importance of this is viewed in the context of the minimal clinically important difference (MCID) in outcomes for COPD. The MCID is "the smallest difference in a score in the domain of interest which patients perceive as beneficial and which would mandate, in the absence of troublesome side effects and excessive costs, a change in the patient's management" [54]. The 62m improvement shown in this review exceeds the 25m or 35m MCID for the 6MWD in people with COPD [55,56].

An earlier review by Puhan et al [57] found that an improvement of 64-215m (in 6MWD) was associated with an -11.1 points (95% CI= -17.1 to -5.2) improvement in SGRQ's total score and reduced risk for hospital admissions (RR= 0.26; 95% CI= 0.12–0.54) and mortality (RR= 0.45; 95% CI= 0.22–0.91). This review's 62m improvement is lower than the lower limit (64m) linked with these positive clinical benefits. This, perhaps, accounts for the lower values of 2.31 points (SGRQ total score) and 1.3% (FEV_1) compared with their MCIDs of 4 units and 100ml respectively [58,59] respectively.

In previous systematic reviews, it has been shown that exercise training undertaken in the context of ≥4 weeks pulmonary rehabilitation produces a small but significant increase in daily PA [60] and 64-215m (in 6MWD) [57] which is short-lived because these gains decline- 75m (6MWD), 7.3 points (SGRQ total score) and 1.3% (FEV_1) ($p<0.05$) after 3 months of PR [20]. Exercise maintenance classes following PR have been shown to reverse this declining trend. For example, at 6 months follow-up, there was significant difference between exercise maintenance programmes and usual care for 6MWD (SMD, -0.07; 95% CI, -0.29-0.14; P=0.50). However, only minimal difference was observed for HRQoL (SMD, -0.07; 95% CI, -0.29-0.14; P=0.50) [21]. This current review shows that with exercise maintenance the declining trend in outcomes is reversed with increases in free living PA, 62m (mean 6MWD), reduced dyspnoea, 2.31 and 15.66 points improvement in SGRQ and CRDQ total scores respectively as well as 1.3% improvement in FEV_1 at 3-6 months.

An important contribution of this review is that it suggests how improvements in exercise capacity, dyspnoea, and self-efficacy following pulmonary rehabilitation might translate into

increased physical activity. This was not explained in previous reviews/statements [21,61] and was a key area for future research recommended by Watz et al [61]. Addressing the facilitators and barriers to activity participation identified in this review provides an insight in this regard. For example, COPD patients who believe that professional advice to be physically more active are beneficial to them may more interested in becoming more active in agreement with the 'Perceived Benefits of Taking Action' construct of the Health Belief Model [62]. Similarly, participants who perceived less barriers to their course of action will be more likely to increase their physical activity, again in line with the 'Perceived Barriers' construct of the Health Belief Model. Though participants in all studies attended PR programmes and continued in home or community-based exercise maintenance programmes, the qualitative data address attitudes to PR and not the post-PR maintenance programme and whether or not these attitudes apply to the latter is unclear.

From a methodological perspective, this review has some strengths and limitations. A strength is a comprehensive search of six databases, however, there is always a possibility that some eligible studies were not found. A limitation is the heterogeneous characteristics of the joint PR and exercise maintenance programmes with regards to components, frequency, intensity and duration of training, timing of follow-up intervals, outcome measures and statistical techniques which precluded pooling of the data. Another limitation is the inclusion of only English language studies which may have resulted in language bias [63-65]. Nonetheless, a previous study of the importance of comprehensive searching and language restriction [66] found that systematic reviews of studies published in English language and accessible in the major electronic databases will always yield findings that are closely similar to those obtained from reviews based on more comprehensive searches that are free of language restriction. Finally, the evidence in this review is obtained from a relatively small sample of quantitative studies with only one RCT, one nRT and four cohort studies. Lack of blinding of assessors and lack of allocation concealment was quite common and this may have biased individual results in the RCT and nRT and reduced the overall quality rating of quantitative studies.

The positive relationships reported in this review are largely based on 6MWD and physical activity questionnaires. Objective measurement of free living activity was recorded only in one paper [30]. The study found a non-significant improvement (7±35%; p=0.21) in average walking time in daily life at 3 months and a significant improvement (20±36%; p=0.008)

after 6 months. Movement intensity during walking improved significantly after 3 months (p=0.046) with further improvements after 6 months (p=0.0002). No significant changes occurred in the pattern of time spent walking in daily life. The observed changes in walking time in daily life at 6 months were significantly related to changes in dyspnoea (r=0.43; p=0.02). Despite the positive relationships, it is unclear if patients' levels of activity can be classified as very low, low, medium or high. It is also unclear if patients' activity levels meet the recommended guidelines for adults (50-65 years) and older adults (≥65 years) with chronic health problems such as COPD [67]. This is a clear area for future research.

With regards to the external validity (generalizability) of the findings of this review, it is noted that most of the qualitative studies were conducted in the UK [36,39,40,44,46] and other European countries [37,38,47,48], therefore applicability to UK setting remains high. In contrast, only one of the quantitative studies [33] was conducted in the UK. Further research on this topic in the UK is required.

Conclusion

We conclude that up to 6 months after PR, increased levels of activity in people living with COPD were associated with improvements of 62m (in 6MWD), 2.31 and 15.66 points in SGRQ and CRDQ total scores respectively, 1.3% FEV_1 and reduced dyspnoea. Although the improvement in 6MWD was higher than the MCID for 6MWD, it was associated with lower MCIDs for health status and FEV_1 in people with COPD. No study reported on hospital admission. The reported associations were mediated by healthcare professionals, social support, reduced fear and seeing benefits (increased activity and reduced breathlessness) and hindered by lack of social support, fear, co-morbidities and changing in physical health. These factors mostly reflect issues around PR programmes. The relationships reported here are largely based on 6MWD and PA questionnaires which are problematic when relating to HRQoL since HRQoL contains activity and activity limitation e. g the activity domain of the SGRQ and CRDQ. There is need for objective assessment of free living PA in exercise maintenance phase as well as participants' views of the post-PR maintenance programme.

Declaration of interest

The authors report no conflicts of interest

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3.2 Summary

It was noted that the relationship between levels of PA and outcomes such as health status, exercise capacity, FEV1, and hospital admission existed pre-PR. Currently, there is limited knowledge on free living daily PA and its relationship with clinical outcomes for people with COPD who have completed an initial rehabilitation programme and attending CEPs. A mixed-methods systematic review was conducted to understand the current status of research on the post-PR relationship between PA and clinical outcomes. This published journal article included in this chapter suggests further research into objective assessment of free living daily PA in the post-rehabilitation phase of COPD management, with particular attention given to its relationship with clinical outcomes along with participants' views of the benefits of CEPs as well as facilitators and barriers to activity participation. Exploration of these areas will ascertain whether community-based CEPs are effective in prolonging initial benefits from PR, particularly with regards to improved levels of daily PA and health status along with fewer hospital admissions. Statistical results of any post-PR association may help improve understanding about the likelihood of hospital admission and health status given a participant's current PA level. Furthermore, qualitative outcomes regarding barriers and facilitators potentially has practical implications for rehabilitation professionals, especially in improving understanding of how to make rehabilitation programmes more long-lasting.

Based on dominant concepts and findings from the systematic review and other empirical studies, a conceptual framework/model was developed for this research. The next chapter presents the conceptual framework and hypotheses formulated to address the research questions.

CHAPTER FOUR

THE CONCEPTUAL FRAMEWORK FOR THIS STUDY

4.0 Introduction

This chapter presents the proposed conceptual framework/model of the relationship between the concepts in this study. This framework is based on information gleaned from the review of literatures (Chapters 2 and 3) and it serves as the framework for the research design and data analysis of the present study. It also underpins the formulation of 13 hypotheses used to address the research questions outlined in section 1.5.

As previously stated, CEPs are some of the strategies for improving and maintaining initial benefits from PR in patients with COPD (NICE, 2010; Vestbo, et al., 2013; Beauchamp, et al., 2013). Many researchers and a multidisciplinary Task Force of experts representing respiratory societies agree that further studies are needed to assess the *"impact of pharmacological and non-pharmacological interventions that aim to maintain or increase PA levels in patients with COPD"* (Watz, et al., 2014, p.1532). Five dominant concepts in the literature relating to the impact of PR and CEPs are; PA, exercise capacity, pulmonary function, health status and hospital admission (Verrill, et al., 2005; Heppner, et al., 2006; Ries, et al., 2007; Egan, et al., 2012; Beauchamp, et al., 2013). These are key inputs in the model developed for this study (Figure 5). The main purpose of this study was to investigate whether participating in CEPs increase participants' free living daily PA and if there is a relationship between daily PA and the other concepts. The following is a brief review of each of these concepts as they relate to people with COPD.

4.1 Physical Activity

As previously stated, PA is defined as *"any bodily movement produced by skeletal muscles that requires energy expenditure"* (Caspersen, Powell and Christenson, 1985). In the broadest of contexts, PA is any movement of the body and should not be considered synonymous with the term exercise, which Caspersen, Powell and Christenson (1985), defined as a PA that is planned, structured, repetitive, and intentionally performed to increase or maintain physical fitness. From the lens of this definition, exercise is different from PA but it is a subsection of

it. The International Classification of Functioning, Disability and Health, ICF, framework (WHO, 2001) extended Caspersen and Colleagues' definition of PA to include the execution of a task or action by an individual. The ICF framework is a classification of health and health-related domains. It is the WHO framework for measuring health and disability at both individual and population levels. The ICF was formally endorsed by all 191 WHO Member States in the 54th World Health Assembly in May 2001 as the international standard for describing and measuring health and disability.

Typically, PA is commonly described or characterised based on four key dimensions: type, frequency, intensity and time (duration) (Caspersen, Powell and Christenson, 1985; WHO, 2010). There are various types of PA and exercise behaviours. The ICF's extension of the definition of PA to include the execution of a task makes it a multidimensional concept and complex behaviour that covers several domains (types) such as (a) self-caring tasks (b) caring for household objects and assisting others (c) carrying, moving and handling objects (d) walking and moving (e) moving around using transportation (f) mobility (g) completing household tasks and (h) other unspecified activities like singing and dancing (WHO, 2001). Also included in the PA domains are occupational, domestic, sports and leisure-time activities (Caspersen, Powell and Christenson, 1985) as well as free living PA, defined as activity undertaken in everyday functioning (Steele, et al., 2003b), including activities of daily living (Katz, 1983; Fricke, 2013).

Although Caspersen, Powell and Christenson (1985) clearly distinguished between PA and exercise, a PA such as walking can also be performed as an exercise. For example, an individual may walk 1-2 miles not for exercise, but because s/he needed to visit his/her friend and does not own a car. However, another individual may walk the same distance mainly to maintain or improve his/her level of physical fitness. There is a distinct difference in what motivated the activity (walking) behaviour. This appears to be true for all types of PA and exercise behaviours. Some people may engage in behaviours mainly for pleasure and because they enjoy doing it whereas others engage in similar behaviours due to necessity. Hence, it is essential to consider these motivational differences when studying various types of PA and exercise behaviours in any population.

PA may also vary by frequency, duration and intensity. Regularity or frequency of PA refers to the number of times an activity is performed and is commonly measured per week. For

example, a person may walk 3 days a week as a means of getting to work. The same person may also walk to the gym on a Friday making his/her frequency total 4 for the week. Duration of activity refers to the length of time in which an activity lasts. This is usually reported in minutes or hours per day/week. For measurement of PA in people with COPD, duration is a useful measurement, because it provides the basis for determining levels of PAs (Schnohr, Scharling and Jensen, 2003; Garcia-Aymerich, et al., 2006; ACSM, 2013). The intensity of an activity is a measure of the physiologic response to the activity. It reflects the amount of physical effort needed to complete an activity. Marshall and Welk (2008) explained that intensity is measured by the quantity of metabolic work or energy expended while performing the activity. Because it is difficult and expensive to measure metabolic work, researchers use perceptual categories of physical effort such as very light, light, moderate, vigorous, and very vigorous to measure or describe intensity of PA (Sallis and Owen, 1999). Sallis and Owen (1999) expressed intensity as a ratio of the energy expended while performing the activity and that expended at rest. If the energy expended in completing an activity is 3-6 times more than that expended at rest, the activity is considered of moderate intensity, whereas that requiring ≥7 times more than that expended at rest is referred to as a vigorous intensity PA. In addition, in some studies (Watz, et al., 2008; 2009), participants were asked to list the activities they have completed and researchers converted the activities into Metabolic Equivalents (METs). METs are multiples of the resting (VO2), which is a measure of oxygen uptake per kilogram of body weight. METs do not specifically measure metabolic work, but provide estimates of the intensity of PA.

The recommended PA guidelines for health in healthy adults (WHO, 2010; NHS, 2013) and people with COPD (ACSM, 2013) incorporated frequency, intensity, and duration of activity (see sections 2.8.1 and 2.8.2). As of yet, no study has reported on whether or not people with COPD meet the suggested PA guidelines (ACSM, 2013). It is important for their health and wellbeing that the recommendations be achieved.

The range of instruments for measuring PA in people with COPD was discussed in section 2.8.5. The model/framework used for this study uses AM300 (PAM BV Doorwerth, the Netherlands), a PA monitoring device, to measure participants' levels of daily PA. A description of AM300, rationale for its choice and how it was used in this study are highlighted in the methodology chapter (see sections 5.6.6 and 5.6.7).

4.2 Exercise capacity/tolerance

Exercise is defined as a PA that is planned, structured, repetitive, and intentionally performed to increase or maintain physical fitness (Caspersen, Powell and Christenson, 1985). Exercise capacity has mostly been described in relation to the quantity of oxygen consumed during PA. Dennis (1992) defined maximal exercise capacity as *"the maximum ability of the cardiovascular system to deliver oxygen to exercising skeletal muscle and of the exercising muscle to extract oxygen from the blood"* (p. 1382). According to this definition, an individual's exercise capacity depends on his/her pulmonary gas exchange, efficiency of cardiovascular system and skeletal muscle metabolism. In the views of Jette, Sidney and Blumchen (1990) and Morris, et al. (1993), exercise capacity refers to an individual's ability to increase his/her oxygen uptake above the amount utilised whilst at rest (e.g. sitting quietly in a chair). When at rest, the human body utilises a basal or resting amount of oxygen to carry out basic metabolic functions. This amount of oxygen usage is termed one Metabolic Equivalent (1MET) and it is approximately 3.5ml O_2/kg/min (Jette, Sidney and Blumchen, 1990). However, how this value was calculated was not explained.

A suggestion of how an individual's exercise or work capacity might be conceptualised was provided in a paper published by Dill (1936). Work capacity was conceptualised as a ratio of work metabolic rate to basal metabolic rate (BMR) and proposed a definition for different intensity of work or PA as: moderate-intensity PA (requiring oxygen uptake of <3 times BMR); hard or vigorous-intensity PA (requiring oxygen uptake of 3-8 times BMR). Dill (1936) also suggested a maximal work/exercise capacity for ordinary people (work requiring oxygen uptake 10 times BMR) and athletes (work requiring oxygen uptake 20 times BMR). During minimal exertion, e.g. walking on a level ground, the amount of oxygen uptake increase 2-folds (2MET). Higher levels of physical exertion (e.g. brisk walking, jogging, cycling) further increases the amount of oxygen consumption and these can only be performed by individuals with greater exercise capacity (Jette, Sidney and Blumchen, 1990; Morris, et al., 1993). Goldstein (1990), therefore, defined exercise capacity as *"the maximum amount of physical exertion that an individual can sustain"* or tolerate. In most studies of PA in people with COPD, exercise capacity is used interchangeably with exercise tolerance (Bendstrup, et al., 1997; Garcia-Aymerich, et al., 2003; 2006; Beauchamp, et al., 2013).

Gagge, Burton and Bazett (1941) developed a system of units for describing the exchange of heat between the human body and the environment during physical exertion. It was suggested that, under conditions of thermal neutrality, the human body expended a thermal activity unit of 50 $kcal \cdot h^{-1} \cdot m^{-2}$ at rest. Thus, Gagge, Burton and Bazett (1941) appear to be the first to use METs in relation to energy expenditure. The MET is now defined in relation to energy expenditure, as the ratio of work metabolic rate to a standard BMR of 1.0 kcal (Ainsworth, et al., 2000). It is now widely used, in several studies, as a physiological concept that expresses the energy an individual expended in performing a PA as a multiple of his/her basal metabolic rate (BMR) (Schutz, Weinsier and Hunter, 2001**;** Watz, et al., 2008; 2009). In a compendium published by Ainsworth, et al. (2000), different types of physical activities were described as multiples of this standard resting energy value (1 MET). These range from sleeping (0.9 MET) to running at (18 METs). Ainsworth, et al. (2000) assigned every PA an intensity level in METs and recommended that the energy expended in performing the activity be calculated by multiplying the MET level by the standard BMR value (1.0 $kcal \cdot kg^{-1} \cdot h^{-1}$). However, this method appears not to be very accurate for measuring energy expenditure due to its reliance on participants' recall of the PA done in the past (Leenders, Sherman and Nagaraja, 2000). In addition, research evidence is lacking regarding whether or not the standard value (1.0 $kcal \cdot kg^{-1} \cdot h^{-1}$) accurately reflects BMR across different individuals and this may also affect the accuracy of the energy expenditure calculated using this method.

Ainsworth, et al. (2000) noted that the aim of their PA compendium was not to calculate the accurate amount of energy expended in performing the activities they listed but to provide a system for classifying PAs that will enable researchers standardise MET intensities in their studies. Nevertheless, researchers, clinicians, and practitioners use the MET system to identify and recommend PAs of different intensities (Pollock, et al., 1998; Ainsworth, et al., 2000; Watz, et al., 2008; 2009). Montoye, Kemper and Saris (1996) suggested that it is acceptable for exercise physiologists to use the MET system to express energy expenditure in relation to people's body weight. PAs of different intensities (light, moderate and heavy/vigorous) have been defined by the ACSM (Pollock, et al., 1998) and equated with specific MET levels. These have been used by exercise trainers for exercise prescription to clients (Ainsworth, et al., 2000).

Skeletal muscle wasting and weakness is one of the cardinal manifestations of COPD (Chung and Adcock, 2008; Soltani, et al., 2010; Seymour, et al., 2010; Shrikrishna, et al., 2012) and this is a significant determinant of reduced levels of PA (Shrikrishna, et al., 2012) and exercise capacity (Gosselink, Troosters and Decramer, 1996; Debigare and Maltais, 2008; Barnes and Celli, 2009; Troosters et al., 2013). A progressive decline in exercise capacity is ubiquitous in people with COPD (Oga, et al., 2005) and this is associated with lower levels of PA (Pitta, et al., 2005a; Watz, et al., 2009; van Gestel, et al., 2012), poor health status (Tsiligianni, et al., 2011; Beauchamp, et al., 2013) and higher number of hospital admission (Spruit, et al., 2012). One of the main objectives of pharmacological and non-pharmacological therapies for managing COPD is to reduce airflow restriction in the remodelled airways and, as a consequence, improve dyspnoea and exercise capacity (Vestbo, et al., 2013). Exercise training, an integral component of PR and CEPs (Desveaux, et al., 2014a; Beauchamp, et al., 2013), has several benefits for people with COPD, including an improvement in exercise capacity (Ries, et al., 2007; Beauchamp, et al., 2013; Watz, et al., 2014).

Different protocols have been used to assess exercise capacity in patients with COPD. The choice of protocol appears to be informed by the aim of the study. Clinically, exercise capacity is determined by measuring three physiological parameters: oxygen uptake (V_{O2}), carbon dioxide production (Vco_2), and minute ventilation (McElroy, Janicki and Webber, 1988; Reddy, et al., 1988) during exercise training. Gas analysers that are able to determine the concentrations of O_2 and CO_2 in inspired and expired air respectively are used for this purpose. Maximum O_2 uptake (V_{O2max}) has a strong linear correlation with blood flow in skeletal muscles during physical exertion (Reddy, et al., 1988). These methods of determining exercise capacity have also been used in previous (Oga, et al., 2003) and more recent studies (Bautista, et al., 2011; Diaz, et al., 2013).

A systematic review of studies that investigated the impact of pharmacological therapies (bronchodilators) on exercise capacity identified two categories of tests for assessing exercise capacity (Liesker, et al., 2002). These include steady-state tests and incremental tests, each assessing different aspects of exercise capacity. During steady-state exercise tests, participants' work rate is more or less constant. While incremental exercise tests measure participants' maximal exercise capacity in terms of the highest level of exercise they can perform, the steady-state tests is concerned with the maximal capacity that participants are able to tolerate over a longer time period. In most cases, incremental tests are completed on a

cycle ergometer, but occasionally treadmills and shuttle-walking tests are used (Bradley, et al., 2007; Beauchamp, et al., 2013). Three of the most frequently used steady-state exercise tests include the 6MWD test, 12-minute walking distance (12MWD) test and cycle endurance tests (Liesker, et al., 2002; Puhan, et al., 2005; Amardottir, et al., 2007; Bradley, et al., 2007; Beauchamp, et al., 2013).

Incremental exercise tests enable researchers better understand how participants' body systems respond when workloads are increased gradually. They are mostly completed on bicycle or treadmill ergometers that use a protocol of fixed increments in demanded exercise (Puhan, et al., 2005; Bradley, et al., 2007). Researchers use the resistance on the cycle ergometer or the slope and/or speed on the treadmill ergometer to gradually intensify the workload to be completed by participants and encourage participants to continue exercising until they become exhausted. The physiological and physical parameters that are frequently recorded during these tests include maximal oxygen consumption ($\dot{V}O_2max$), maximal workload (Wmax), distance covered, time to exhaustion (TTE), maximal ventilation, maximal heart rate, maximal dyspnoea or Borg score (BSmax) and maximal carbon dioxide production ($\dot{V}CO_2max$) (Puhan, et al., 2005; Bradley, et al., 2007).

In a shuttle-walking test, two cones are kept 10 meters apart and participants are asked to repeatedly walk from one cone to the other (Bradley, et al., 2007). Researchers use audio signals to increase the speed at which participants are required to cover the fixed distance. The time available for participants to complete each of the subsequent 10-m distances decreases after they complete each 10-m distance. The main parameter of interest in this test is the distance participants walked until they stop as a result of their breathlessness or other complaints. Some researchers record the distance walked until the participant's movement intensity reduces to the extent that s/he is unable to cover the distance in time. The distance walked when the participant's heart rate equals about 85% of the maximal heart rate for his or her age is sometimes reported (Bradley, et al., 2007).

The steady-state exercise tests such as the 6MWD and 12MWD are self-paced tests for measuring exercise capacity in which researchers instruct participants to walk as far as they can in six and twelve minutes respectively (McGavin, Gupta and McHardy, 1976; Amardottir, et al., 2007; Bradley, et al., 2007; Beauchamp, et al., 2013). McGavin, Gupta and McHardy (1976) demonstrated the benefits of the 12MWD test. Butland, et al. (1982) later showed that the benefits of the 6MWD were similar to those of 12MWD. Guyatt, et al. (1984) demonstrated that participants' motivation and encouragement influence their 6MWD

test scores. Hence, they advocated standardising the 6MWD test and not to motivate or encourage participants whilst performing the test. Participants require time to learn their optimal exercise level and strategy. To minimise or remove the learning effects from the result, it is recommended to perform two test sessions.

The endurance cycle test is carried out with a constant workload. Workloads of moderate-intensity result in steady-state responses that can be compared to several PAs in daily life, while high intensities of a constant workload will produce maximal values of exercise parameters such as TTE, $\dot{V}CO_2max$, $\dot{V}O_2max$, maximal ventilation and BSmax (Bradley, et al., 2007; Beauchamp, et al., 2013)

The model/framework used for this study uses the 6MWD test to measure participants' exercise capacity. This test has been standardised (ATS, 2002), validated (Cote, et al., 2008) and shown to correlate with PA levels in people with COPD (Pitta, et al., 2005b; Garcia-Rio, et al., 2009).

4.3 Pulmonary (lung) function

The lungs are tissues of the respiratory system. Simpkins and Williams (1990) summarised the functions of the lungs in the following text: *"Energy required by the body is released from organic molecules in tissue respiration. Aerobic respiration requires oxygen and releases carbon dioxide as a waste product. These respiratory gases are exchanged between the atmosphere and blood in the lungs by external respiration and between the blood and tissues by internal respiration*" (p. 217). It can thus, be argued that pulmonary function reflects or defines how well a person's lungs perform these gas exchange functions. In people with COPD, the airways are abnormally and characteristically narrowed so much so that gas exchange (airflow) is obstructed and breathing becomes very difficult (Vestbo, et al., 2013). Hence, a progressive and rapid decline in pulmonary function is ubiquitous in COPD (Bridevaux, et al., 2008; Fischer, Pavlisko and Voynow, 2011). Pulmonary function has previously been identified as a determinant of health status (Tsiligianni, et al 2011) and correlate of hospital admission (Bridevaux, et al., 2008) and level of PA (Watz, et al, 2009; Pitta, et al., 2005a; 2008; Hernandes, et al., 2009; Waschki, et al., 2012).

Pulmonary function testing is used to detect airflow obstruction and for diagnosing and staging COPD severity (Vestbo, et al., 2013). In summary, the simplified guideline presented by the Global Initiative for Chronic Obstructive Lung Disease (Vestbo, et al., 2013) is the

existing diagnostic criterion for airflow obstruction and the basis for COPD definition. According to this guideline, airflow obstruction (COPD) is diagnosed when an individual's ratio of FEV_1 to FVC is less than 70%. In addition, the severity of COPD is classified by the individual's FEV_1. Assessment of pulmonary function is recommended when evaluating the effects of pharmacological and other non-pharmacological interventions (Liesker, et al., 2002; Vestbo, et al., 2013; Watz, et al., 2014).

Pulmonary function and severity of COPD are assessed by spirometry (Vestbo, et al., 2013; Miller, et al., 2005; BTS, 2005). In this study, a mini-spirometer (model COPD-6, Vitalograph Ltd, Ennis, Ireland), was used to assess participants' pulmonary function. COPD-6 has been demonstrated to significantly predict COPD (Thorn, et al., 2012).

4.4 Health status

Health status has become a vital clinical outcome in COPD management, but still lacks a widely accepted definition (Smith, Avis and Assmann 1999). It is often confused and used interchangeably with other constructs such as well-being, quality of life (QoL), HRQoL in healthcare research (Bradley, 2001; Haywood, Garratt and Fitzpatrick, 2005). Smith, Avis and Assmann (1999) differentiated between QoL and health status. In their definitions, they related to psychological or mental health and health status to physical functioning. Other authors have related HRQoL to functional impairment and disability (Guyatt, Feeny and Patrick, 1993). The WHO broadened the meaning of health status, by defining the construct as "*… a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"* (WHO, 1948, pp. 1). As a result of this broader definition, other authors now consider health status as an overall concept that covers important domains such as physiological functioning, symptoms, functional impairment, quality of life, and social functioning (Wilson and Cleary 1995; Rumsfeld, 2002; Sousa and Kwok 2006). Researchers have now demonstrated that these domains covered by health status have about sixteen sub-domains (Peters, et al., 2007; Vercoulen, et al., 2008), with each sub-domain representing a unique aspect of health status. Regardless of the different definitions of health status in the medical literature, it is now evident that an individual's functioning consists of several conceptually distinct sub-domains. It is therefore imperative for these sub-domains to be assessed when considering the effectiveness of any intervention. Patient-centered care has also become the focus of disease management interventions (Doward and McKenna, 2004;

Smith, et al., 2006; Evangelou, Tsianos and Loannidis, 2008) and this warrants the use of different instruments to assess the whole aspects (domains) of health status.

4.4.1 Implication of a decline in health status in people with COPD

The decline in health status in people with COPD is characterised by pulmonary function impairment, experience of clinical symptoms (chronic cough, sputum production and dyspnoea) and frequent exacerbations (Vestbo, et al., 2013). Some patients also experience other symptoms such as wheezing (laborious or whistle breathing), rhinorrhoea (persistent watery mucus discharge from the nose), chest tightness, fatigue, weight loss and anorexia (loss of appetite for food) (Vandevoorde, et al., 2007). The severity of these symptoms over time varies from one person to another and is usually the reason why people seek medical care. A decline in health status, indicated mainly by frequent exacerbations, is responsible for frequent hospital admissions (Burgel, et al., 2009; Terzano, et al., 2010) and readmissions (Garcia-Aymerich, et al., 2003). Some people are more susceptible to exacerbation than others. People who experience higer number of exacerbations have more severe lung function impairment, poor health status (Jones, et al., 2011), increase risk of hospital admission (Burgel, et al., 2009; Terzano, et al., 2010) and death (Garcia-Aymerich, et al., 2010) than those who experience exacerbations less frequently. Overall, poor health status in people with COPD is associated with increase number of hospital admissions, use of healthcare resources and huge economic burden. Measures of health status are currently included in the overall assessment of COPD severity and/or response to therapeutic and non-therapeutic interventions (Liesker, et al., 2002; Vestbo, et al., 2013; Watz, et al., 2014).

4.4.2 Measuring health status in people with COPD

Health status is an important outcome measure in COPD research. One reason for this may be that clinicians and researchers have recognised that treatments for COPD patients are mainly symptomatic. A second reason is the need to integrate both symptomatic measures and clinical measures as co-primary end points. On one hand, the main symptomatic measure in most studies is health status, on the other hand, the most important clinical measure is the FEV1. While FEV_1 is measured by spirometry, there is currently no single “standard" instrument for measuring health status. Nevertheless, health status can be assessed objectively and/or subjectively (Singh and Dixit, 2010; Paddison, et al., 2013). Objectively, patients’ health status may be measured by clinicians, who perform an examination and rates the patient along any of many aspects such as diagnosis of disease, risk factors, severity of

disease, and overall health (Garcia-Aymerich, et al., 2003; Garcia-Aymerich, et al., 2006; Sofi, et al., 2008). Health status is also assessed by asking people to report their perceptions of health in different domains such as physical functioning, emotional well-being, pain or discomfort, and overall perception of health (Kessler, et al., 2011; Juuso, et al., 2013). Although it is theoretically attractive to argue that the measurement of health should consist of a combination of objective and subjective aspects, no such measure has been developed as of yet.

Different tools have been developed to measure health status. The specific aim of these tools is to standardise and quantify the impact of COPD on different aspects of people's life; health, physical and general well-being (Jones, 2001). Such impacts are usually quantified in a standard and objective manner by means of health status measuring tools. Essentially, the process has close similarity to the people's clinical history of specific disease. However, the end results are not clinical impressions but measurements that are objective and scientifically useful.

Widely used instruments measure generic or disease-specific health status. Examples of generic health questionnaires include the EuroQoL 5 Dimension (EQ-5D) questionnaires and scales (Pickard, et al., 2008), the Short Form 36 (SF-36) (Martinez, et al., 2000) and the Short Form 12 (SF-12) (de Miguel-Díez, et al., 2010). The COPD-specific heath status questionnaires include; the Chronic Respiratory Questionnaire (CRQ) (Rutten-van Molken, Roos and Noord, 1999), the St. Georges Hospital Respiratory Questionnaire (SGRQ) (Jones, Quirk and Baveystock, 1991), the Breathing Problems Questionnaire (BPQ) (Hyland, et al., 1998), the QOL Respiratory Illness Questionnaires (QOL-RIQ) (Maille, et al., 1997), the Clinical COPD Questionnaire (CCQ) score (Sundh, et al., 2012), the AQ20-a 20-item instrument that takes 2–3 minutes to complete and score (Hajiro, et al., 1999) and a more recent shorter test, the COPD Assessment Test (CAT) (Jones, et al., 2012). In addition, symptom-specific questionnaires such as the modified Medical Research Council (mMRC)-dyspnea scale (Bestall, et al., 1999) have also been developed. Furthermore, two questionnaires: the modified Pulmonary Functional Status and Dyspnea Questionnaire (PFSDQ-M) (Lareau, Breslin and Meek, 1996) and the Pulmonary Functional Status Scale (PFSS) (Weaver, Narsavage and Guilfoyle, 1998) which are similar to health status instruments have been designed to measure functional limitation in people with COPD. Some researchers have assessed patients' ability to perform activities of daily living by using

COPD-specific activity of daily living scales (such as the London Chest Activity of Daily Living scale, LCADL and the Groningen Activities of Daily Living Restriction Scale (GARS) that are similar to functional limitation questionnaires (Garrod, et al., 2000; Habraken, et al., 2011). Regardless of the description and content of existing questionnaires, their aim is to address the different effects of COPD and perhaps derive an overall score that summarises the overall effect of the disease or the overall impact of treatment.

COPD-specific health status questionnaires are expected to meet certain criteria; being simple, easy to administer and having guidelines for scoring and interpretation (McHorney and Tarloy, 1995). The use of inappropriate measures of health status has serious consequences and is likely to yield misleading results and underestimation or overestimation of the impact of COPD. This underscores the need for reliable instruments that, in the view of Kocks, et al (2010), should also be validated for the participants who completes the questionnaire. Table 4 summarises the health status measuring tools that have been validated for people with COPD.

Table 4: List of validated COPD-specific health status questionnaires

Health status questionnaire	Domains/Components	Validity and Reliability tested by	Research application
Chronic Respiratory Questionnaire (CRQ)	○ Dyspnoea ○ Fatigue ○ Emotional function ○ Mastery	Wijkstra et al (1994) Curtis and Patrick (2003)	Pitta, et al. (2011)
St. Georges Hospital Respiratory Questionnaire (SGRQ)	○ Symptoms ○ Activity ○ Impacts (on daily life) ○ A total score	Jones et al (1991)	Xu, et al. (2009)
Clinical COPD Questionnaire (CCQ)	○ Symptoms ○ Functional state ○ Mental state	van der Molen (2003) Kocks et al (2010)	Sundh, et al. (2012)
COPD Assessment Test (CAT)	○ Symptoms ○ Energy ○ Sleep ○ Activity	Jones et al (2009)	Jones, et al. (2012)
Modified Medical Research Council (mMRC)-dyspnoea scale	○ Breathlessness: Grades 1, 2, 3, 4 & 5	Bestall et al (1999)	Patel, et al. (2012)

The framework used for this present study uses the SGRQ. This is a validated tool for assessing COPD-specific HRQoL (Jones, et al., 1991; Xu, et al., 2009). It was designed to measure health impairment in people with asthma and COPD (Jones, et al., 1991). SGRQ is composed of 76 items that are weighted to produce scores in three domains: symptoms, activity and impact. A total score is calculated from all items and provides an overall view of a participant's respiratory health. The scores range from 0–100, a score of 100 indicates maximum disability. A difference of ≥4 units in SGRQ total score was shown to indicate a clinically important effect (Jones, 2005). Other aspects of health status not captured by the SGRQ were explored through qualitative interviews.

4.5 Hospital admission

The term hospital admission or hospitalisation has been measured and reported as an outcome in several studies (Garcia-Aymerich, et al., 2003; 2006; 2010; Pitta, et al., 2006; Borges and Carvalho, 2012), but definition of the concept is lacking. According to the NHS (2012), hospital admission is a formal acceptance by a hospital or health care facility of a patient who is to be provided with room and nursing service at least overnight. Typically, people are admitted into hospitals because they are too physically or mentally unwell to stay at home, need continuous nursing care, and/or are receiving treatments and undergoing tests and/or operation that can only be done in the hospital. Some researchers (Garcia-Aymerich, et al., 2008; 2009; 2010) have also used the term hospital admission to include other forms of health service use such as visits to doctors (GP surgeries) and/or Accidents and Emergency (A/E) departments as a consequence of an exacerbation.

The burden of COPD related hospital admission in England is huge. COPD accounts for 115,000 emergency admissions and about a million 'bed days' in hospitals every year (NHS England, 2014). Hospital admission is also as a major risk factor for mortality. About 15% of patients admitted to hospital due to COPD die within 3 months, while 25% of them die within 12 months in the UK. A national COPD Audit conducted by Price, et al. (2006) noted that 7.4% of a cohort of 7,529 patients admitted to hospital due to exacerbations died within 12 months. 31.4% of the patients were readmitted to hospital after 3 months of discharged, while 15.5% died 3 months after hospital discharge. In England, COPD accounts for 24,000 deaths every year and 16,000 deaths within 90 days of admission per year (NHS England, 2014). As

noted earlier (see section 2.2), hospital admission is associated with huge economic burden both to the individual and to society.

The risk factors and methods of assessing hospital admissions are well documented. In people with COPD, hospital admission is frequently a consequence of COPD exacerbation (Garcia-Aymerich, et al., 2000; 2003). In several studies, the number/frequency of hospital admission has usually been obtained from participants through self-report using self-administered questionnaires on health service use (Garcia-Aymerich, eta al., 2006; Benzo, et al., 2010) or from review of their medical and/or National Health records (Garcia-Aymerich, eta al., 2008; 2009; 2010; Pitta, et al., 2006b; Chan, et al., 2011).

In this study, participants' number of hospital admission was based on self-report. A Self-Reported Hospital Admission Questionnaire (SHAQ) was developed and used for this purpose. The SHAQ is a self-administered non-validated tool designed to obtain participants' frequency of hospital admission. The instrument is composed of 7 items that are designed to obtain the number of times participants had been admitted to a hospital or use health care resources because of their chest or breathing trouble three months before and after attending the CEP. This approach to determining number of hospital admission is consistent with practice adopted by other researchers (Garcia-Aymerich, et al., 2006; Benzo, et al., 2010).

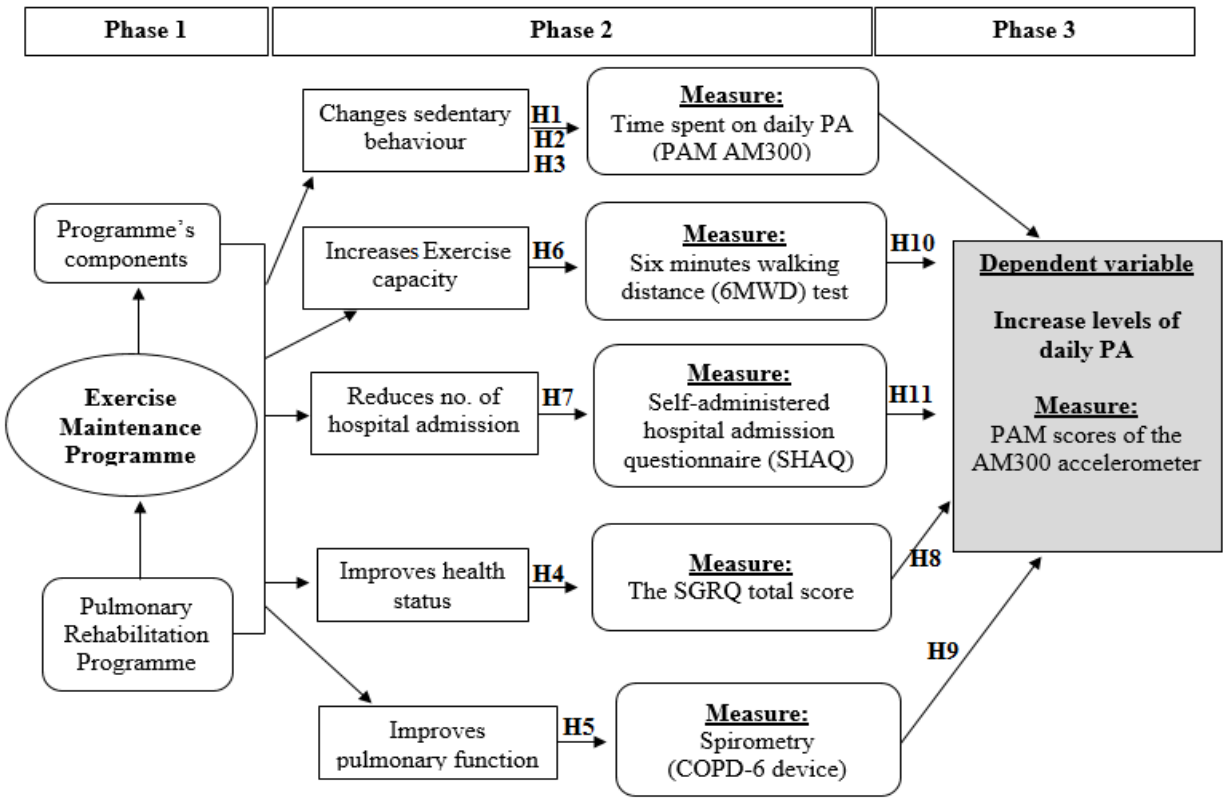
4.6 The proposed Conceptual Framework and hypotheses for this study

In modelling the post-PR relationship between levels of daily PA and health status and hospital admission in people with COPD, this study draws on findings from previous empirical studies of the relationship between these variables in people who have not previously completed PR. Figure 5 below illustrates a 3-phase conceptual framework developed for this study. It is based on the current guidelines for exercise maintenance in COPD (Vestbo, et al., 2013; Desveaux, et al., 2014a; Beauchamp, et al., 2013) and the correlates of PA in people with COPD prior to completing PR (see section 2.9). Accordingly, the first phase recognises participants' referrals to CEP following completion of a hospital-based PR. The second phase involves the identification of variables of interest which have previously been reported as correlates of PA. This phase also identifies the methods for measuring the variables. The third phase examines how the measured variables are related to participants' daily PA. The third phase also examines participants' views of the benefits of the CEP, leading to identification of factors that influence the

observed relationship between variables. A total of 6 variables are included in the model. These were identified from literature and have been described above.

The dependent variable of the study was level of daily PA which was operationalised by an indicator, average daily PAM scores measured by AM300 device. This is also regarded as the primary outcome in this study. The independent variables, which were also considered to be the secondary outcomes included: (a) total time spent on PA in all three zones (b) energy expenditure (c) health status, operationalized through COPD-specific instrument, SGRQ total scores (b) exercise capacity, operationalized through participant's 6MWD test scores (c) hospital admission, operationalized through self-report of number of hospital admissions 3 months before and 3 months following participation in the CEP and (d) change in pulmonary function, operationalised through spirometrical measurement of participants' FEV_1.

Figure 5: Proposed Conceptual Framework and Hypotheses



4.7 The study hypotheses

Twelve hypotheses were formulated to address the main research questions of this study. The null hypotheses were tested using the above conceptual model/framework. The null hypotheses are outlined as follows.

Null hypothesis 1 ($H_0$1): There is no significant statistical difference between participants' daily physical activity (average daily PAM scores) at Time Points 1 and 2.

Null hypothesis 2 ($H_0$2): There is no significant statistical difference between participants' total time spent on physical activity) at Time Points 1 and 2.

Null hypothesis 3 ($H_0$3): There is no significant statistical difference between participants' health status at Time Points 1 and 2.

Null hypothesis 4 ($H_0$4): There is no significant statistical difference between participants' pulmonary function (FEV_1) at Time Points 1 and 2.

Null hypothesis 5 ($H_0$5): There is no significant statistical difference between participants' exercise capacity (6MWD test scores) at Time Points 1 and 2.

Null hypothesis 6 ($H_0$6): There is no significant statistical difference between participants' number of hospital admission at Time Points 1 and 2.

Null hypothesis 7 ($H_0$7): There is no negative relationship between daily physical activity (average daily PAM scores) and health status (SGRQ total scores)

Null hypothesis 8 ($H_0$8): There is no positive relationship between daily physical activity (average daily PAM scores) and pulmonary function

Null hypothesis 9 ($H_0$9): There is no positive relationship between daily physical activity (average daily PAM scores) and exercise capacity.

Null hypothesis 10 ($H_0$10): There is no negative relationship between daily physical activity (average daily PAM scores) and number of hospital admission.

Null hypothesis 11 ($H_0$11): There is no significant positive relationship between participants' daily physical activity and time spent on physical activity at Time Point 2.

Null hypothesis 12 ($H_0$12): None of the clinical variables (health status, pulmonary function, exercise capacity and number of hospital admission) will significantly predict levels of daily PA at Time Point 2

4.8 Summary

This chapter has presented the theoretical and conceptual framework used for this study based on the current guidelines for exercise maintenance in COPD and previous research on the correlates of PA in people with COPD. The conceptual model of the relationship between levels of daily PA and other outcomes was developed as a basis of analysis and the five dominant concepts surrounding the model were discussed. Twelve (12) hypotheses were developed to address the research questions and were tested in chapter 6. The next chapter presents the different methods employed for collecting and analysing data relevant to the research questions.

CHAPTER FIVE

RESEARCH METHODOLOGY

5.0 Introduction

The overall purpose of this study was to investigate post-PR relationship of level of daily PA with clinical outcomes (health status and hospital admission) along with participants' views of the benefits of a CEP. The specific research questions that guided the study were presented in Chapter one. These are restated:

(a) Does participation in a Community-based Exercise Programme improve clinical outcomes in people with COPD following pulmonary rehabilitation?

(b) Is there a relationship between free living daily PA and measures of health status and hospital admission in people with COPD following pulmonary rehabilitation and participation in a community-based Exercise Programme?

(c) Can any of the clinical variables such as health status, pulmonary function, exercise capacity and number of hospital admission predict levels of daily PA following PR?

(d) What are participants' views of the benefits of a community-based exercise programme to which they were referred after completing pulmonary rehabilitation?

(e) What helps people with COPD to be able to attend the weekly exercise classes and what makes it more difficult for them to attend?

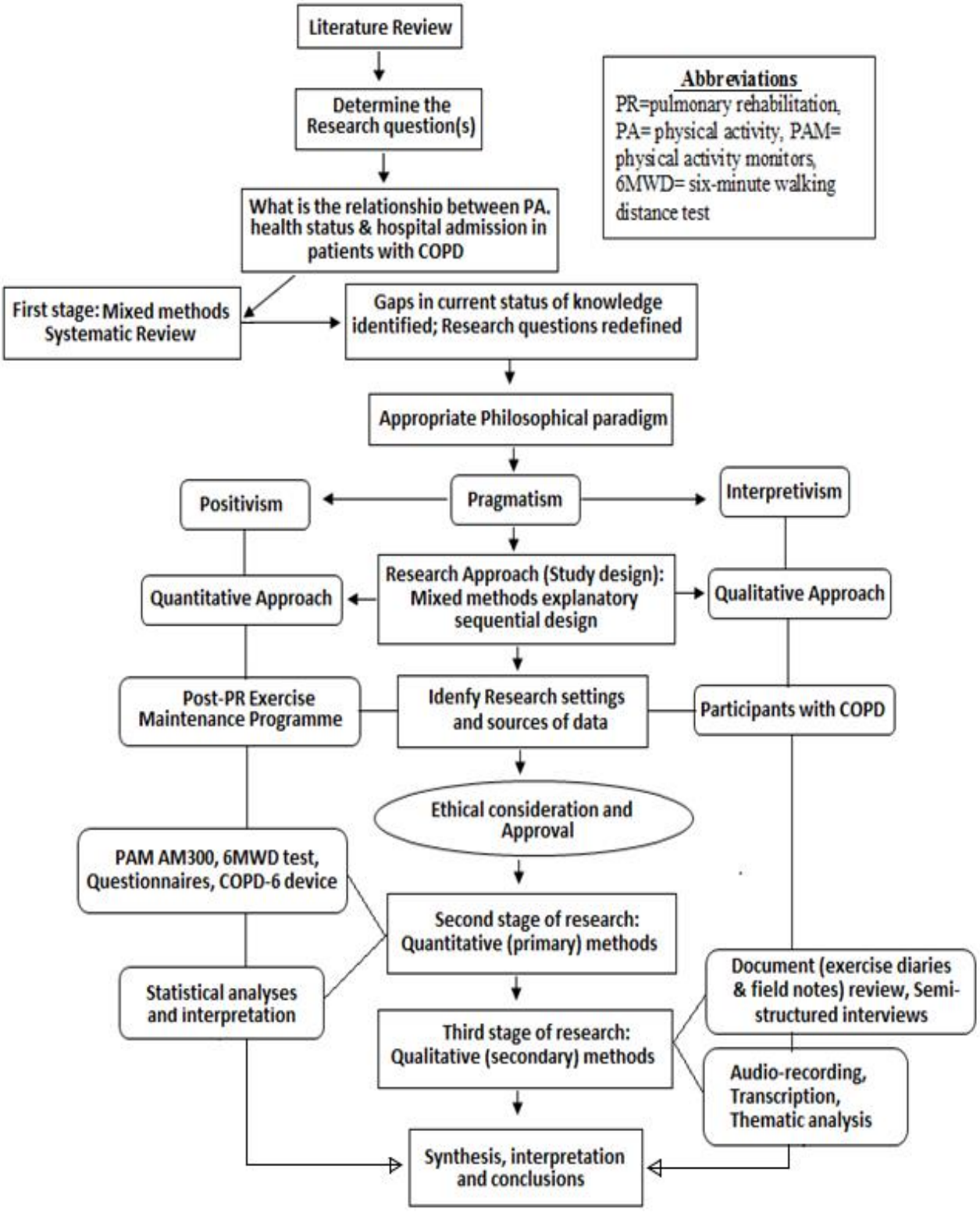
After presenting an overview of the research process, this chapter discusses the philosophical assumptions that underpinned the conduct of this study and highlights the research design, data collection methods and data analyses procedures that were considered appropriate for answering the formulated research questions. The chapter is organised and presented in three sections. Section one describes the background to the pragmatic philosophical paradigm and identifies how it underpins this study. Pragmatism uses both the positive and interpretive traditions which imply an objective and subjective epistemology and the ontological belief that reality is socially constructed. Pragmatism underpins mixed research approach, combining quantitative and qualitative methods, as used in this thesis. The advantages of

using pragmatism and the justification for this paradigm are also discussed. Other parts of the studies that are discussed in this section include the research settings and how participants were identified and recruited. The section ends with a discussion of the selection and definition of a mixed methods sequential explanatory study design as well as a clarification of the importance of the approach. The quantitative and qualitative approaches and methods used in this mixed methods explanatory study design are articulated in sections two and three respectively. The selection and definition of a prospective observational cohort study design and qualitative interviews are articulated, highlighting their validity and usefulness to this study. Both sections also discussed the techniques that were used for analysing quantitative and qualitative data.

5.1 The Research process

The different steps and decisions taken during this research are illustrated in Figure 6. These steps are similar to those in the research process described by Mackenzie and Knipe (2006). The figure shows the paradigms, methodology and data collection tools within the research process. The author started the research process by performing a literature on the epidemiology and management of COPD, the dominant concepts of the study (PA, health status, pulmonary function, exercise capacity and hospital admission) and how they are assessed in people with COPD. This was followed by an overview of the different interventions for improving levels of PA in people with COPD. A mixed-methods systematic review was performed to summarise the current status of knowledge on the post-PR relationship between levels of daily PA and study variables. This review identified gaps in knowledge and this led to the statement of the research problem, setting out the aims and research questions. Thereafter, the paradigm and methods of data collection and analyses suitable for addressing the research questions were identified. Following this, the ethical issues about the study were thoroughly considered and ethical approval was obtained after which participants were identified and recruited. Following participants' recruitment, relevant data were gathered using a combination of both quantitative and qualitative methods. The final stages of the research process included data analyses, interpretation of finding, discussion, drawing conclusions from analysed data, implications of findings to rehabilitation professionals, writing up of findings, and identification of areas for future research. Although the process is diagrammatically illustrated in a linear fashion, practically it was cyclical. This enabled the researcher to return to previous steps while at the same time progressed to later steps.

Figure 6: The Research Process



Derived from: Mackenzie and Knipe (2006)

Section One

5.2 The Research Paradigm and Framework of the study

Before starting any research project, Mackenzie and Knipe (2006) emphasised the need to establish the philosophical assumptions that will underpin the conduct of the research, as this will offer a sense of direction for the entire project. Researchers differ in their beliefs and in the ways they view and interact with their environments. As a result, they perform research in different ways. Researchers' beliefs and what they do are guided by their paradigms, the belief systems (or theories) or a set of principles that guide the way things are done. These can range from researchers' thought patterns to their actions. Without identifying a paradigm at the beginning of a study, Mackenzie and Knipe (2006) opined that "*there is no basis for subsequent choices regarding methodology, methods, literature or research design"* (p. 193).

According to Bogdan and Biklen (1998), a paradigm is *"a loose collection of logically related assumptions, concepts, or propositions that orient thinking and research"* (p. 22). Weaver and Olson (2006) defined paradigms as *"patterns of beliefs and practices that regulate inquiry within a discipline by providing lenses, frames and processes through which investigation is accomplished"* (p. 460). These definitions imply that specific paradigm could influence and guide the conduct of a study. Therefore, to better understand why and how the research approaches and methods of data collection and analysis were chosen and applied in this study, it is important to first discuss the philosophical paradigm that best fits its primary focus. Thereafter, the particular methodologies that were used will be discussed.

In the context of health care research, researchers' paradigmatic positioning relates to their understanding of the nature of knowledge (their epistemological view) and of reality (their ontological view). They vary greatly in their epistemological and ontological views, and these paradigmatic differences have an important influence on their study objective and design, and thus on the type of knowledge they contribute. Nonetheless, researchers may actually draw on a number of different paradigmatic positions to achieve the best possible outcome in terms of knowledge production. The commonly used philosophical paradigms in the Western tradition of natural and social sciences (including nursing and health science) include positivism, post-positivism, interpretivism, critical social theory, and pragmatism (Weaver and Olson, 2006; Mackenzie and Knipe, 2006; Broom and Willis, 2007). This mixed-methods study was guided by the pragmatic philosophical tradition and used a combination

of methods from positivism and interpretivism: the former implies an objective epistemology and believes in single and stable reality, while the later implies a subjective epistemology and the ontological belief in multiple and socially constructed realities. An overview of these three philosophical traditions is discussed in the following paragraphs.

5.2.1 Positivism (the scientific method)

As it relates to science and social science, positivism is based on empirical and naturalistic philosophies respectively (Blaikie, 2007) and originated as a philosophical paradigm in the 19th century when Auguste Comte rejected metaphysical views and emphasised that only scientifically derived knowledge can reveal the truth about reality (Mertens, 2005). As a result, the positivist paradigm is occasionally described as the 'scientific method' or 'science research'. Positivism was also championed by other philosophers such as Aristotle, Francis Bacon, John Locke, Immanuel Kant (Mertens, 2005) who asserted that effects or outcomes are perhaps determined by causes and that for events to be real, they must be empirically observable and logically analysable (Creswell, 2013). Positivism exerted an influence on scientific practice and sociologists later applied the same philosophy to social events with the assumption that social and natural events can be investigated using similar approaches, that there is a value-free method for investigating social phenomena and that cause-and-effect relationships can be explained (Mertens, 2005). According to O'Leary (2004), positivists are interested in testing theories or describing experiences by observing and measuring events in order to predict and/or understand the world around them.

The post-positivist paradigm emerged and replaced positivism after the Second World War (Mertens, 2005). Post-positivists typically assume that research is influenced by several well-developed theories (Mackenzie and Knipe, 2006). They also argued that existing theoretical frameworks are temporary and will be challenged by new understanding. Post-positivist stance asserted the need for researchers to see the complete view or an overview of the world. In other words, post-positivists argued that reality is open to more than one interpretation (O'Leary, 2004). This appears to align, in some sense, with the constructivists' perspective. People view things differently and *"what might be the truth for one person or cultural group may not be the truth for another"* (O'Leary, 2004, p. 6). Generally, positivist and post-positivist research paradigms align with quantitative methods of data collection and analysis.

5.2.2 Interpretivism (anti-positivism)

Mertens (2005) explained that interpretivism originated from two philosophies- phenomenology and hermeneutics (interpretive understanding)- advanced by Edmund Husserl, Wilhelm Dilthey and other German philosophers. It developed as a critique of the application of positivism in the social sciences, hence the terms 'anti-positivist' or 'anti-naturalistist' have been used to describe the interpretivist research paradigm, whose principal tenet *"is that there is a fundamental difference between the subject matters of the natural and social sciences"* (Blaikie, 2007, p. 124). The interpretivists assert that the study of social phenomena requires an understanding of the social world that people have constructed and which they reproduce through their continuing activities. However, people are constantly involved in interpreting and re-interpreting their world. Blaikie (2007) identified social situations, other people's actions, own actions, natural and humanly created objects as parts of a person's world. Accordingly, Cohen, Manion and Morrison (2001) noted that interpretivists approach research with the aim of understanding people's experiences. This suggests that *"reality is socially constructed"* (Mertens, 2005, p.12). Interpretivists therefore depend on participants' perceptions of the phenomenon being studied (Creswell, 2013) and identify the influence of their background and personal experiences on the findings of their study. They differ from post-positivists in that they do not usually start their investigation with a theory, instead they *"generate or inductively develop a theory or pattern of meanings"* (Creswell, 2013, p.9) throughout the research process. Interpretivists mostly depend on qualitative methods of data collection and analysis. Some may use mixed-methods (combine qualitative and quantitative methods), by using quantitative data to support or expand the qualitative information.

5.2.3 Pragmatism

The pragmatic philosophical tradition is not devoted to any philosophical system or reality. Pioneers of this paradigm *"rejected the scientific notion that social inquiry was able to access the 'truth' about the real world solely by virtue of a single scientific method"* (Mertens, 2005, p. 26). Pragmatism debunks the concepts of truth and reality (Feilzer, 2010) and focuses instead on 'what' the research question is and 'how' it can be answered (Creswell, 2013). In this sense, the paradigm allows researchers to be *"free of mental and practical constraints imposed"* (Feilzer, 2010, p.8) by the *''forced choice dichotomy between post-positivism and constructivism''* (Creswell and Clark, 2007, p. 27), and researchers do not have to be loyal to a specific research method. It can be essential to the conduct of research as it is seen as a

means to logically link empirical scientific approach and the relatively recent methods of qualitative inquiry (Mertens, 2005; Creswell, 2009).

The term pragmatism is derived from the Greek word 'pragma' which means action. It was founded in the second half of the 19th century by Charles Sanders Peirce, an American philosopher. Other historical philosophers and academics such as William James, Arthur Bentley, John Dewey and George Mead further expanded the work of Charles Sanders Peirce (Thayer, 1981; Ormerod, 2006; Creswell and Clark, 2011). Although a discussion of the individual contribution of these philosophers cannot be exhaustively explained here, a summary is provided and the core idea of pragmatism is worth mentioning. They rejected the views and assumptions of other researchers regarding truth, reality, the nature of knowledge and how it can be studied (Thayer, 1981; Ormerod, 2006) and did not subscribe to the view that only the singular scientific method can provide access to the real world. Instead, they believed that a successful understanding of the real world is achievable through a desire to improve the world and an understanding of the experiences of those who live in it (Thayer, 1981).

In his early work, Charles Sanders Peirce criticised the scientific method for dealing with reality (world) on three levels: the object under observation, the observing scientist/researcher, and the signs the scientist record and used to understand, describe and explain reality (Thayer, 1981). He explained that *"beliefs are guides to actions and should be judged against the outcomes rather than abstract principles"* (Ormerod, 2006, p. 892). However, at the time (1857-1866) his views were not very popular. It was the work of George Mead that first contributed significantly to the popularity of the pragmatic philosophical movement. He used 'social behaviourism' to influence social scientists and psychologists. According to Thayer (1981), Mead advanced the idea known as 'the act' or 'presentism' which he used to characterise reality. 'The act' proposed that for a phenomenon to be real, it must be happening now. Nevertheless, Dewey has been credited for making the most important contribution to scientific research and the arguments surrounding pragmatism. His views on education, women suffrage, politics and global peace have been well recognised (Thayer, 1981). Dewey also contributed to knowledge advancement in empiricism, process philosophy, humanism, naturalism, and contextualism and he is regarded as one of the leading thinkers of the 20th century (Haggbloom, et al., 2002). Credited for pioneering and championing outcomes based learning, Dewey believed in repositioning the

educational system in such a way that students do not just learn dead facts but are able to completely integrate skills and knowledge into their lives, a concept referred to as learning by doing (Alan, 1997; Tozer, Senese and Violas, 2006), which stemmed from his belief in pragmatism (Haggbloom, et al., 2002; Ormerod, 2006). Dewey's pragmatic approach to religion, ethics and aesthetics are regarded as the most influential of all his several contributions to knowledge (Haggbloom, et al., 2002*)*.

The history of pragmatism is characterised by two distinct periods. The early period which spanned 1860-1930, was dominated by the main originators, Charles Sanders Peirce, William James, Arthur Bentley, John Dewey and George Mead (Thayer, 1981; Ormerod, 2006). The First World War (WWI) and the resultant economic recession inhibited the progress of the pragmatic philosophical movement (Tashakkori and Teddlie, 2003), probably due to lack of funding for research and scholarly works of academics who adhere to this philosophy. The second period, known as neo-pragmatism (late twenty century), is believed to have had the greatest influence on the philosophy of science and research methods in social science disciplines (Tashakkori and Teddlie, 2003; Ormerod, 2006). This rebirth of pragmatic beliefs has driven a new way of thinking about this paradigm and its role in philosophy, science and life. Pragmatism is a philosophy and method of conducting research as much as it is a political, religious and aesthetic statement in this current era. This view has been by Tashakkori and Teddlie (2003) and Teddlie and Tashakkori (2009).

Brandom (2011) asserted that contemporary pragmatism shares some of the fundaments of older pragmatic beliefs and that it is founded on the use of common sense and committed to transforming cultures and the controversies among scholars. In general, pragmatists support the view that human thought is inherently associated with actions and people's experiences of reality can change. External forces do not shape humans, instead, through intellect humans are capable of shaping experiences (Tashakkori and Teddlie, 2003). Other contemporary authors such as Cherryholmes (1992), Rorty (1991), Campbell (1992), Patton (1990), Tashakkori and Teddlie, (2003), Teddlie and Tashakkori (2009), Johnson and Onwuegbuzie (2004), Feilzer (2010) and Creswell and Clark (2011) have all embraced and also contributed to the advancement of pragmatism as a modern way of philosophising.

Every research is founded or underpinned by one or more 'worldviews' or philosophical paradigm adopted by the researcher, whether or not this is explicit in the research (Creswell

and Clark, 2011). Creswell and Clark (2007) argue that all paradigms have similar philosophical elements and that these elements are constantly evolving. Hence, there are no standard criteria defining what paradigms should be and there is also no boundary delineation. Instead, Creswell and Clark (2007) argued that because researchers are more inclined to classify different types of paradigms according to their commonalities, the different paradigms should not be seen as rigid classifications but as organisational frameworks that provide opposing stances. The paradigms differ in their common elements.

Creswell's (2013) table, 'Interpretive Frameworks and Associated Philosophical beliefs' (pp. 36-37) and Creswell and Clark's (2011) table, 'Elements of Worldviews and Implications for Practice' (p. 42) present a clear picture of some of the reasons pragmatism stimulated so much arguments among social science researchers. Pragmatism is a unique research paradigm with distinct common philosophical elements or beliefs. Unlike other paradigms, the focus of pragmatism is on the consequences of the research. Pragmatists believe that the research questions are more important than the methods used in research and that several methods can be used to collect data considered relevant to the research questions (Creswell and Clark, 2011). Because reality can be singular or multiple in nature, pragmatists support combining inductive and deductive approaches in order to present various views of reality (Creswell and Clark, 2011). Epistemologically, the most important consideration in the pragmatic tradition is practicality. When addressing research problems pragmatists ask themselves what method(s) works for that specific problem. This is unlike the traditional scientific methods, mainly underpinned by positivism, where researchers are restricted to collecting data objectively (Creswell and Clark, 2011).

The anxiology of pragmatism is also worth noting. Axiology focuses on the philosophical study of values and their roles in research studies (Creswell and Clark, 2011; Creswell, 2013). The multi-stance approach to research underpinned by pragmatism allows researchers to include perspectives that are both biased and unbiased. It is now becoming widely accepted that knowledge produced from the application of positivist and interpretivist traditions are of immense value to research (Creswell and Clark, 2007). Methodologically, pragmatists combine both quantitative and qualitative methods of data collection (Tashakkori and Teddlie, 2003; Creswell and Clark, 2011; Creswell, 2013). This contributes to the robustness of the findings of research. In addition, several authors (Creswell and Clark, 2011; Tashakkori and Teddlie, 2003; Teddlie and Tashakkori, 2009) agree that pragmatism allows

researchers to contribute both formal and informal rhetoric which enables the dissemination of scientific and literary scholarly work. Researchers in the social sciences have discussed the role of pragmatism in social research. Tashakkori and Teddlie (2003) and Teddlie and Tashakkori (2009) mentioned that some researchers expressed concerns that the reliability and reputation of the positivist approach to research would be affected if the pragmatic paradigm is widely accepted. Providentially, the seemingly stalemated 'paradigm wars' has made it possible for pragmatism to be considered as providing greater diversity to research than solely applying a positivist or interpretivist paradigm (Teddlie and Tashakkori, 2009).

Brandom (2011) opined that pragmatism allows researchers to escape from the constricted boundaries and bindings of empirical and pragmatic methods and that there can be one or more (mixed) methods of inquiry. Creswell and Clark (2011) further supported this views when they justified the need for contemporary researchers to apply mixed or multiple approaches to research in social science. They mentioned that the most important concern for researchers should be the appropriateness of the approach they adopt to address their research problems. The only paradigm that aptly fits this approach to research is pragmatism because it enables, without limitations, research projects to be performed without being delayed or obstructed by a set of rules peculiar to one paradigm. Pragmatism is unique because it serves as a key that unlocks the process of researching a wide range of issues in the most practical way.

5.2.4 Rationale for choosing the pragmatic paradigm

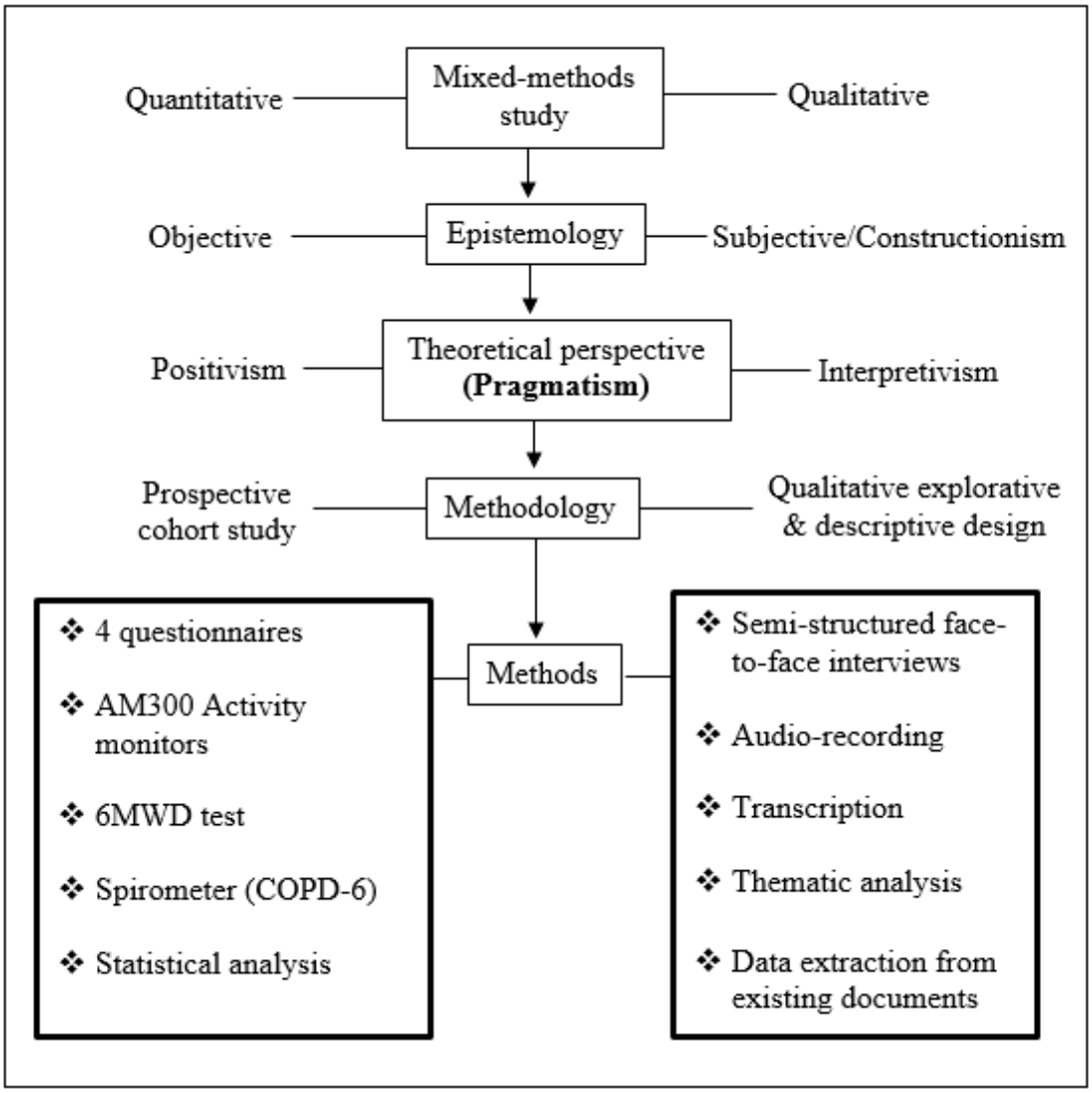
The positivist and interpretivist paradigms underpinning quantitative and qualitative approaches respectively have inherent strengths and limitations and one approach cannot be considered to be better than the other. One can therefore argue that there is no one best paradigm and research approach to advancing knowledge. Valuing and choosing one approach will invariably limit the ability to move beyond its peculiar boundaries. Recognizing the argument between scholars about quantitative and qualitative approaches to research and trying to understand it, potentially permit early and experienced researchers to create important and unique means of answering their research questions. Both approaches can and have ideally been used in combination to comprehensively address research problems (Creswell and Clark, 2011).

Supporters of the pragmatic paradigm consider it as a philosophy that encourages the use of common sense in research and makes purposeful human inquiry its centre of interest (Creswell and Clark, 2011). The pragmatic researcher focuses on the research questions and will apply a combination of paradigms, approaches and methods of data collection and analysis to understand the problem, without being loyal to any alternative paradigm. Broom and Willis (2007) noted that *"health researchers are increasingly pragmatic, as they choose the best means to answer a research question and use a mixed-method approach, rather than being explicitly philosophically driven"* (p. 18). For example, a quantitative study (RCT) of the effects of a self-management programme in 248 COPD patients, found no difference in HRQoL (measured by the SGRQ) between the intervention and control groups at 12-month follow-up despite the fact that participants verbally expressed satisfaction with the intervention (Monninkhof, et al., 2003). To understand this discrepancy, 20 of the participants in the trial were interviewed using in-depth, semi-structured interview method in a separate study (Monninkhof, et al., 2004). The participants spoke positively of the programme as they perceived increase in their exercise capacity and the social aspect of the group training as well as increased ability to manage COPD exacerbations. Most of the participants also mentioned that they felt safe as a result of the regular follow-up visits and access to health care professionals. The qualitative interviews supported the view that a quantitative method of data collection and analysis might not capture important aspects of people's experience of an intervention.

The over-riding concern in the choice of a suitable paradigm to underpin this study was the research questions that were set out in Chapter One (see section 1.6). Recognising the multiple factors that influence levels of daily PA in people with COPD, and adding to this the subjectivity of the impact of an intervention as well as barriers and facilitators of adherence to the intervention, it is believed that a pragmatic paradigm was appropriate for this study. The current study aims to objectively measure and investigate the relationship of level of daily PA with clinical outcomes (e.g. health status, pulmonary function, exercise capacity and hospital admission) along with participants' views of the benefits of a CEP. To achieve this aim, pragmatism offered the author/researcher multiple means of thorough investigation of real life experiences of daily PA. Data on levels of PA, health status, pulmonary function, exercise capacity and hospital admission were collected, relationships investigated and findings interpreted. Data on participants' views of the benefits of the programme were also collected, analysed and interpreted. The most appropriate means of exploring these within the

pragmatic paradigm is through the use of a mixed methods sequential exploratory design. The framework illustrated in Figure 7 guided the conduct of this study.

Figure 7: Overview of the framework underpinning this study



5.3 The Research Approach: Quantitative vs Qualitative

As can be seen in Figure 7, this study used both quantitative and qualitative approaches to address its research questions. These are two broad approaches to the gathering of data for research purposes (Johnson and Christensen, 2012). The strategies adopted by different researchers differ greatly, ranging from those who see the two approaches as completely distinct and based on different philosophical worldviews, to those who are pleased to combine these approaches within their study (Creswell and Clark, 2011). For instance, Johnson and Onwuegbuzie (2004) argued in favour of a combination of quantitative and

qualitative approaches, but Hughes (1997) suggests that this undervalues the legitimacy of researchers' choice of methods. The discussion of quantitative versus qualitative as two opposed approaches to research has a long tradition and cannot be exhaustively explained here. Nevertheless, a summary is presented in the following paragraphs.

The quantitative approach is the early form of research that originated in the natural sciences such as biology, chemistry and physics. Cormack (1991) linked the origin of quantitative research to the scientific methods employed in physical sciences. It concerns itself with investigating things which researchers could observe and measure objectively using some techniques. Such observations and measurements can be recorded and always have the characteristics of being able repeatable. Two philosophical terms: 'empiricism' (Leach, 1990) and 'positivism' (Duffy, 1985) were used to describe quantitative research. This research approach is an unbiased, objective recognized methodical process that uses numerical data for describing, testing and examining cause and effect relationships (Burns and Grove, 1987), using a deductive method of gaining knowledge (Duffy, 1985).

Researchers in the field of social sciences notably psychology, sociology, anthropology, etc. became interested in investigating human behaviour and the social world in which humans live. They asserted that it is difficult to explain human behaviour in determinate or quantifiable terms. Although measurements provide information about the frequency or number of people with certain behaviour, but they are inadequate in explaining why people behave the way they do. According to Creswell (2013), qualitative research attempts to enhance our understanding of why things are the way they are in our social world and why people act the way they do.

The key characteristics and differences between quantitative and qualitative approaches to research are summarised in Table 5. Firstly, whereas quantitative research approaches test theory deductively from current knowledge, by developing hypothesized associations and proposing the outcomes of research, qualitative approaches are steered by some ideas, perspectives or guesses regarding the research participants to be studied (Cormack, 1991).

Table 5: Quantitative versus qualitative Research Approach

Criteria	Quantitative Approach	Qualitative Approach
Purpose	To test hypotheses, look at cause & effect and make predictions	To understand and interpret social interactions i. e explore phenomena
Group Studied	Larger & randomly selected	Smaller & not randomly selected.
Type of data collected	Number and statistics	Words, images or objects
Question format	Closed-ended	Open-ended
Data format	Numerical (obtained by precise measurements using structured and validated data-collection instruments and/or by assigning numerical values to response)	Textual (obtained from audiotapes, videotapes, participant observations, field notes and reflections.
Instruments for data collection	Instruments use more rigid style of eliciting and categorising responses to questions. Use highly structured methods such as questionnaires, surveys and structured observation.	Instruments use more flexible, iterative style of eliciting and categorizing responses to questions Use semi-structured methods such as in-depth interviews, focus groups and participant observation.
Type of data analysis	Identify statistical relationships	Identify patterns, features, themes
Objectivity/subjectivity	Objectivity is critical	Subjectivity is expected
Role of researcher	Researcher & their biases are not known to participants in the study, & participant characteristics are deliberately hidden from the researcher (double blind studies).	Researcher & their biases may be known to participants in the study, & participant characteristics may be known to the researcher.
Results	Generalizable findings that can be applied to other populations.	Particular or specialized findings that is less generalizable.
Scientific method	Confirmatory: the researcher tests the hypothesis and theory with the data.	Exploratory: the researcher generates a new hypothesis and theory from the data collected.
Flexibility of study design	Study design is subject to statistical assumptions and conditions	Study design is subject to statistical assumptions and conditions.
Most common research objectives	Describe, explain, and predict.	Explore, discover and construct.
Focus	Narrow-angle lens; tests a specific hypothesis.	Wide-angle lens; examines the breadth and depth of phenomena.
Nature of observation	Study behaviour under controlled conditions; isolate causal effects.	Study behaviour in a natural environment.
Nature of reality	Single reality; objective.	Multiple realities; subjective.
Final report	Statistical report with correlations, comparisons of means and statistical significance of findings.	Narrative report with contextual description and direct quotations from research participants.

Derived from: Johnson and Christensen (2012)

Secondly, quantitative approach develops theory deductively while qualitative researchers approach research inductively as they do not explicitly intend to present their findings in quantifiable terms, instead they make effort to describe such findings in the language they used during the research process (Leach, 1990). Duffy (1987) opined that qualitative approaches are employed as means of learning or investigating the empirical world from the subjective impressions of the participant and not from the perspective of the investigator(s). This aspect of qualitative research was further explained by Benoliel (1984, p. 1) when he described qualitative approaches as *"... modes of systematic enquiry concerned with understanding human beings and the nature of their transactions with themselves and with their understandings"*. The main objective of qualitative research is to provide a description of some, if not all, aspects of a phenomenon, without leaving out the research subjects of the study (Cormack, 1991). Duffy (1985) described the methodology itself as phenomenology or as a humanistic and idealistic approach as described by Leach (1990). Thirdly, Cormack (1991) explained that qualitative methodologies derive from disciplines such as history, philosophy, anthropology, sociology and psychology. This historical origin, which is different from that of physical science, has been viewed as one of the many weaknesses of qualitative research approaches. Both approaches differ in several other aspects; types of data they produce, sampling techniques (Bhopal, 2007; Duffy, 1987; Creswell, 2013), level of involvement of the researchers or the relationship between researchers and the study participants, study design and methods of data collection (Bhopal, 2007; Creswell and Clark, 2011), reliability, validity and generalisability of findings (Duffy, 1985).

Measuring and investigating the relationship between levels of daily PA and clinical outcomes on the one hand, and participants' views of the benefits a CEP as well as the facilitators and barriers to participation, on the other hand, raise an extremely important question regarding the appropriate research approaches to be adopted and their sequence in the study. During this study, the author aimed to understand how the key concepts are measured. The next element involves determining whether or not the CEP improved levels of PA and other outcomes following a 3-month follow-up as well as the relationship between the variables. These constituted the major component of the study, clarified the nature of the research problems to be addressed and guided the formulation of the hypotheses (see section 4.7).

In this study, apart from the preliminary information on the key concepts in the study (COPD, PA, health status, exercise capacity, pulmonary function, and hospital admission), their measurement and the current status of the post-PR relationship between them, the author constructed 13 hypotheses which were tested. Within the formulated hypotheses and data collected, the research problems were addressed.

It is worth noting that there are three main aspects in the comprehensive understanding of the research questions in this study. Firstly, there is a consideration of the improvements in clinical outcomes due to participation in the CEP and the relationship between the outcomes. The second aspect related to participants' experiences and views of the benefits of the intervention and what facilitated or acted as barriers to their participation. Finally, there is a consideration of the context within which study was conducted to provide an indication of where findings can be generalised. Data about the first aspect were gathered by using quantitative methods of data collection and analyses, notably, use of objective measuring instruments and validated and non-validated questionnaires (listed in Figures 9 and 19). However, the use of only empirical data, without understanding participants' views of the benefits of the programme, facilitators and barriers to participation as well the charcteristics of the CEP, makes it impossible to address the entire aims of the study. In this regard, the mixed methods approach appeared exceedingly justified. It enabled a better understanding of the research questions because it integrated elements of both quantitative and qualitative approaches.

According to the following authors Monninkhof, et al. (2003; 2004); Creswell and Clark (2011), qualitative methods of data collection such as semi-structured or in-depth interviews may be used to validate or explain surprising or unexpected findings from quantitative data. The decision to adopt a combination of methods from both research approaches was aimed at capturing the needed information at various stages of the study. Because the various methods and procedures of data collection and analyses have different aims and effects, it has been argued that using different methods can possibly cancel or even out the 'method effect' and enhance the robustness and reliability of the findings of the study (Creswell and Clark., 2011; Monninkhof, et al., 2003; 2004).

Another important consideration in this study was the decision regarding the approach that needs to be prioritised in addressing the study's questions and therefore drive the study

theoretically. This study was more focused on objectively measuring daily PA and statistical relationships between daily PA and clinical outcomes. According to these, the main features of this study very closely align with the deductive philosophical approach. Therefore, the quantitative approach was prioritised (primary method) over the qualitative methods (secondary method). This approach is congruent with recommendations by Creswell and Clark (2011) and previous studies in people with COPD (Monninkhof, et al., 2003, 2004)

The nature of this study, as explained above, clearly underscored the need to collect data using a combination of both quantitative and qualitative techniques, for primary and secondary data respectively, due to their dependency. Therefore, it is this combined approach that ensured the progress and eventual success of this study. With this mixed methods approach, recognised from the start of the study, the research questions of the study were addressed after completing data collection, analyses and interpretation of findings by the author.

5.4 The Study Design: A Mixed Methods sequential explanatory study

Mixed methods studies are increasingly becoming popular in social science literature, confirming and accentuating their acceptance in disciplines such as nursing, sociology, health and social care as well as education (Creswell and Clark, 2011; Creswell, 2013). Hitherto, some writers have argued that the collection of quantitative and qualitative data is not a recent practice. What appears to be relatively new is the practice in which researchers combine both forms of data and present them as a separate research design (Creswell and Clark, 2011; Creswell, 2013; Teddlie and Tashakkori, 2009). Nevertheless, social scientists still hold different views regarding the meaning, place and application of mixed methods in social science inquiry. Teddlie and Tashakkori (2009) contended that mixed methods is a methodology in its own right. As a methodology, Creswell and Clark (2007) recognised that mixed methods studies are underpinned by pragmatism and that this adds some degree of complexity to a study. Creswell and Clark (2007) argue that every researcher indisputably has a fundamental philosophical assumption guiding his/her research and scholarly work and in the case of mixed methods researchers, this may be a single or multiple worldviews. In addition to this perspective, Creswell and Clark (2011) and other writers such as Teddlie and Tashakkori (2009) emphasised that the major considerations in mixed methods research are the methods of data collection and analyses (Creswell and Clark, 2007).

The definition of mixed methods research advanced by Creswell (2007) was employed in this study. Creswell's definition integrates the philosophical tradition underpinning mixed methods, pragmatism, and supports the idea that mixed methods is a methodology as well as emphasised the significance of its methods of data collection and analysis. Several writers have consistent views regarding the fundamental principles of mixed methods research. They strongly maintained that a more robust understanding of the research question(s) is achieved by combining quantitative and qualitative approaches than what can be achieved from using one of the approaches alone (Creswell and Clark, 2007; Teddlie and Tashakkori, 2009; Feilzer, 2010). This fundamental concept of combining approaches can be supported in several ways. Firstly, quantitative and qualitative approaches have their inherent weaknesses which mixed methods research helps to strengthen. This is appropriate for this current study which requires an approach to assessing levels of daily PA, a complex behaviour, and its relationship with clinical outcomes along with participants' views.

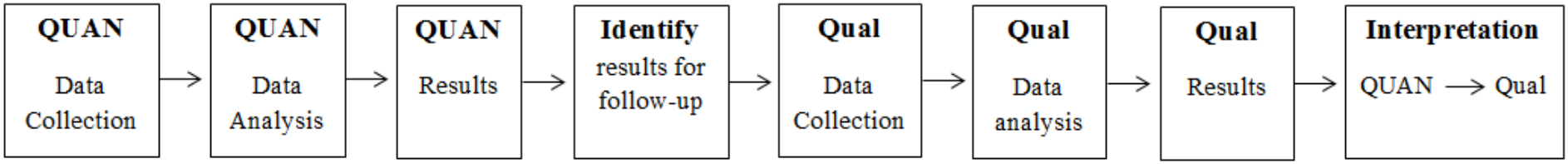
Secondly, mixed methods design allows researchers to draw on different instruments of data collection and analysis to comprehensively address research problems. The relative complexity of this current study is illustrated in its proposed conceptual framework (see Figure 5). Hence, a paradigm and research approach that supports multiple data collection methods was an important consideration in this study. Thirdly, mixed methods research addresses research problems that cannot be addressed by one research approach. In this regard, mixed methods research can encourage interdisciplinary and collaborative research in which researchers from different fields of inquiry combine ideas to provide comprehensive solutions to problems. Further, mixed methods research is widely accepted as the most practical way to approach research problems as it supports the use of 'what works' and multiple paradigms to underpin research (Creswell and Clark, 2007; Feilzer, 2010). This practicality that mixed methods research contributes to social science inquiry focuses on the idea that people are inclined to solve problems through numbers and words. As stated earlier, this study adopted the pragmatic philosophical paradigm to address its questions and this aligns with current practice and recommendation in social science research (Creswell and Clark, 2007; Creswell, 2013; Feilzer, 2010).

Although one cannot assert that the paradigm debate has been won or lost, the last two decades has witnessed an increase in the number of mixed methods researchers, indicating a widespread acceptance of this approach as a distinct study design in its own right especially

in the turn of the millennium (Creswell and Clark, 2007; Teddlie and Tashakkori, 2009; Creswell, 2013; Feilzer, 2010). Morse (1991) introduced an idea of using symbols to facilitate the conduct of mixed methods studies. He used plus symbol (+) to represent methods which are performed concurrently (at the same time) and arrow symbol (→) to represent methods which occur sequentially. Morse's idea is increasingly being featured in mixed methods texts (Teddlie and Tashakkori, 2009; Creswell and Clark, 2011). Mixed methods writers such as Feilzer (2010) and Creswell and Clark (2011) contributed to Morse's ideas by adding more notations and using diagrammatical formats to explain the complexities of their study designs. Typically, when different methods of inquiry are combined, one is considered the primary method and is represented with uppercase letters while the other is regarded as the secondary method and indicated by lowercase letterings (Steckler, et al., 1992). The different steps in the research process are represented with geometrical shapes such as squares (□), rectangle (▭) and circles (⬭). Parenthesis, ( ), is used to represent methods which are embedded within other methods (Steckler, et al., 1992; Creswell and Clark, 2007). This system of using notations and diagrammatic formats has been adopted by several mixed method researchers. They use it to provide an initial visual illustration of all the processes and methods to be applied from the beginning to the end of a study. According to Creswell and Clar (2011), it is important for researchers to use rigorous research designs to guide their decisions about the methods of data collection and set the logic underpinning the interpretation of findings.

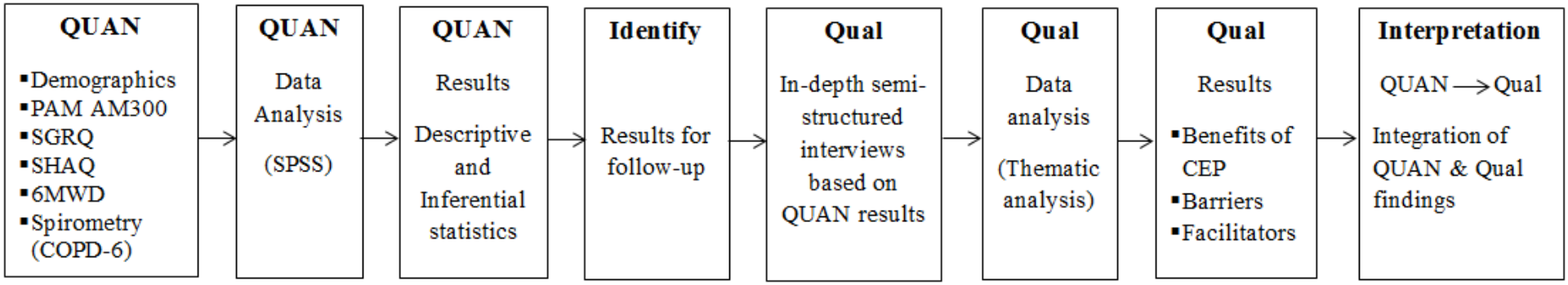
Creswell and Clark (2007) advanced a prototypical version or model of a mixed methods explanatory study design. A diagrammatic illustration of this model is shown in Figure 8, while Figure 9 shows the use of Creswell and Clark's (2007) model in this current study. A mixed method sequential explanatory study design is well appropriate for this study. It is a two phase study design integrating both quantitative and qualitative approaches. Within this design, the qualitative data was used to triangulate and provide explanations to the findings from the quantitative part of the study as suggested by Creswell and Clark (2011).

Figure 8: A model of mixed methods explaratory study design



Source: Creswell and Clark (2007, p. 73)

Figure 9: A mixed methods exploratory study design to address research questions



Source: Creswell and Clark (2007, p. 73)

Other supporters of this design such as Tashakkori and Teddlie (2003) also assert that it is a valuable tool for researchers who aim to use qualitative data to provide better understanding of quantitative results they consider important, unimportant or surprising. Researchers can also use it if they wish to form cohort(s) of study participants based on quantitative findings and follow the cohort prospectively with qualitative study. Furthermore, the contributions of Creswell and Clark (2011) to the usefulness of a mixed method explanatory approach appear to suggest three main criteria that should be fulfilled before using this approach. These include: (a) the research question(s) should be more quantitatively oriented; (b) there should be sufficient time for the study to be conducted in two phases and (c) the study should develop new research questions from the results of the quantitative study. In addition, Creswell and Clark (2011) explained that the design helps researchers to identify, from the quantitative study, participants that can be recruited to participate in the qualitative aspect of the study.

As illustrated in the Creswell and Clark's (2007) model, in practice, the researcher started by collecting and analysing quantitative data and this was immediately followed by the qualitative aspect which developed from the quantitative findings. Creswell and Clark (2011) noted that the quantitative aspect of the design is the most important because it has the priority for addressing the study's questions and therefore, acts as the theoretical drive for the study. Thereafter, important aspects of the quantitative findings that need to be triangulated or further explained are identified. These are then used to steer the qualitative study, and together, both aspects provide a comprehensive understanding of the research questions as demonstrated by the works of Monninkhof, et al. (2003; 2004). Four of the articulated features of sequential explanatory studies include; quantitative orientation, conducted in two stages, connectedness with evolving research approaches in which a later phase can be planned based on findings from an initial phase, and finally they can comprehensively address research problems (Creswell and Clark, 2011; Monninkhof, et al., 2003; 2004).

The aim/focus and research questions of this study have been clearly stated (sections 1.4 and 1.6). The first (quantitative) aspect of this study used both validated and non-validated data collection instruments (see section 5.6) to gather information on participants' socio-demographics, levels of daily PA, health status, FEV_1, exercise capacity and number of hospital admission. These quantitative data were the grounding for the study. Analyses of the

quantitative data observed the impact of the intervention (CEP) on the study variables as well as the relationship of level of daily PA with other variables. In-depth semi-structured interviews were conducted to further validate some of the quantitative findings or explain findings that need further clarification. As the literature demonstrates, some of the phenomena of this study (experience of the benefits of the CEP, barriers and facilitators of daily PA) are subjective by nature. Underpinning this study with a purely positivist (quantitative) approach would have been inadequate in providing an in-depth understanding of participants' experiences of the benefits of the CEP as well as what makes it easier and/or more difficult for them to participate. Quantitative and objective measurement of participants' daily PA and other outcomes were important to identify statistically significant differences between data collected at Time Points 1 and 2 and the statistical relationship of level of daily PA with other variables. The quantitative measurements were also used to steer the in-depth semi-structured interview which validated and explored what influenced the quantitative findings.

This current research was a three-stage study that integrated quantitative and qualitative approaches to draw upon a wide range of data from literature and systematic reviews, questionnaires, existing documents, general observations, and qualitative interviews. After establishing that the gap in current knowledge was lack of objective measurement of free living daily PA and its relationship with clinical outcomes for people with COPD post-PR along with participants' views), this research continued with the positivist perspective. It focused first of all deductively on objective measurement of participants' levels of daily PA and five clinical outcomes (time spent on daily PA, health status, FEV1, exercise capacity and number of hospital admissions). Appropriate statistical techniques were then used to observe how participants' levels of daily PA were associated with the five variables as well as determine if daily PA scores could be predicted from scores of clinical variables. This deductive, quantitative approach provided a strong foundation for the later inductive qualitative element of the study so as to extend the breadth of data analysis and strengthen the overall evaluation of the factors mediating the observed relationship of daily PA with other variables. Therefore, both positivist and interpretivist paradigms underpinned this study.

The key elements of the quantitative and qualitative methods employed in this research are further elaborated in sections two and three respectively, following a discussion of the research setting, participants' identification and recruitment.

5.4.1 The Research Setting

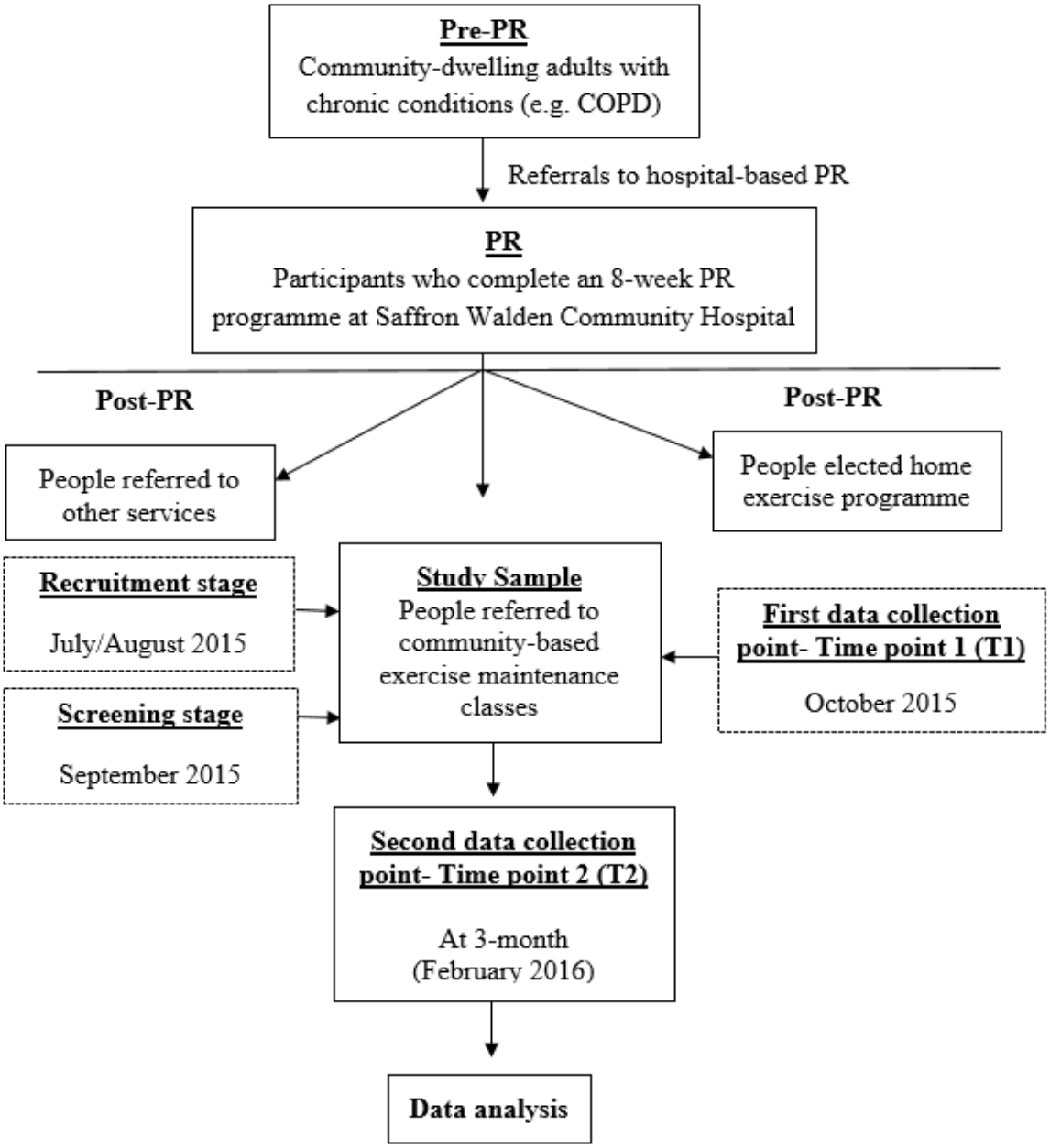
This study was carried out in the context of a CEP which was provided by a local district council in partnership with a lifestyle and facilities management company that engaged with people in local communities to enhance lives through health and wellbeing, PA, learning and the arts. The CEP was offered at a community recreation facility in the UK. Participants meet to complete structured and supervised moderate-intensity exercise training for 90 minutes/session twice per week.

5.4.2 How participants were identified and recruited

Figure 10 is a flow chart showing recruitment site and key stages of the study. Amongst those using the fitness gym was a group of adults with chronic health conditions, including COPD, attending post-PR exercise training classes. The group was identified through the help of a respiratory nurse specialist at the pulmonary rehabilitation (PR) unit of a community hospital. At the unit, a team consisting of a physiotherapist, a respiratory specialist nurse and a health care assistant provides exercise, education and self-management trainings for adults with main diagnosis of COPD or other chronic diseases. Community-dwelling adults access the PR service through referral by health professionals from primary or secondary care. They complete an eight-week PR in the local hospital.

In order to help participants prolong initial benefits of PR, they are encouraged to continue with a home-based exercise programme, referred to the CEP or other services based on each participant's personal circumstances. Participants in this study were recruited from the cohort of those who were referred to the CEP.

Figure 10: Flow chart showing recruitment site and stages of the study



5.4.3 How and when Consent was obtained from participants

Following ethical approval of the study by the SCREC and Uttlesford District Council on on 8th June 2015 and 20th August 2015 respectively, the exercise instructor who co-ordinated and supervised the CEP was contacted and potential study participants were approached at the usual venue of their weekly exercise training sessions (commercial fitness gym). The primary investigator (PI) visited the research site in August 2015 to give Recruitment flyers (see

Appendix 2) to all prospective participants and explain all stages of the study. Some prospective participants indicated initial interest in the study immediately after the meeting. Others contacted the PI by telephone and through the exercise instructor a week after the initial visit. The PI arranged another visit to the site and provided all prospective participants with Participant Information Sheets, PIS (see Appendix 3) which described the study in detail. A 2-week time frame was allowed for participants to read the PIS and make an informed decision about participating in the study. In the fourth week of September 2015, the PI had a meeting with the prospective participants. At the meeting the PI answered all questions and addressed concerns raised by participants about the risks and benefits of the study. Those who decided to take part in this study were screened for eligibility and given Consent Form (see Appendix 4) which they completed, signed and returned to the PI immediately after the meeting.

It is worth noting that participants were not blinded to any of the study procedure. However, because it is known that the use of accelerometer-based PA monitors can potentially induce reactivity in research participants (Rachele, et a., 2012; Nelson and Hayes, 1981), the participants in this study were blinded to the reading and interpretation of data stored my the PAM AM300 devices. This was used as a strategy to minimise reactivity i.e for participants to carry out their usual daily PA without modifying their behaviours due to being aware that they are being observed or recorded by the activity monitors.

The following sections (5.5 and 5.10) outline the quantitative and qualitative approaches and methods used to address the research questions in this study.

Section Two

5.5 The quantitative approach to the research

Quantitative research involves the systematic collection of numerical information, often under conditions of considerable control, and the analysis of that information using statistical procedures (Stewart, 2010). It is concerned with collecting and analysing data that focus on numbers and frequencies, seeking to establish cause and effect and relationships between variables, rather than on meaning or experience (Hulley, et al., 2013). In order to objectively measure and investigate the relationship of daily PA and clinical outcomes (health status, pulmonary function, exercise capacity, and hospital admission) in people with COPD, it was appropriate to use a quantitative approach and methods of data collection. Therefore, in this part of the study an appropriate quantitative study design was used to address the first three research questions:

(a) Does participation in a Community-based Exercise Programme improve clinical outcomes in people with COPD following pulmonary rehabilitation?

(b) Is there a relationship between free living daily PA and measures of health status and hospital admission in people with COPD following pulmonary rehabilitation and participation in a community-based Exercise Programme?

(c) Can any of the clinical variables such as health status, pulmonary function, exercise capacity and number of hospital admission predict levels of daily PA following pulmonary rehabilitation?

As stated earlier, participants in this study were recruited from a cohort of people with COPD attending exercise training classes at two leisure centres. Among these participants, it is natural that there will be variation in attendance or adherence to the weekly training sessions. This suggests that there will be differences in levels of exposure PA among this population. Such difference may be associated with differences in other key clinical outcomes such as health status, pulmonary function, exercise capacity, and number of hospital admission.

To address the research questions stated above, twelve (12) hypotheses were formulated (see section 4.7) and tested. Since there is no existing repository of data on participants'

daily PA and other outcomes, it was deemed important for these data to be obtained, compared and analysed statistically using appropriate techniques. The central decision that confronted the researcher is whether to take a passive role in measuring these outcomes in an observational study or to apply an intervention and evaluate its effectiveness in an experimental trial. In epidemiological research, four classical observational study designs; Randomised Controlled Trials (RCTs), cohort, case-control and cross-sectional study designs are widely used to quantify and measure associations between outcomes (Bhopal, 2007; Hulley, et al., 2013). It has been argued that no one design is better than the others and that it is paramount to carefully consider research questions when making any judgment regarding the study design that will be most efficient in getting satisfactory answers (Hulley, et al., 2013). In addition, Young and Solomon (2009) emphasised that the choice of a suitable study design for any piece of research should be informed by the research objective and questions.

Although a discussion of the four classical observational study designs cannot be exhaustively explained here, a summary of the core ideas of a prospective/longitudinal observational cohort study design (Bhopal, 2007; Hulley, et al., 2013) which was used in this study is provided. The rationale for the choice of this study design is also discussed as follows.

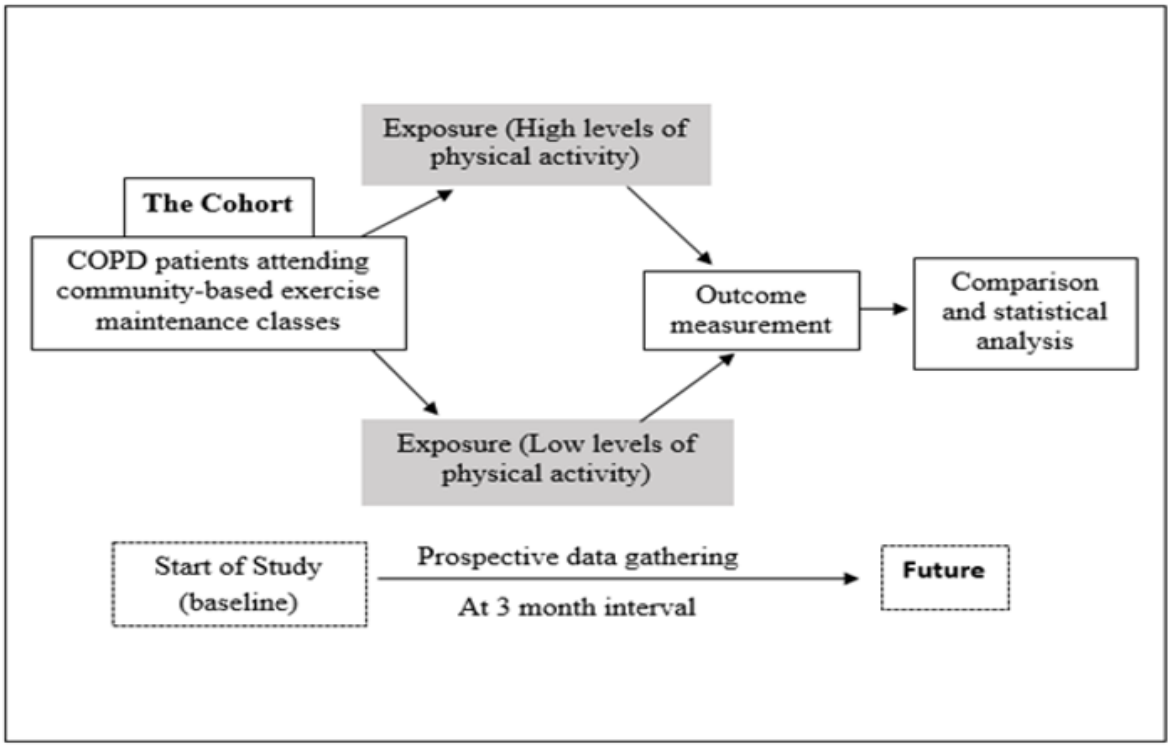
5.5.1 The Cohort Study Design

In a cohort study, the research participants are identified, recruited and followed over a period of time (Hulley, et al., 2013), a feature reflected in three synonyms: follow-up, longitudinal, and prospective (Bhopal, 2007). Unlike case-control and cross-sectional studies, the hallmark of a cohort study is that clinical outcome are collected on the same individuals at different time points (Bhopal 2007, Hulley, et al., 2013). The idea is to understand part of the natural history of the risk factors or disease outcomes in the study participants and to relate one or more characteristics (Bhopal, 2007), in this study, level of daily PA, to future outcomes such as time spent on PA, health status, FEV_1, exercise capacity and number of hospital admissions. According to Bhopal (2007) and Hulley, et al. (2013), cohort studies are further divided into prospective studies that start in the present and follow participants into the future, and retrospective studies that examine information collected over a period of time in the past. Due to the absence of past data on the outcomes of interest, a retrospective cohort design is deemed inappropriate for the purpose of this study.

The prospective observational cohort study design is considered appropriate for providing the relevant data needed to address the above research question. This design is distinguished by its ability to enable data collection at more than one time point (Bhopal 2007, Hulley, et al., 2013) and investigate causal or predictive relationships between variables. Since exposure is measured at the inception of the study before outcomes are observed or determined over time, it becomes easier to attribute the outcome of interest to the exposure. Mann (2003) argued that, in causal research, an important criterion is that an exposure must precede an outcome.

Figure 11 illustrates a modified standard model of a prospective cohort study that was implemented in this study. In essence, participants were identified, recruited and followed up for 3 months. They naturally self-select into different levels of daily PA because activity participation is behaviourally motivated and based on their attendance at the exercise classes. Outcomes were measured at Time Point 1 and after 3 months (Time Point 2).

Figure 11: Modified Model of a Prospective Cohort Study design



Derived from: Bhopal (2007)

Details of the sample size, inclusion criteria and methods of data collection and analysis are described as follows

5.5.2 The quantitative sample: sample size

The quality of a piece of research is not based solely upon the appropriateness of methodology and instrumentation but also on the suitability of the sampling strategy that is adopted (Cresswell, 2007; 2009). Quantitative and qualitative researchers use different approaches to sampling. Sampling techniques for both quantitative and qualitative methodologies appear to be complex and must be performed to satisfy the requirements of the data collection strategy. Both approaches involve identifying recruiting samples that are representative of a larger population of people with similar characteristics. Creswell and Clark (2011) described two main methods of sampling: probability (random) sampling and non-probability (purposive) sampling. Although a non-probability sample is often acceptable for pilot, exploratory or qualitative studies, for most quantitative studies the use of non-probability samples is problematic because they are rarely representative of the population (Polit and Beck, 2004). While non-probability sampling is convenient and economical, a major disadvantage is its potential for bias (Polit and Beck, 2004).

With regards to mixed methods research, sampling plays a significant role and the methods apply appears to be linked with the study design (Creswell and Clark, 2007; 2011). In general, the sample size in a quantitative study is larger than that in a qualitative study (Creswell and Clark, 2011; Monninkhoff, et al., 2003; 2004). Quantitative and qualitative data collections are dependent in a typical mixed methods sequential study design and one form of data builds on another. When conducting a mixed methods sequential study Creswell and Clark (2007) supported using the same participants in both phases of the study. Most statistical texts recommend sample size calculation to determine the number of participants needed in a quantitative study (Stewart, 2010; Vergura, et al., 2009; Spiegel and Stephens, 2011).

No formal sample size calculation was performed for this study. As the nature of any relationships between variables was unclear post-PR and no similar study was found, it was not possible to obtain the estimated parameters (e.g. variance) needed for a sample size calculation. And as time for this study was limited, the plan was to recruit 30-40 participants based on feasibility of access to people with COPD attending a CEP. According to Westland (2013), a sample size of 30 is adequate to observe the bell-shaped curve of normally distributed data. In total, 30 participants consented to participate in this study, out of which 4

dropped out, leaving 26 who completed the quantitative phase of the study. Details of participants' characteristics are provided in the results chapter.

5.5.3 Participants' eligibility

5.5.3.1 Inclusion criteria

Existing and consecutive participants attending a post-PR community-based exercise classes were included in this study if they fulfilled the following criteria:

- They were community dwelling adults with clinical diagnosis of COPD. Each participant fulfilled the case definition for COPD and its severity that falls within the definitions provided by GOLD (Vestbo, et al., 2013). These guidelines used the reduction in measured FEV_1 as percentage of the predicted normal FEV_1 to define and classify people with COPD (FEV1/FVC <0.7 and $FEV_1 \geq 80\%$; see Table 1).

- Participants had previously completed a hospital-based primary PR and referred to the CEP.

- Willing to participate in the quantitative or qualitative elements of the study or both

- Clinically stable (had no increase in respiratory symptoms or changes in treatment) during recruitment and data collection phases of the study.

- Communicated effectively in English language.

- Had no hearing or other physical problems that prevented effective collaboration.

5.6 The quantitative methods of data collection

According to Hulley, et al. (2013) methods refer to the instruments and/or procedures applied by researchers to obtain and analyse data relevant to their studies. However, Creswell and Clark (2011) argued that methods of data collection and analyses are separate aspects of every research process and that methods are more than simply techniques of collecting data. Tashakkori and Teddlie (2003) expanded the definition of research methods to include ethically appropriate ways, instruments, and techniques that are used to obtain thoughtful, relevant and accurate data as well as the ways or strategies employed in manipulating them. The justification for researchers' choice of methods of data collection is their knowledge of what exactly needs to be found (Creswell and Clark, 2011). Accordingly, the choice of methods in the quantitative phase of this research was informed by the question: *"what did I*

want to find out or investigate?" The aim of this phase is to measure and investigate the relationship between participants' levels of daily PA and the following clinical outcomes: time spent on PA, health status, FEV_1, exercise capacity and number of hospital admission.

Having clearly identified the outcomes to be measured, how they will be measured was the second question that needed clarifying. In this regard, Hulley, et al. (2013) encouraged drawing on *"instruments from other investigators who have conducted studies that included the measurements of interest"* (p. 231). The literature and systematic reviews chapters (2 and 3 respectively) identified different instruments and procedures for measuring the outcomes of interest. Validated activity questionnaires and PA monitors (PAMs) as well as timed-walking tests are used to measure levels of PA. Validated and non-validated questionnaires were extensively used by researchers to obtain participants' health status and number of hospital admission data respectively. A concise description of all instruments and procedures that were used to collect relevant data in this study are discussed in the following sections.

5.6.1 Questionnaires

Questionnaires are written sets of questions or statements used to seek written or verbal responses from people. They are essentially data collection methods designed and given to individuals mainly for collecting information relevant to the research (Hulley, et al., 2013). Parahoo (1997) noted that the use of questionnaires is a quantitative approach because of their three intrinsic features: (a) they are constructed before the start of the study (b) they are standardised (the same questions in the same order are asked of all respondent) and (c) they are structured (respondent are mainly required to choose from the list of responses offered by the researcher). To be used in qualitative studies, Hulley, et al. (2013) maintained that they have to be designed with open-ended questions.

Three major reasons informed the choice of questionnaires in this study. First, they are increasingly being used in COPD research due to their availability. Second, there are validated questionnaires for assessing outcomes relevant to this study. Finally, questionnaires are potentially the quickest and cheapest, and relatively confidential and frequently anonymous, methods of collecting large amounts of information from participants (Parahoo, 1997, p. 249). The major drawback associated with using questionnaires is that they do not offer any opportunity for respondents to give detailed description and clarify their answers. The researcher is unable to read respondents' body language and can also not immediately

probe the respondents further about the answers provided. When designing a questionnaire for a quantitative study, Cohen, Manion and Morrison (2001) suggested a simple rule of thumb regarding the nature of the questionnaire:

"... the larger the size of the sample, the more structured, closed and numerical the questionnaire may have to be, and the smaller the size of the sample, the less structured, more open and word-based the questionnaire may be. Highly structured, closed questions are useful in that they can generate frequencies of response amenable to statistical treatment and analysis. They also enable comparisons to be made across groups in the sample" (p. 247).

In this study, three short questionnaires were used for data collection; Socio-demographic questionnaire, Self-reported Hospital Admission Questionnaire (SHAQ), and Saint George's Respiratory Disease Questionnaire (SGRQ).

5.6.2 The Socio-demographics Questionnaire

Before quantitative data were collected from participants, they first provided socio-demographic information about themselves. According to Tsui and O'Reilly (1989), demographics are characteristics of participants in a study. Polit and Beck (2004) identified socio-demographic questionnaires as important instruments for collecting background information which enable researchers to establish a pattern of previous behaviours, exposures and/or experiences. Participants' background information can be used to develop a framework for discussing different issues generated by the data as well as broaden the scope of data analysis. They also permit the comparison of results from different subgroups. Tsui and O'Reilly (1989) posited that knowledge of participant's characteristics can help explain differences in outcomes of interest between participants. Beiske (2002) stated that, although participants' socio-demographic questionnaires have been criticised for having low construct validity and providing no opportunities for researchers to follow up and clarify issues, researchers still find them appealing because they are cost effective and not associated with significant adverse impact on study participants.

Where there are no standard tools for measuring demographics, Hulley, et al. (2013) suggested designing purpose specific ones. A non-validated, self-administered questionnaire was designed by the researcher (Appendix 5) to assess participants' age, sex, education, marital status, ethnicity and smoking status. They were also asked to state the date

(month/year format) they started attending the exercise classes. The reason for collecting these data was to have a framework of variables that can later be used to identify characteristics, commonalities and differences in measured outcomes between participants.

5.6.3 Self-administered Hospital Admission Questionnaires (SHAQ)

To date there are no 'gold standard' instruments for assessing hospital admission in any patient population. Purpose-specific non-validated questionnaires are often used by researchers to obtain hospital admission data (Garcia-Aymerich, et al., 2006; Benzo, et al., 2010). In this study, participants' numbers of hospital admission were based on self-report. A SHAQ was developed and used for this purpose (see Appendix 6). As its name implies, the SHAQ is a self-administered non-validated tool designed to obtain participants' number of hospital admission. It is composed of 7 items that are designed to obtain the number of times participants had been admitted to a hospital or use health care resources because of their chest or breathing trouble three months before and after attending the CEP.

5.6.4 The Saint George's Respiratory Disease Questionnaires (SGRQ)

The SGRQ is a validated tool for assessing COPD-specific HRQoL. It was designed to measure health impairment in people with asthma and COPD (Jones, Quirk and Baveystock, 1991). The SGRQ is made up of two part; 1 and 2 (see Appendix 7). Part 1 (questions 1-8) addresses the frequency of respiratory symptoms. It is designed to assess patient's perception of recent respiratory problems. Part 2 (questions 9-16) addresses patient's current state (i.e. how they are these days). The Activity score measures disturbances to daily PA. The Impacts score covers a range of disturbances of psycho-social function. The Impacts score is the broadest component of the questionnaires, covering the whole range of disturbances that people with respiratory problems experience in their lives.

The researcher personally distributed all questionnaires to the 30 participants in this study. Participants returned completed questionnaires to the researcher in a sealed envelope at the research site(s).

5.6.5 The Six-minute Walking Distance (6MWD) test

The 6MWD test is a test of exercise tolerance in people with chronic respiratory disease and heart failure. In recent studies it is used as a performance-based measure of functional exercise capacity (Amardottir, et al., 2007; Bradley, et al., 2007; Beauchamp, et al., 2013).

The test was standardised by ATS (2002), validated by Cote, et al. (2008) and shown to correlate with performance of daily PA in people with COPD (Pitta, et al., 2005b; Garcia-Rio, et al., 2009). Typically, it measures the distance an individual is able to walk over six minutes on a hard, flat surface. The objective is for the individual to walk as far as possible in six minutes. The individual is allowed to self-pace and rest as needed as they traverse back and forth along a marked walkway.

Before performing the 6-MWT, each participant practised the test once for familiarity and to minimize learning effects. The 6MWT was performed in a 50-meter long corridor according to recommended protocol (ATS, 2002). Participants were not encouraged during the walking test. The researcher only reminded participants of the aim of the test, which is to walk as far as they could in 6 minutes. Walking was started on the command 'start' and stopped at the end of six minute on the command 'stop'. A stopwatch was used for the timing while the distance walked was measured with a meter tape.

5.6.6 Physical Activity Monitor (AM300)

Participants' levels of free living daily PA were assessed with internet-connected, three-axis accelerometer devices (Personal Activity Monitor, PAM., model AM300, PAM BV, Doorwerth, the Netherlands). The rationale for choosing AM300 devices over other available activity monitors was because they are; relatively inexpensive, convenient to use, have little participant burden, light-weight (20mg), able to store data constantly for over 60 days and have previously been validated to objectively measure daily PA among healthy adults (Slootmaker, et al., 2009) and those with COPD (Vooijs, et al., 2014). According to the manufacturer, an AM300 device objectively measures level of PA by measuring acceleration with the aid of an integrated accelerometer and uses a piezoelectric sensor to convert the measured acceleration into an activity score (the PAM score). The device also offers the possibility to objectively measure daily and weekly amount of time (minutes) participants spent on light, moderate and vigorous-intensity PA as well as energy expenditure.

Participant were asked to wear the AM300 device always on their waists (belt, edge of pants/skirt as shown in Figure 12) for seven consecutive days (Wednesday to Tuesday), 24 hours per day with the exception of the time spent on bathing or showering because the device is not waterproof. Participants were given verbal instructions and practical demonstrations on how to wear the device. During the seven days of use, the PAM scores

were not visible to the participants in order to minimize the influence of wearing the accelerometer. To reduce participants' burden, they were not provided with instructions on how to access stored data.

Figure 12: AM300 and its attachment

Source: PAM Coach (2016)

5.6.7 How participants' PA data were accessed

All AM300 worn by participants were retrieved for analyses. Data stored by the devices were accessed according to manufacturer's instructions (PAM Coach, 2016). In order to access data stored by the device, the AM300 software was first installed on a personal computer (PC). AM300 has a 3D accelerometer and a wireless connection. It is connected to the PC with a USB receiver. When AM300 is connected with the PC, it automatically connects to the Pam Online Coach. The researcher registered each participant on the PAM Online Coach website. Upon login in, participants' daily/weekly activity data were immediately uploaded, displayed and stored on their personal PAM Web Page. The PAM Online Coach displayed each participant's PAM score, energy expended (in Kcal) and the precise time (in minutes) that the participant spent on PA in three zones:

(a) The Living Zone (LZ), defined as fidgeting, doing chores around the house
(b) The Health Zone (HZ), defined as walking or other moderate-intensity PA.
(c) The Sport Zone (SZ), defined as running or other vigorous-intensity PA.

A PAM point (score) measured participant's expended energy. It is the ratio between the amount of energy the participant expended while performing PA and the amount of energy expended while at rest, multiplied by 100%. The exact number of points achieved depended

on the intensity of the activity. On every subsequent log-in, the PAM Online COACH, presents all the uploaded data (PAM scores, time spent on PA in every zone and energy expended) in orderly graphs per day, week or month as illustrated in Figure 13, 14 and 15).

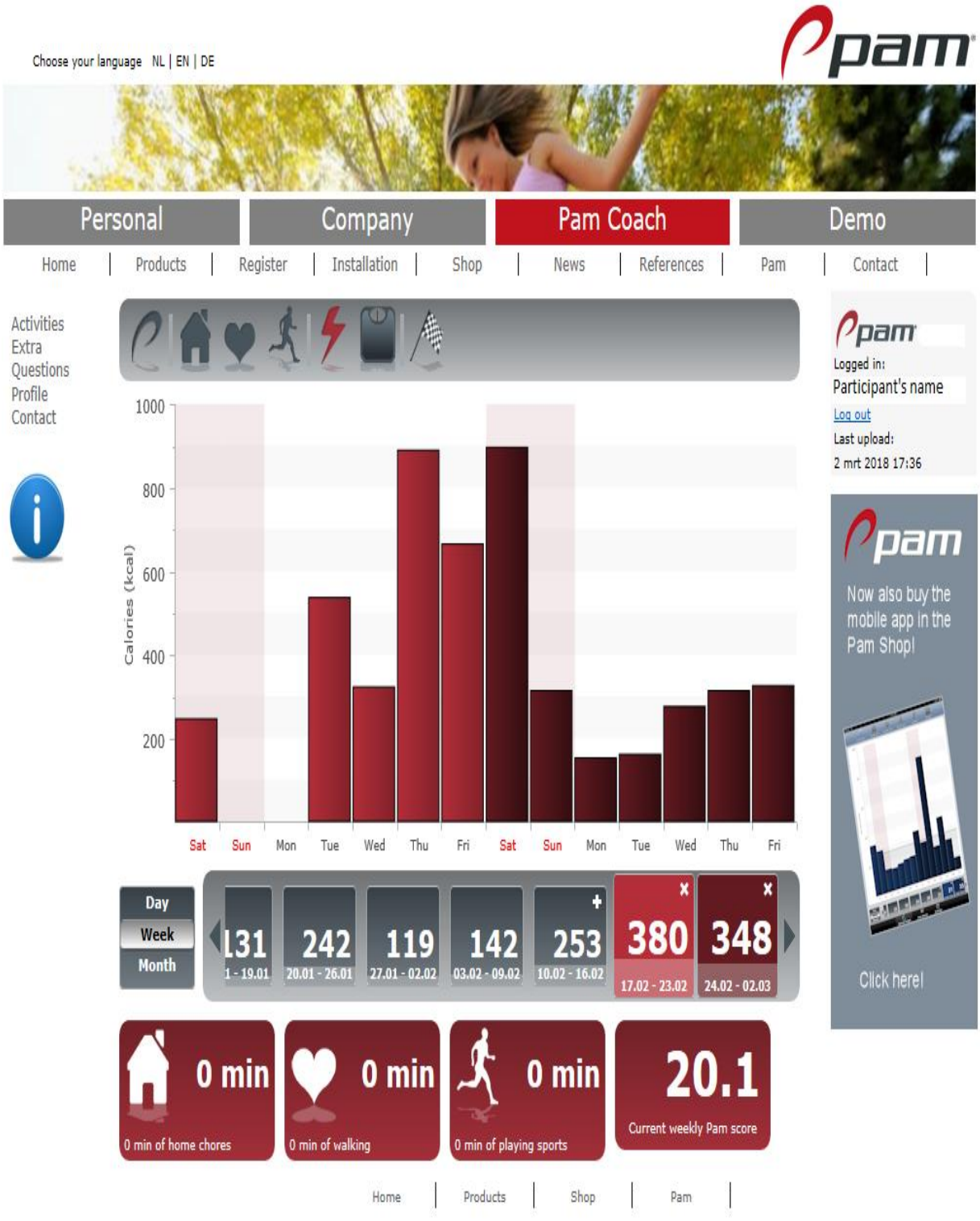
Figure 13: Screenshot showing a participant's daily PAM scores

Source: PAM Online Coach Website (2016)

Figure 14: Screenshot showing time spent on PA in the Living, Health and Sports Zones

Source: PAM Online Coach Website (2016)

Figure 15: Screenshot showing energy expenditure (Kcal)



Source: PAM Online Coach Website (2016)

Unlike in a previous study (Slootmaker, et al., 2009) where participants' uploaded PAM scores were accompanied by tailored PA advice as well as motivational tips for increasing PA, participants in this study were not given any individualised PA advice. The reason was to objectively measure participants' daily activity. Relevant data were extracted from participants' personal Pam Web Page.

5.6.8 Spirometer (pulmonary/lung function test)

Participants' pulmonary function was measured with a COPD-6 device (Vitalograph Ltd, Ennis, Ireland, Figure 16), which is a mini-spirometer. A spirometer is a mechanical device used to measure lung function, disease severity and response to treatments in people with respiratory conditions (Vestbo, et al., 2013). It determines the volume of air they can expel from the lungs after a maximal inspiration (Miller, et al., 2005). The choice of the COPD-6 device was mainly informed by its affordability and reliability as it has recently been demonstrated to significantly predict COPD (Thorn, et al., 2012). The tests were performed as per manufacturers' instructions (Vitalograph, 2013) which are consistent with recommended guidelines for spirometry (Miller, et al., 2005) (see Appendix 8).

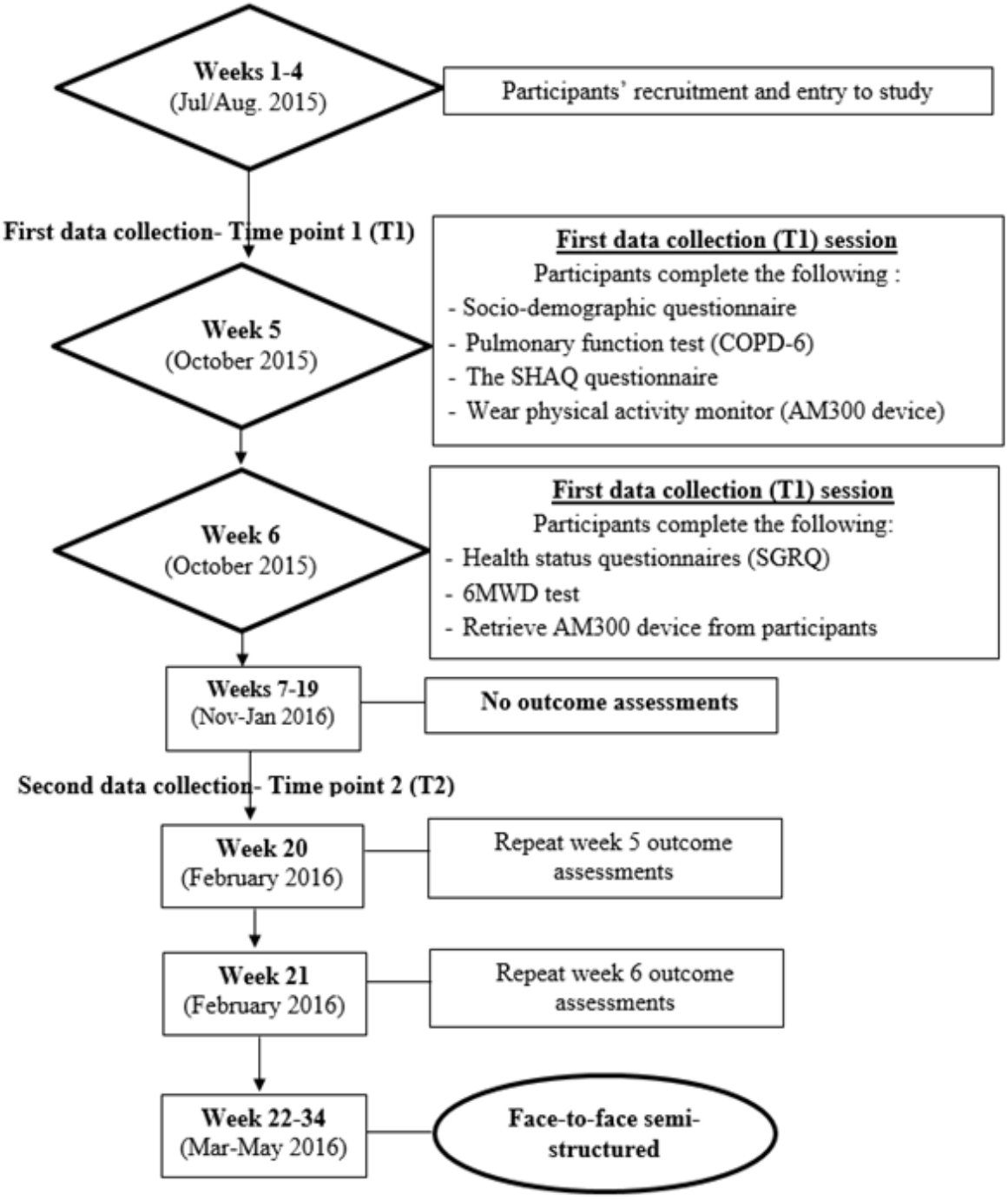
Figure 16: Vitalograph COPD-6 COPD Screening Device

Source: Vitalograph (2013)

5.7 Data collection schedule

The different stages and order of procedures carried out in this study are shown in Figure 17.

Figure 17: Flow chart of study procedures



Quantitative and qualitative data were collected between October 2015 and April 2016. After recruitment, the following outcome measurements were carried out in the first data collection point, time point 1 (T1): participants completed (a) Socio-demographic questionnaire (b)

SHAQ and (c) pulmonary function test. Instructions and demonstrations on how AM300 devices are used were given. Each participant wore an AM300 for 7 consecutive days, 24 hours per day with the exception of time spent on bathing or showering. There was a second T1 data collection session 7 days after the first assessment session. All AM300 worn by participants in the last 7 days were retrieved and participants completed the SGRQ and 6MWD test. These measurements were repeated at the second data collection point, time point 2 (T2) after 3 months interval. Data were gathered and analysed as described below.

5.8 The research variables: Dependent and Independent variables

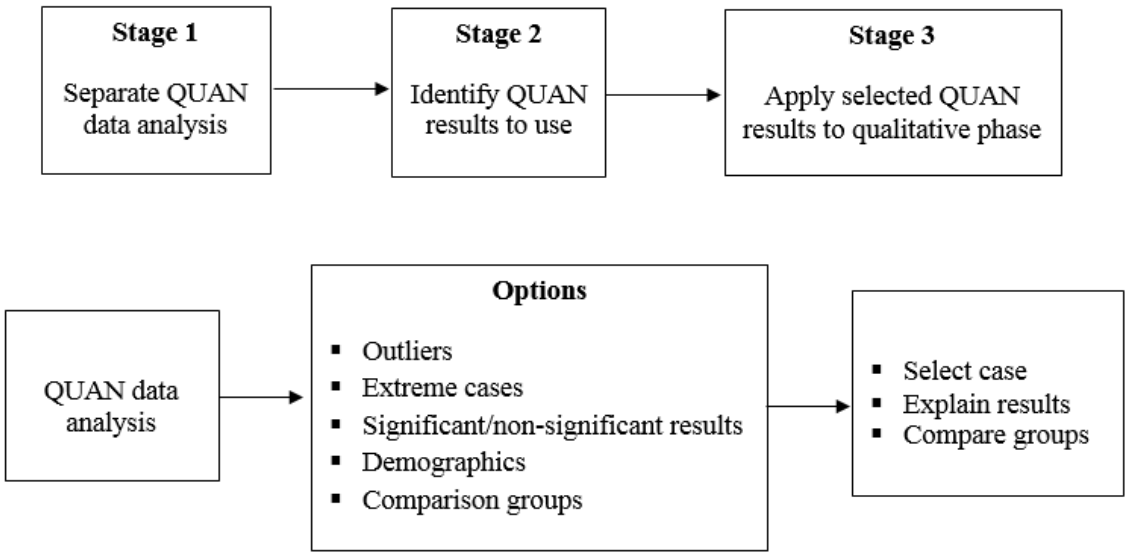
Stewart (2010) defined variables as the key concepts which researchers are interested in in a study. The variables in a study are characterised in different ways and may have implications for analysing the data. One approach to characterising variables is based on their role in an analysis. In this context, Stewart (2010) identified two types of variables: dependent and independent variables. The independent variable is a variable that stands alone and is not affected or changed by other variables the researchers are trying to measure (Stewart, 2010). For example, participants' age might be an independent variable because other factors (e.g. what the participants' diet, level of activity, attendance, medication) are not going to change their age. A dependent variable, on the other hand, is a variable that depends on other factors (Stewart, 2010). For example, scores on a health status questionnaire could be regarded as dependent variables because they could change depending on several factors such as how much a participant exercise, dosage of medication taken, etc. Usually when researchers look for a relationship between two variables they try to find out what makes the dependent variables change the way they do. Based on these definitions, the variables in this study are characterised as follows.

There are five dominant variables of interest in this study: levels of daily PA, time spent on PA, health status, FEV_1, exercise capacity, and number of hospital admission. Although level of daily PA can be an independent variable, it was operationalised as a dependent variable in this study because it was thought that daily PA can be influenced by other clinical outcomes which were regarded as independent variables. Whether or not these variables are able to predict participants' levels of daily PA was also investigated.

5.9 Data analysis

As suggested by Creswell and Clark (2007), data analysis in a typical mixed methods study involves a separate analysis of quantitative and qualitative data using methods appropriate to each of the approach (Figure 18). The approach to data analysis in a mixed methods study depends on the study design adopted. Because this study is a mixed methods sequential explanatory design, a sequential approach to data analysis was adopted in which quantitative and qualitative data were analysed separately followed by an integration of the findings (Creswell and Clark, 2007).

Figure 18: The Sequential Approach to Data Analysis



Source: Creswell and Clark (2007)

As can be seen the sequential approach enabled the first quantitative data analysis to inform the second qualitative data collection and analysis. The major goal was to provide a comprehensive understanding of the mixed research questions in this study. This approach to data analysis underscores the significance of both phases of the study which are dependent on each other and fundamentally contributed to the success of this mixed methods study.

5.9.1 Quantitative Data Analysis

The quantitative data were analysed during and after completion of the quantitative phase of the study. Quantitative data from the validated questionnaire (SGRQ) were individually scored using the appropriate scoring tool supplied with the questionnaire. Data from the first

and last incomplete measurement days (from AM300) were excluded from analyses due to the fact that participants came to the research site, returned the devices and completed other measurements. This was done to eliminate or minimise data that Watz, et al. (2009) regarded as exogenous. Therefore, the measurement period for daily PA was six days (maximum total: 144 hours). Watz, et al. (2009) found that five measurement days of ≥22.5 hours per day were required to reliably measure PA in patients with COPD. This study considered at least 5 days of PA measurement a valid measurement period. PA data from participants with <5 days were excluded from analyses.

Quantitative researchers apply statistical techniques to organise, summarize, evaluate, analyse, interpret as well as make sense of collected quantitative data (Bhopal, 2007; Vergura, et al., 2009; Stewart, 2010). Statistics can be classified as descriptive or inferential (inductive). Whereas descriptive statistics are used to summarize and present raw data in a meaningful way, inferential statistics are valuable for comparing and establishing relationships between variables as well as make generalisations about the populations from which samples are drawn (Vergura, et al., 2009). In this study, descriptive statistics were first used to summarise participants' characteristics at Time Point 1 and data on variables that were measured. Inferential statistics were then used to compare the variables to observe differences and relationships. A summary of the statistical methods used in this study are discussed in the following sections.

5.9.2 Descriptive and inferential statistics used in the study

Descriptive statistics were used to describe and summarize data in order to show an overall picture of the raw quantitative data. Normal distribution of data was checked by the Kolmogorov-Smirnov test. Normally distributed data were presented as mean and standard deviation (M±SD), while median was used to describe data with skewed distribution. Analysis was conducted of data collected at two time points (T1 and T2).

Inferential statistics are based on the laws of probability. Most, if not all, statistics texts agree that inferential statistics are widely used to compare and make general statement about the populations from which samples are drawn as well as establish the relationships between variables (Stewart, 2010; Vergura, et al., 2009). A relationship is a link or connection between measured variables, for example, participants' levels of activity, exercise capacity and health status.

Twelve (12) hypotheses were formulated and tested in this study (see chapter 4, section 4.7). The null hypotheses were stated. For example, that there was no statistical significant relationship between daily PA and other outcomes, and that any observed relationship must have happened by chance. On one hand, rejecting a null hypothesis supports the research hypothesis that relationship exists between the variables and that this is not due to chance. On the other hand, if the null hypothesis is not rejected it suggests that the differences and/or relationship observed by the study may be due to chance. Statisticians use the terms "Type I error" to refer to an error that occurs when a null hypothesis is incorrectly rejected. A "Type II error" occurs when a null hypothesis is accepted instead of been rejected. Hence, it is highly important to control these errors in order to avoid misinterpreting the research findings. Most authors of statistical texts (Polit and Beck, 2004, Stewart, 2010; Vergura, et al., 2009) agree that the risk of making a Type I error is usually controlled by establishing a level of significance.

Inferential statistics utilise theoretical sampling distribution and the laws of probability as a basis for deciding whether or not research outcomes are probable or improbable (that is whether they happen by chance). Probability (p) is defined as a measure of the likelihood of an event occurring. Conventionally, p, is measured from one to zero (1-0). 1 and 0 imply that the event is unavoidable and impossible respectively (Stewart, 2010). When testing for significance, p, is defined as the likelihood of the results of the study differing from those expected from the research hypothesis by random chance. The closer the p-value is to 0, the smaller the chance that the difference between the observed and expected results is due to chance, therefore, the more significant the results of the study (Stewart, 2010).

Quantitative researchers establish rules that help them decide whether or not their tests results are significant. They do this by selecting a significant level (Vergura, et al., 2009; Spiegel and Stephens, 2011). They reject the null hypothesis if their test statistics are below or above a critical on the applicable theoretical distribution, and to accept the null hypothesis otherwise.

This study used the conventional guidelines to determine the significance of the difference between the observed and expected results. When $p<0.05$, the difference was considered as significant. When $p>0.05$, the difference was regarded as non-significant. When p is far

<0.05, the difference was considered to have a greater level of significance (Stewart, 2010). P-value <0.01 or 0.001, indicated a significance with a greater order of magnitude (Stewart, 2010). In some cases, the p-values for some tests were assigned one, two or three asterisks (*) to indicate that the p-values are <0.05, 0.01 and 0.001 respectively.

In practice, researchers do not construct sampling distributions and calculate critical regions. Instead, quantitative data from studies are used to calculate test statistics using suitable formulae (Polit and Beck, 2004; Stewart, 2010). Two broad classifications of statistical analyses have been identified: parametric and nonparametric tests. Parametric tests are statistical tests in which assumptions are made about the parameters or defining properties of the population distributions from which data are drawn. Typically, parametric tests have three attributes: (a) they involve the evaluation or measurement of parameters (b) they require measurement on at least an interval scale (c) they involve many assumptions, for example, they assume that variables are normally distributed in the population from which they were drawn (Spiegel and Stephens, 2011). The parametric test used in this study was Paired samples t-test. It was used to test if there were statistically significant differences in the mean scores of variables measured at Time Points 1 and 2 if the viariables were measured at ordinal levels and were normally distributed. Pearson's correlation coefficient was used to test statistical relationship of daily PA with other clinical outcomes as recommended by Stewart (2010), Pallant (2010) and Spiegel and Stephens (2011).

By contrast, in nonparametric tests parameters are not estimated and assumptions are not made. They are often used when data have been measured on a nominal or ordinal scale and provide possible ways to handle data that are not normally distributed (Spiegel and Stephens, 2011). The Wilcoxon Signed Rank test was the only nonparametric test applied in this study. It was used to test if there was a statistical difference in the population mean scores of variables measured at Time Points 1 and 2 (repeated measurement on a single sample) when the viariables were measured at ordinal levels and have skewed distributions.

To investigate the relationship of daily PA and other clinical outcomes, Pearson product-moment correlation coefficient (r) was used. Before performing all correlation analyses, scatterplots of the relationship between variables were first generated. This was used as preliminary analyses that enabled an overall assessment of the assumptions of normality, linearity, homoscedasticity and nature of the relationship between variables.

To explore the predictive ability of clinical outcomes on level of daily PA, simple and multiple logistic regression techniques were employed. The aim was to determine how well these variables are able to predict participants' daily PA. The dependent variable level of daily PA (average daily PAM scores) was continuous. Simple linear regression analyses were first conducted to determine if average daily PAM scores could be predicted from 6MWD test scores, SGRQ total scores, FEV1 scores, number of hospital admission, BMI, age and years in CEP (independent variables) at Time Points 1 and 2. A multiple regression was then conducted by including the three stronger predicators considering the potentially important variables obtained from the simple linear regression models due to the small simple size (n=26).

Parametric tests are more powerful than nonparametric tests and are usually preferred. There is also some disagreement regarding the use of nonparametric tests. To avoid incorrect conclusions Pallant (2010) supported using an equivalent nonparametric procedure when the most common assumption of approximate normality is not satisfied by the data. However, Spiegel and Stephens (2011) appear to suggest that statistical decisions are not affected when parametric assumptions are not satisfied. Polit and Beck (2004) presented a moderate position in this debate. They explained that nonparametric tests are mostly useful when data cannot be understood as interval level or when the distribution is evidently non-normal. The decision on the inferential statistics that were used in this study was informed by the following considerations; number of participants that completed the study (n=26), the nature of the variables (level of measurement) and the type of research questions. This was guided by the recommendations by Pallant (2010). Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) software (version 20; IBM SPSS; Chicago, Illinois). The results of the quantitative data analysis are presented in chapter 6 and discussed in chapter 7.

Section Three

5.10 The Qualitative Approach to the Research

The qualitative phase of this study was conducted immediately after the quantitative data collection in order to address the secondary research questions of this study (see chapter 1, section 1.5.2). The secondary research questions are restated:

(i) What are COPD patients' views of the benefits of the community-based exercise programme to which they were referred after completing pulmonary rehabilitation?

(ii) What helps participants to be able to attend the weekly exercise classes and what makes it more difficult for them to attend?

Qualitative research approaches have holistic focus, use methods such as grounded theory, ethnography, phenomenology, case study, narrative research and ethnomethodology (Creswell, 2013) and shares its philosophical foundation with the interpretivist paradigm (Mackenzie and Knipe, 2006; Blaikie, 2007). According to Creswell (2013), qualitative approaches are employed as means of learning or investigating the empirical world from the views of the participant(s) and not from the perspective of the investigator(s). This aspect of qualitative research was earlier explained by Benoliel (1984, p. 1) when he described qualitative approaches as *"... modes of systematic enquiry concerned with understanding human beings and the nature of their transactions with themselves and with their understandings"*. The main objective of a qualitative research is to provide a description of some, if not all, aspects of a phenomenon study (Cormack, 1991).

Qualitative methods are more flexible and lead to a profound understanding of the phenomenon being investigated (Tashakkori and Teddlie, 2003; Creswell and Clark, 2011). They can also allow research participants to express concerns and issues which researchers did not include in a structured research design, thus enriching the quality of retrieved data as demonstrated by Monninkhof, et al. (2003, 2004). The qualitative phase of this study was conducted to validate and explain and enrich the quantitative findings, thus, providing a robust picture of the benefits of a CEP and the factors influencing the differences and observed relationship of daily PA with clinical outcomes.

It is important to emphasise that the qualitative phase of this study did not lean towards any of the four main qualitative study designs (narrative studies, phenomenology, grounded theory and ethnography) commonly used in the interpretivist philosophical tradition (Creswell and Clark, 2011; Creswell, 2013). The study only used methods of data collection that are common to these designs.

5.11 The qualitative data collection tools

Interviews, focus group discussion, observation and document analysis are some of the methods of data collection used by qualitative researchers (Creswell, 2013). The main method of data collection used in this study was semi-structured in-depth interviews. Relevant data were also extracted from documents relating to the programme and general observation of the programme during recruitment and data collection process. A basic overview of each of these methods is discussed below.

5.11.1 Semi-structured in-depth interviews

Interviewing is a vital method of data collection in most qualitative studies (Creswell, 2013). Typically, it involves asking participants some questions related to a given issue and getting answers from them. There are two forms of interviewing; one-to-one face-to-face interviews and face-to-face group interviewing. Participants can also be interviewed telephonically or through other electronic devices (Creswell, 2013; Desveaux, et al., 2014b, Monninkhof, et al., 2004), for example over the Internet using software applications such as Skype. According to Creswell (2013), interviews can be structured, semi-structure or unstructured and a study can use one or a combination of these. This section focuses on the semi-structured in-depth interviews that were used in this study.

The 12 interviews conducted in this study were guided by issues developed from the quantitative data and related literatures. As suggested by Creswell (2013), issues identified from the quantitative results and a previous study (Desveaux, et al., 2014b) were used to develop an interview guide (see Table 6) which provided the basis for more in-depth exploration. As can be seen in Table 6, the interview guide is a list of questions and topics that needed to be covered during each interview. Because the issues identified were similar to those raised in an earlier study (Desveaux, et al., 2014b), the interview guide used by the authors was used in this study after receiving a written permission from the corresponding

author. The interviews enabled a better understanding of important issues related to the experiences of the benefits of the CEP and to explore issues related to barriers and enablers of their daily PA

Table 6: The Interview Guide

Topic	Questions (For participants)
1. Referral	(a) Who suggested that you might attend this exercise class? (b) Why do you think you were referred to this exercise class?
2. Satisfaction/Benefits	(a) Do you think that this class would have any health benefits for you? (b) Do you think the program is beneficial? Why or why not? (c) What do you like best about the programme? (d) What do you like least about the programme?
3. Barriers and Facilitators	(a) What helped you to be able to attend the weekly community exercise classes? (b) What made it more difficult for you to attend? (Probe: program elements such as time of day, duration, proximity, personal factors such as health, supportive relationships, etc.)
4. Recommendations for improvement	(a) What would you recommend we keep the same? (b) What would you recommend we change? (Probes: frequency, length, time of day of the program?)

Adapted with permission from: Desveaux, et al. (2014b)

Participants who had fully completed the quantitative phase of the study were approached to participate in the qualitative phase to explore the above issues. The semi-structured in-depth interviews were used.

Semi-structure interviews are easy, effective and practical means of collecting qualitative data. They enable researchers obtain relevant data in an open and relaxed manner. According to a number of qualitative writers (Tashakkori and Teddlie, 2003; Fetterman, 2010; Creswell, 2013), semi-structured in-depth interviews focus on the issues under discussion but less structured and not intimidating compared to structured interviews. They also provide

opportunity to probe participants' feelings and emotions that are not easily observed as well as explore sensitive issues in a manner that is considered ethically appropriate.

Sometimes, some authors criticise the reliability and validity of data collected through interviews. However, others support the view that data collected from semi-structured interviews are highly reliable and valid because the participants talk in detail and explain meanings and rationales for their actions with minimal or no input from the person facilitating the interview (Tashakkori and Teddlie, 2003; Fetterman, 2010; Creswell, 2013). Another criticism against the validity of data from interviews is the fact that the research has no way of ascertaining the veracity of participants' narratives. It is possible for them to fabricate responses to questions and/or intentionally or unintentionally say something they feel the researcher expects them to say. Some authors have also argued that 'hindsight' plays important role in semi-structured interviews and this contributes to low validity of data collected through this method (Tashakkori and Teddlie, 2003). Hindsight, in this context, implies that the participants have experienced the phenomenon, reflect on it, rationalise their actions including responses to interviewers' questions. Nevertheless, several criteria, described with different terminologies, are employed to evaluate the quality of the evidence generated from interviews. In general, qualitative researchers are concerned with enhancing the trustworthiness and validity of the findings of their studies (Creswell, 2013). The criteria currently accepted are those advanced by Lincoln and Guba (1985); credibility, dependability, confirmability and transferability. A brief description of these concepts and how they were achieved in this study are discussed in a later (see section 5.13). The explanatory nature of the in-depth interviews in this study added additional depth to the issues addressed and also validated and explained some of the the quantitative findings.

5.11.2 Information extraction from programme related documents

Information gathering from existing documents is one of the qualitative methods listed by authors such as Corbin and Straus (2008), Creswell and Clark (2011) and Creswell (2013). Basically, as its name implies, it involves extracting and making sense of information from existing documents. According to Lincoln and Guba (1985), a document is a written or recorded material that has not been prepared to satisfy the objective(s) of a research or prepared at the request of the researcher(s). Bowen (2009) explained that *"... documents contain text (words) and images that have been recorded without a researcher's intervention"* (p. 27). They may be internal or external to a programme or an organization.

Records of the components of a disease management programme that are implemented in any setting is an example of an internal document, while records of emergency department visits by patients attending the management programme can be considered as an external document (Centre for Disease Control and Prevention, CDC, 2009). *"Documents may be hard copy or electronic and may include reports, programme logs, performance ratings, funding proposals, meeting minutes, newsletters, and marketing materials"* (CDC, 2009, p. 1).

The value of data extraction from existing documents varies and is very much dependent on the accessibility and accuracy of the documents. Guba and Lincoln (1981) and Bowen (2009) argued that data from existing records can help researchers have an insight about their research settings and/or cohort of individuals, especially when there are no alternative ways of achieving this aim. In relation to investigating the impact of a programme, as in this study, existing documents helped the researcher understand the history, philosophy, and operation of the programme as well as the organisations supporting the programme. The CDC (2009) also supported using data from existing documents to determine whether or not there is a difference between formal statements of the purpose of an intervention and its actual implementation. It is also possible for researchers to extract data from exixting documents to formulate questions when developing questionnaires, qualitative interview guides, focus group discussions, observation guide and to identify events to be observed (CDC, 2009). In the views of Creswell (2013), reading existing documents has an important strength over other methods of collecting qualitative data. In practice, it appears to be relatively invisible and requires very minimal cooperation from study participants. Bowen (2009) added that data extraction from existing documents is *"unaffected by the research process"* (p. 31). Despite the usefulness and several advantages of using existing documents in qualitative studies, it has been criticised due to issues relating to irretrievability. Creswell (2013), noted that gatekeepers can sometimes deliberately block access to relevant documents. It has also been criticised for having insufficient details to address research problems because the documents were created independent of a research process and can also be biased, especially in the context of institutional documents which are very much inclined to align with corporate policies and procedures (Bowen, 2009). Nevertheless, these criticisms appear to be inherent limitations and not significant disadvantages and considering the facts that it is efficient and cost-effective, obtaining data from existing documents provides advantages that undoubtedly outweigh its inherent flaws.

When extracting information from existing document, Corbin and Straus (2008) supported thorough reading, examination of document and thoughtful interpretation in order to contribute to empirical knowledge. In this study, releveant data were extracted from four existing programme related documents; Participants' Exercise Recording Sheets, Health Screening Questionnaires, referral forms and programme information leaflets. Data from these documents were used in combination with information from general observation during recruitment and data collection phases of the study. General observations were recorded on Field Notes. Table 7 shows a list of existing programme related documents and the data they contributed to the study. With the exception of Field Notes, the other documents are organised and bound in two separate office folders which are stored in a lockable filing cabinet inside the exercise instructors' office. Hence, the source of the reviewed documents is considered as organisational files (Bowen, 2009). The documents contain participants' personal information (such as full name, date of birth, age, gender, weight, height, and contact details), date of referral to the programme, main diagnoses, comorbidities, names of prescribed medication(s), date of exercise session, responses to health screening questions, as well as and participants' accounts of events and experiences (for example exercise modality, frequency and duration of exercise completed), and important information about the CEP.

Table 7: List of documents and data contributed to the study

S/no	Reviewed documents	Information extracted
1	Exercise Recording Sheets	Participants' personal information (such as full name, date of birth, age, gender, weight, height, and contact details), accounts of events and experiences (for example exercise modality, frequency and duration of exercise completed).
2	Health Screening Questionnaires	Participants' personal information (such as full name, date of birth, age, gender, weight, height, and contact details), main diagnoses, comorbidities, prescribed medications including nebuliser and ambulatory oxygen therapy
3	Referral Forms	Participants' personal information, history of participation in pulmonary rehabilitation, previous, exercise modality (intensity, frequency and duration), sources and dates of referrals.
4	Programme Information Leaflets	Contextual data for this study, the two organisations or agencies supporting the CEP, history and philosophy of the CEP
5	Written Field Notes	General observations relating to participants' physical activity behaviours in the research settings.

Data extraction from these documents provided appropriate description of the CEP and put the quantitative findings of the study into context within which the study participants operated. The appropriateness of this approach was decided because it fulfilled the requirements that necessitated its use as indicated by the CDC (2009).

5.12 The qualitative sampling methods and sample size consideration

Qualitative researches require in-depth data collection and analysis, they engage with small and selective sample that allow findings to be generalised to broader groups (Cormack, 1991). Qualitative researchers therefore, develop a sampling plan that specifies the number as well as how participants will be selected for their studies. More importantly, they are not concerned with issues of generalizability but rather with obtaining a complete understanding of the phenomenon under study, discover meaning or uncover multiple realities (Cresswell, 2013). In most qualitative studies, sampling decisions are made in the course of data

collection based on informational and theoretical needs and typically the inquirers do not develop a formal sampling plan at the start of the study (Polit and Beck 2004; Creswell, 2013).

In this mixed methods sequential explanatory study, Creswell and Clark's (2007) recommendation was adopted with regards to how qualitative samples were recruited. They also supported using the same participants in both phases of the study. He stated clearly that, although it is crucial to use the same participants in both phases, using the same number of participants is not a compulsory requirement. What is considered important is for researchers to purposively select qualitative samples from the cohort of participants in the quantitative part of the study. In addition, Creswell and Clark (2007) recommended the selection of participants who, in the opinion of the researcher, will provide the data required to expand findings from the quantitative phase. As stated earlier, quantitative data were collected at Time Points 1 and 2 (3 month follow-up interval). At the end of the quantitative phase of the study, a combination of snowballing and purposive non-probability sampling methods were used to draw up a sample of participants who were invited to answer some questions in a face-to-face interview.

Snowballing sampling is a method whereby the researcher starts with one member of a group who in turn refers the researcher to other participants whose experiences would be relevant to the study (Creswell, 2013). Although the some participants were referred to the researcher, the researcher also purposively selected some participants who were perceived to be information rich and appropriate for the study. Cohen, Manion and Morrison (2001) explained that purposive sampling is based on the belief that researchers' knowledge about the population can be used to select samples. The researcher believed that the participants attending the exercise classes were in the best position to inform the research regarding the impact of the intervention and issues around it. With the assistance of the exercise instructor, the researcher was able to identify participants who, in turn, further referred other participants to the researcher.

A general assumption in most qualitative studies is that their primary focus is not to generalize the findings but to elucidate the phenomenon under study (Pinnegar and Daynes, 2007). Beyond this assumption all qualitative study designs raise specific sample size considerations. There are no criteria or rules for sample size calculation in qualitative studies.

Sample sizes appear to be determined based on informational needs and the quality of the informants. A guiding principle in sampling is data saturation, that is a sampling to the point at which no new information is obtained and redundancy is achieved (Polit and Beck, 2004; Corbin and Strauss, 2008). Corbin and Strauss (2008) noted that the number of participants needed to reach saturation depends on a number of factors. If participants are good informants who are able to reflect on their experiences and communicate effectively, saturation can be achieved with a relatively small sample. In this study, recruitment and interviews of participants from the same cohort of participants in the quantitative phase continued until data saturation was reached after interviewing 12 participants who consented to be interviewed. Their characteristics are summarised in the results chapter (see section 7.2).

5.13 Qualitative (Interview) data analysis

Qualitative data analysis involves preparing and organising data in order to draw conclusions and present or communicate research findings (Cresswell, 2007). As recommended by authors such as Cresswell (2013) and Fetterman (2010) the general process used during this qualitative analysis included; audio-recording of all interviews, transcribing the soft data into text, and analysis. The qualitative data were thematically analysed and guided by the recommended six phases of thematic analysis approach advanced by Braun and Clark (2006, see Appendix 9).

Thematic analysis is a method of qualitative data analysis in which researchers identify, analyse and report themes or patterns within collected data (Braun and Clark, 2006). Thematic analysis involves a more cautious and intensive reading, re-reading and review of collected data. The researcher examines the selected data more closely, codes and constructs categories based on the features of the data in order to identify themes relevant to the issues being investigated. Critics of thematic analysis have argued that this method lacks rigour. There are several criteria for ensuring rigour in studies using thematic analysis approach. When performing any qualitative analysis, Creswell (2013) notes that researchers need to define what they intend to do and what they are doing and ensure that these are consistent with each other.

The decision to use thematic analysis in this study was informed by some of its advantages which Braun and Clark (2006) considered to include its flexibility, appropriateness to a

pragmatic paradigm, simplicity and academic acceptability. Thematic analysis is also a useful tool for providing rich description of data, identifying similarities and differences within data and allowing social and psychological interpretation of data (Braun and Clark, 2006).

To ensure clarity, rigour and increase the strength of the results, the application of the steps or a stage of thematic analysis in this study were summarised in Appendix 9. The researcher carried out all analytic processes individually with supervision and checking by an experienced academic. During analysis, the researcher first generated an initial coding framework. The supervisor and researcher both looked at the interviews, transcripts and initial coding together to reach consensus regarding the final coding framework. At this point, it was also discussed as to how to group the codes into initial themes and the final themes and subthemes were agreed when the coding was completed.

The researcher applied various techniques to ensure rigour and trustworthiness of the data analysis process. These included the application of the four criteria; dependability, credibility, confirmability and transferability advanced by Lincoln and Guba (1985). Essentially, dependability is concerned with the consistency and repeatability of the results. Findings from similar studies of participants' experiences of the benefits of rehabilitation programmes strongly supported the dependability of this study (Desveaux, et al., 2014b; Lewis and Cramp, 2010; Monninkhof, et al., 2004; Hellem, Bruusgaard and Bergland, 2012). The methods of data collection were previously described (see section 5.11) and the different steps of the thematic analysis process were also provided (see Appendix 9). The final themes that emerged were checked, discussed and rechecked by members of the supervisory team. Quotes were used to support subthemes in order to ensure that the content of all interviews are in agreement with the final themes. As in other studies, quotations were labelled with codes that referred to the participants who made the statement (Desveaux, et al., 2014b; Hellem, Bruusgaard and Bergland, 2012). Although conscious effort was made to bracket presumptions, bracketing, the "identification and setting aside of the researcher's assumptions" (Fischer, 2009; p.584) was not achieved totally because analysis of the data was influenced by some theoretical concepts from previous literature.

Credibility involves ascertaining that results of a study are believable from the views of the participants in the study. Due to the assumption that every researcher brings a unique perspective to his/her study, confirmability ensures that results are corroborated by other

researchers. This determines *"the extent to which the findings of a study are shaped by the respondents and not the researchers' bias, motivation, or interest"* (Hellem, Bruusgaard and Bergland, 2012, p. 217). Although participants in this study were interviewed and analysis performed by one researcher, credibility and confirmability were enhanced by member checking or respondent validation (Lewis and Ritchie, 2003). During interviews, the researcher obtained feedback from participants about the accuracy of the data they have given (responses to questions). The rsearchers' interpretation of collected data was also checked with the participants for accuracy. In addition to these, credibility and confirmability were enhanced by the supervisory roles of an experienced researcher, who provided feedback on data analyses. Discrepancies between researcher and supervisor's ideas regarding coding framework, interpretation or meaning of data, accuracy and relevance of data were resolved by discussion within the team until consensus was reached.

Transferability refers to the degree to which the findings of a study can be extrapolated to other contexts. In terms of this criterion, the sample size in this study was small (n=12) and recruited from a single CEP. Transferability of results was enhanced by detailed description of the characteristics of participants in the study (see Tables 9 and 19) as well as the setting and context of the study (see sections 5.4.1 and 6.2). These reflect some elements of thick description, a qualitative research concept which Ponterotto (2006) defined as a way of not only describing observations (usually of human behaviours) but also the context in which the behaviours occur. According to Lewis and Ritchie (2003) and Creswell (2009), the use of thick description in a study provides the necessary framework that supports inter-contextual comparison and transfer of results. With these, others will be able to assess the findings' transferability.

5.14 Triangulation and how it was used in this study

The idea of triangulation originated from a skill used by land surveyors and navigators, who enhanced the validity of a map by combining measures from different angles (Hesse-Biber, 2010). It was initially used as a technique for locating a previously unknown point by plotting two known points. In the social sciences, triangulation involves using multiple or different methods to measure an aspect of human behaviour (Cohen, Manion and Morrison, 2001) or single phenomenon (Hesse-Biber, 2010). Multiple observation of a phenomenon can provide rich and detailed description of it. For example, an object looks very different when observed from different perspectives. It is possible for an individual reading a report to improve his/her

understanding of the content of the material from various sources. The aim of triangulation is to help researchers improve their understanding of any intricate phenomena and draw conclusions from them. In a quantitative study, Cohen, Manion and Morrison (2001) argues that triangulation might entail using alternative operational definitions of a variable to ascertain whether or not results of prediction (associations between the variables and other outcomes) are consistent across the two definitions. In any qualitative study, different methods of data collection (for example, as in the present research general observation and interviews) might be used to uncover the complete meaning of a phenomenon or participants' behaviour (Creswell, 2013).

The use of triangulation now transcends paradigmatic restrictions as it is increasingly being used across (Creswell, 2013), that is the integration of both qualitative and quantitative data in a single study to compensate for the limitations of each research approach. Morse (1991) claimed that triangulation not only get the most out of the strengths and reduces the weaknesses of each approach, but strengthens the findings of a study and contributes to theory and knowledge development. Denzin (2010) identified and described four types of triangulation in research- data, investigator, theory and methodological triangulations. Data triangulation is the use of different sources of data to validate a conclusion. This can be achieved through time, space and person. In an investigator triangulation, more than one researcher analyse and interpret data before reaching conclusion. Researchers can collaborate and utilise differing theories or hypotheses to analyse and interpret their data. This is referred to as theory triangulation. Typically, methodological triangulation involves using multiple methods to collect data about a phenomenon. The present study used two different types of methodological triangulation:

- **Within-method triangulation:** different methods of data collection within one paradigm (qualitative approach) will be used. For example, semi-structured interviews and general observations.

- **Between-method triangulation:** different methods of data collection in both paradigms (qualitative and quantitative approaches) were also used (Creswell, 2013). For example, participants' level of daily PA using the PAM AM300 accelerometers and interviews; health status using SGRQ and interviews; exercise capacity using

6MWD test and interviews; pulmonary function using a mini-spirometer (COPD-6 device) and interviews.

A fifth type of triangulation, analytical triangulation, was described by Kimchi, Polivka and Stevenson (1991). They described analytical triangulation as the use of more than one statistical or qualitative analytical technique to analyse the same set of data.

Several mixed methods authors, such as Creswell and Clark (2011), Teddlie and Tashakkori (2009) argue that obtaining data from multiple sources enable researchers to fully understand a phenomenon under study and increase the validity of their findings. This function of triangulation is considered valuable for researchers attempting to quantify PA and their relationship with clinical outcomes using both objective and subjective measuring instruments for outcomes (Garcia-Aymerich, et al., 2003; 2006; Monninkhof, et al., 2003; 2004; Cooke, et al., 2009).

It has been argued that paradigm-specific assumptions are neither upheld nor violated when specific methods are used (Creswell and Clark, 2007). The most critical consideration is to use methods that can appropriately address the research problems. This view recognises that quantitative and qualitative research approaches can complement each other for knowledge advancement. Nevertheless, for findings of mixed-methods studies to be valid, Morse (1991) emphasised the need for the methods used to fulfil the methodological standards of the paradigm from which they were drawn.

An important benefit of triangulating data in mixed methods studies is that it helps researchers to examine collected data in the widest possible way, rather than basically accepting results from one method or paradigm (Creswell, 2013). This does not, in any way, undermine contributions from studies that used single method design, but that multi-method designs can have considerable benefits when results are interpreted in addition to providing opportunities to transcend paradigmatic separatism. Methods, data and findings can be combined in a single study. One of the reasons for this is for findings to be confirmed and robust (Creswell, 2013). A finding is confirmed when what is obtained from one method is, to a great extent, consistent with that from another method. Robustness or comprehensiveness of findings is attained when there is a more accurate and complete picture of the phenomenon

under study or when the reasons for the findings are fully explained (Creswell and Clark, 2007; Teddlie and Tashakkori, 2009; Feilzer, 2010).

Creswell and Clark (2007) used the term mixed methods to refer to a study design in which a variety of research methods are combined within one study. They argued that findings from mixed-methods studies are more valid and reliable because they allow researchers to triangulate and double-check their findings in the light of the multiple methods employed. Many researchers have directly and indirectly advocated using multiple methods of data collection in health and nursing research (Monninkhof, et al., 2003; 2004; Cooke, et al., 2009). The inherent strengths and weaknesses of a triangulation approach were exposed by the studies by Monninkhof et al. (2003; 2004). The studies revealed a robust and in-depth understanding of the effectiveness of the self-management programme than would otherwise be impossible. The quantitative (Monninkhof, et al., 2003) and qualitative (Monninkhof, et al., 2004) approaches complemented each other while the weaknesses of each approach were actually counterbalanced. As noted previously, the present study integrates quantitative and qualitative methods of data collection. The ways in which the study was triangulated are summarised in Table 8.

Table 8: Summary of triangulation used in the study

Method of data collection	Type of triangulation	Method of analysis	Purpose/goal
Quantitative + Qualitative	**Between-method**		
PAM AM300 device and semi-structured interviews	Data	SPSS: Descriptive and inferential statistical procedures (see Tables 11-17) Audio-taping, transcription, thematic analysis	Overall picture of PA behaviour and benefits of the CEP (understand differences in levels of PA at Time Points 1 and 2 and correlation with other outcomes) To achieve confirmability and robustness Understanding the barriers and facilitators of programme adherence from the participants' point of view
SGRQ and semi-structured interviews	Data	SPSS: Descriptive and inferential statistical procedures (see Tables 11-17) Validity: participants' views, thematic analysis	Overall picture of the benefits of CEP (understand differences in SGRQ total scores at Time Points 1 and 2 and correlation with other outcomes) To achieve confirmability and robustness
6MWD test and semi-structured interviews	Data	SPSS: Descriptive and inferential statistical procedures (see Tables 11-17) Validity: participants' views, thematic analysis	Overall picture of the benefits of CEP (understand differences in 6MWD test scores at at Time Points 1 and 2 and correlation with other outcomes) To achieve confirmability and robustness
COPD-6 device and semi-structured interviews	Data	SPSS: Descriptive and inferential statistical procedures (see Tables 11-17) Validity: participants' views, thematic analysis	Overall picture of the benefits of CEP (understand differences in FEV_1 at at Time Points 1 and 2 and correlation with other outcomes) To achieve confirmability and robustness

Quantitative only	**Analytical**		
PAM AM300 device COPD-6 device SGRQ 6MWD test SHAQ Socio-demographic questionnaire	**Data**	SPSS: Pearson's correlation coefficient Simple and multiple logistic regression	To achieve confirmability of the relationship of level of daily PA with clinical variables
Qualitative only	**Within-method**		**General observation throughout data collection**
General observations conducted during different time of data collection	Time triangulation	Field notes	Description of participants' PA behaviours within the programme Description of the unique characteristics of the programme Increased dependability
Review of programme related documents	Data	Narrative description	Summarise information about context of the study Description of the unique characteristics of the programme
Participant/respondent validation Inquiry and confirmability audit	Data, investigator Data, investigator	Sessions with participants Sessions with supervisors	Enhanced trustworthiness of study data. Enhanced trustworthiness of study data.

5.15 Ethical considerations

This study was approved by Anglia Ruskin University's Health and Social Care Faculty Ethics Sub-Committee (reference number NS/JC/FMSFREP/15-006, see Appendix 10) and the National Social Care Research Ethics Committee, SCREC (reference number 15/IEC08/0034, see Appendix 11). The SCREC protect the dignity, rights, safety and well-being of all actual or potential research participants in accordance with the Research Governance Framework for Health and Social Care (DoH, 2005) and the Governance Arrangements for NHS Research Ethics Committees (DoH, 2011). This study also abided by the institutional guidelines for applying for ethical approval at Anglia Ruskin University (Scott, 2012). Research consultation and collaboration application with Uttleford District Council, provider of the post-PR CEP, was undertaken (see Appendix 12) and access to the research sites was granted (see Appendix 13).

The aforementioned guidelines listed several ethical principles which were adhered to throughout both phases of this study. These included respect for participants, beneficence, non-maleficence, integrity, veracity, justice and autonomy. Obtaining informed consent from participants is a cardinal requirement for every research (DoH, 2005; 2011). This study adhered to the Research Governance Framework for Health and Social Care (DoH, 2005; 2011) for gaining consent from prospective participants in a study. Particular attention was given to sub-section 2.2.3 of the framework (DoH, 2005) and section 3.2 of Anglia Ruskin University's institutional guidelines for applying for ethical approval (Scott, 2012), which require researchers to consider people's capacity to process information and make decisions for themselves. Gaining consent also requires that prospective participants are given adequate information regarding every stage of the research, what they will be expected to do, as well as the benefits and implications of taking part in the research. The ethical issues, potential risks associated with the study and how they were managed are explored in detail in Appendix 14. A summary is provided in the following section.

5.15.1 Specific ethical issues associated with this study

The conduct of this study was associated with five risks to participants: (a) the use of spirometer raises health and safety issues, poor reading and interpretation of results (b) the time to complete four questionnaires may be a burden to some participants (c) PAM300 presented a risk of intruding privacy when researcher assisted participants in wearing the device (d) risk of falls, breathlessness, physical harm, discomfort and fatigue associated with

the 6MWD tests and (e) the potential for psychological harm or distress during the face-to-face interviews. Potential risks for the researcher were also considered and regarded as minimal, especially during the qualitative interviews. The risk of accidents in travelling to and from the research sites, using public transport (train/bus) or by private car was also considered.

These aforementioned risks were managed in a number of ways. First, the researcher completed the British Lung Foundation's Spirometer in Practice training course. This enabled competent performance of spirometry test according to international guidelines and ensured participants' safety, prevented cross infection, poor reading and interpretation of test results. Second, the interview questions were clearly worded and understandable and did not relate to any sensitive personal issues. Hence, the risk of psychological distress was very low. The topics and questions discussed (see the interview guide, Table 6) related to participants' experiences of the benefits of the CEP and enablers and barriers to attendance. Third, the questionnaires used were simple, clearly worded and did not contain sensitive personal issues. The initial number of questionnaires (n=5) was presented a burden to some participants. Following recruitment and first data collection (Time Point 1) 13 participants decided to withdraw from the study because it was burdensome for them to complete 5 questionnaires. However, they expressed willingness to continue if the number of questionnaires is reduced. To minimise the risk of attrition, it was decided that every outcome of interest should be measured using one method (instrument) instead of the previously planned double method of assessing some outcomes. Participants' daily PA was only measured objectively with the PAM AM300 accelerometers. Subjective measurement of PA using the Physical Activity Scale for the Elderly (PASE) questionnaire was discontinued. Similarly, health status was only measured by the disease specific SGRQ, leaving out the generic health status questionnaire (the 36-item medical outcomes short form, SF-36). This limited the number of questionnaires to 3 and the 13 participants were happy with this and decided to continue with the study.

Fourth, direct contact with participant was avoided to eliminate the risk of intruding their privacy that is associated with assisting with wearing the PA monitors. The researcher did not assist participants with wearing the devices. Instead, he taught participants how to wear and use the monitors through instruction and demonstration. Visual aids with descriptive diagrams of the device were also used to maximize learning and memory of how to attach

and use the device. The risk of falls, physical harm, discomfort and fatigue associated with completing the 6MWD tests was minimise by supervision by the researcher and participants' usual exercise instructor, ensuring that they wore appropriate dresses and footwears, and given the right to opt out of completing the walking tests. Fifth, consent was obtained from participants for audio-recording of each interview. Sixth, participants' safety and privacy were ensured by performing all outcome measurements and interviews in a safe, conducive and private room at the community centre where participants attended their weekly exercise classes. The public settings of the two leisure centres ensured privacy and safety, because other members of the public who were not involved in the data collection, were also on site. The research settings were also accessed, controlled and staffed by a security team, this ensured additional security of persons, facilities and personal belongings.

Seventh, the researcher had a clean UK driving licence and owned a car, with which he commuted to and from the research sites in accordance with road traffic laws/Highway Code, thus, minimising travel-related risks, particularly road traffic accidents. The risk of accidents in travelling to and from the research sites was considered as not different from what people experience in daily life. Eight, data collected from participants were stored in accordance with section 6.1 of Anglia Ruskin University's requirements for storing data (Scott, 2012). As the qualitative phase of the study explored participants' views, ethical principles such as veracity, beneficence, respect for participants, justice, and integrity (DoH, 2005; 2011) were maintained. Collected data were stored and analysed in pseudo-encoded form to maintain confidentiality and linked to each participant due to the longitudinal nature of the study. All quantitative data, audio files, and transcripts of interviews were anonymised. Documents containing participants' personal identification were stored within a passworded laptop. Only members of the research team had access to the locked documents. Confidentiality of participants' data was ensured. Private data including names were not reported.

Finally, to ensure high level of data protection, physical movement of paper-based questionnaires was unidirectional, from data collection sites to the researcher's office. The questionnaires were stored securely in a lockable filing cabinet inside the researcher's office. Physical movement of sounds files were equally restricted to transport from data collection sites to the researcher's office. Electronic sound files and audio-recorders were also stored in the filing cabinet. As the study has been concluded, the electronic and paper documents containing study data have been stored securely and will be destroyed after 3 years as stipulated by Anglia Ruskin University's guidelines (Scott, 2012).

The general principles of good research practice outlined in section 2 of the Research Governance Framework for Health and Social Care (DoH, 2005) were maintained throughout this study. And most importantly, the dignity, rights, decisions, safety and well-being of participants were the principal consideration at every stage of this study.

The researcher upheld the principle of beneficence in several ways. First, the researcher assessed and considered the risks of physical harm and psychological distress and identified how they will be minimised or prevented. Second, the potential benefits of the study to participants were given due consideration. Third, the researcher was sensitive to the welfare and interests of participants by giving them the option to opt out of the study if they are not well enough to continue. Two participants dropped out of the study due to physical health concerns. Finally, the potential benefits of the study to the wider community were reflected in the implications of findings for practice (section 9.2, pp. 253-255)

5.17 Summary

The philosophical paradigm (pragmatism) that underpinned the conduct of this research was outlined in this chapter. The chapter also describe the research process, settings, recruitment process and justified how a mixed methods sequential study design was utilised to address the research questions. The quantitative and qualitative approaches and methods used in the study have been discussed. The validity and rationale for choice of methods were highlighted.

Participants' eligibility (inclusion and exclusion) criteria were also outlined along with the recruitment process for the study. Sample size consideration in relation to this study was addressed. The methods used to collect quantitative and qualitative data have been described and their theoretical and practical uses were supported. The quantitative and qualitative methods of data analysis were discussed separately and how data were triangulated was addressed with reference to its significance in a mixed methods study design. The chapter concludes with a brief discussion on the levels of ethical approval for the study, specific ethical issues associated with the study and how they were managed.

The next chapter present findings of the quantitative and qualitative phases of this study.

CHAPTER SIX

FINDINGS: QUANTITATIVE PHASE

6.1 Introduction

The findings from the quantitative phase of this study are presented in this chapter. The chapter is structured as follows. Section 1 describes the context in which findings of this study were obtained and to which they can be generalized. Section 2 presents findings from the analyses of data obtained from the quantitative phase- a 3-month prospective cohort study in which participants levels of daily physical activity were objectively measured along with clinical outcomes such as health status, pulmonary function (FEV_1), exercise capacity and number of hospital admission. The chapter reports on the number of referrals and dropouts from programme, study recruitment and description of participants' demographics and other characteristics. It also reports on results of the statistical analyses of the impact of the CEP and the relationships between participants' levels of daily physical activity and other variables.

Section One

6.2 Context of the quantitative findings

This section aims to describe the CEP and put the quantitative findings of the study into context. The information presented in this section has come from documents relating to the programme (e.g. exercise recording Sheets, health screening questionnaires, referral forms and programme information leaflets**)** and general observation of the programme during recruitment and data collection process. An observation schedule was not followed as this is not considered a participant observation.

6.2.1 Programme components

Supervised exercise training was the main component of this programme. This included seated warm-up and cool-down exercises, gym-based cardiovascular and resistance exercise training and seated breathing exercises. Exercise training sessions took place in a community-based recreation centres (typical fitness commercial gym). Participants attended training sessions two times per week (Wednesdays and Fridays). Each training session lasted approximately 90 minutes. The specific exercise modalities, intensity, frequency and duration varied according to the individual's capacity and specific needs. Unlike in all PRPs

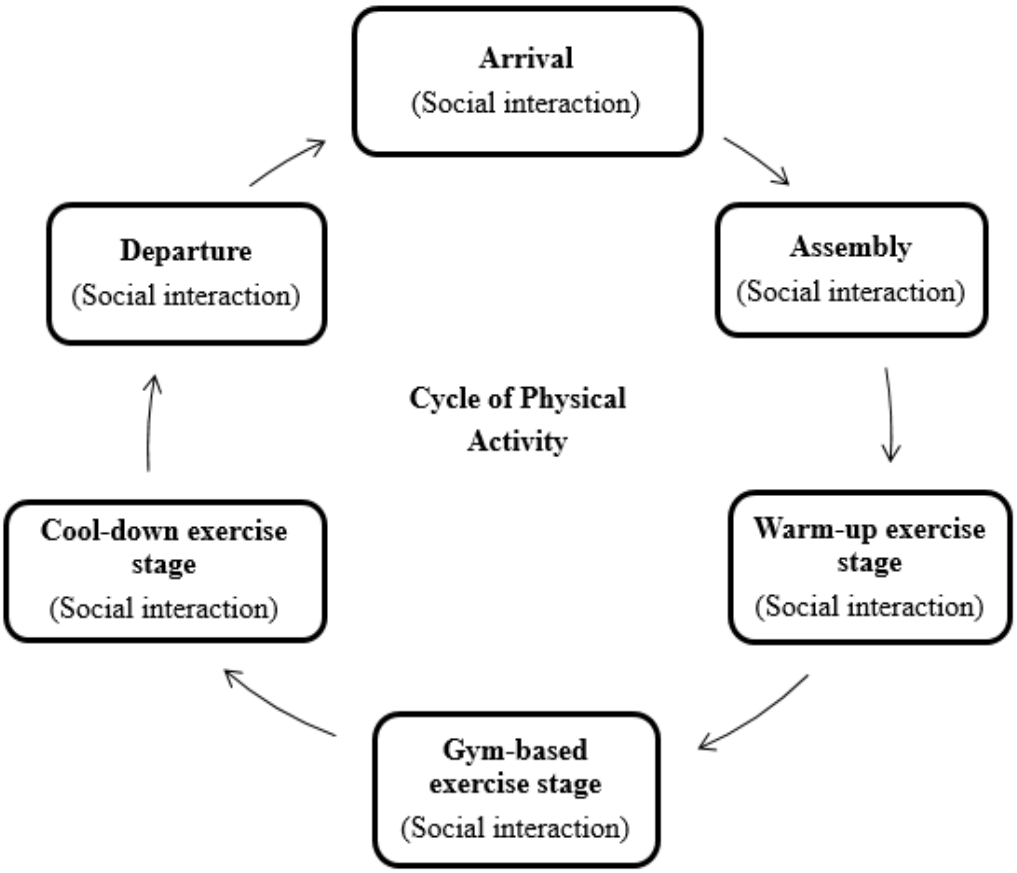
(Desveaux, et al., 2014a, Yohannes and Connolly, 2004), specific patient education and psychological counselling sessions were not included in the design of the CEP. However, data from the qualitative interviews indicate that the group support/social nature of the programme offered patients the opportunity to derive motivation, emotional comfort, moral support, motivation, encouragement and valuable information from one another. During and after exercise sessions participants talked about several issues such as breathing techniques, medications, nutrition, relaxation, holidays, how to stay healthy, complete daily activities with less breathlessness, how to avoid experiencing COPD exacerbations, etc.

The programme was not coordinated and supervised by a health care professional but by a trained exercise instructor who is a member of the Register of Exercise Professionals (REPs), an independent, public register which recognises the qualifications and expertise of health-enhancing exercise professionals in the UK. The instructors also supervised exercise training sessions and assisted patients with using exercise equipment, setting goals and monitoring exercise progression.

6.2.2 The cycle of participants' physical activities

Participants followed a distinct cycle of activity which comprised of six parts that formed a continuum of their physical movement from arrival to departure from the leisure centres. Figure 19 summarises the different parts or stages of the cycle of activity. The six-part cycle is a continuous one where participants arrived, assembled in the cafe area, moved to a multiple-purpose activity room, fitness gym and then returned to the activity room before leaving the recreation centres. This is repeated again on every training session. Every part of the cycle was characterised by different activities. The significance of this cycle of activity is considered in the discussion chapter.

Figure 19: Participants' cycle of physical activity within the CEP



(i) Arrivals and assembly

The exercise instructor and participants come to the exercise classes wearing appropriate footwear and clothing. Upon arriving at about 13:00, participants paid £3.50 each at the reception desk and were let in through electrically controlled barriers. Then they gathered in the café area in front of the reception desk, sat and talked to one another over cups of tea/coffee. They discussed their daily lives but also shared practical information such as what to expect during treatment, how to manage breathlessness, pain, use gym equipment and prescribed medications and/or inhalers. At 13:15, everyone moved to a multipurpose activity room on the first floor via lifts or staircases to complete a set of warm-up exercise modalities described in Appendix 15. It is important to note that not all of these exercises are done in every training session.

(ii) The warm-up chair-based exercise sessions

The chair-based exercises were performed in an activity room with wood flooring and mirrored walls that serves as a site for numerous instructional activities. Participants sat on straight-backed, armless chairs with hard seats. The instructor sat in front of the participants and demonstrated how exercises were to be performed. Instructor asked patients to sit and shuffle forward on the chair with the knees bent, feet flat on the floor and directly under the knees, hands on their knees, shoulders over hips, tummy tucked in and and chin aligned over the chest. This served as the default and stable position from which they were instructed to perform various stretches and exercises. Maintaining this posture during seated exercise is important to help participants maintain a position where the least strain is placed on supporting muscles and ligaments during movement. It also facilitates the full range of motion throughout the naturally S-shaped spinal column. Maintaining such posture during a 12-week exercise programme for adults prone to flexed posture and impaired physical function was associated with improvements in kyphosis (curvature of the spine), muscle strength, range of motion (ROM), and physical performance (Katzman, et al., 2007). A total of 24 seated warm-up stretches and exercise modalities were performed. See Appendix 15 for a summary of some of the different exercises. Every warm-up exercise session lasted 8-10 minutes.

(iii) The gym-based exercise sessions

After completing the seated warm-up exercises, participants headed to the fitness gym for cardiovascular and resistance training exercises (see Appendix 16). These exercises were carried out with minimal supervision and support with exercise equipment by the instructor. A key feature of this part of the cycle was data entry into exercise recording sheets. Participants rested between sets of different exercises and used the opportunity to record details of completed exercises on their recording sheets as well as chat about their experiences of the exercise equipment, ease of use, exhaustion and breathlessness whilst exercising. Each recording sheet contained the following information: full name, date of birth, gender, weight, height, contact details (address and phone numbers), date of referral, main diagnoses, comorbidities, names of prescribed medication(s), date of exercise session, as well as the exercise modality (type), frequency and duration of exercise completed by participants. All exercise recording sheets were stored in a lockable filing cabinet inside the instructors' office. Every gym-based exercise session lasted for 70 minutes.

In total, there were 5 cardiovascular and 12 resistance training exercises. There was considerable variability with respect to the number of patients using each piece of cardiovascular exercise equipment. The intensity and duration of exercise were also relative to each participant and his/her current fitness level. The variability in the use of exercise equipment is dependent on individual fitness and personal preference and the qualitative data indicated the significance of this. Participants reported that the exercise instructor understood their conditions and personal capacities and limitations. He therefore adapted the exercises to each individual, was very flexible, promoted choice of exercise option and did not force them to go on all equipment. This facilitated regular attendance and contributed to participants' feeling safe within the programme.

(iv) Cool-down exercises and departure

Following the gym-based exercises participants returned to the multipurpose activity room for cool-down stretches and exercises which were mostly the same as the warm-up exercises described in Appendix 15 and lasted for nearly 10 minutes. The instructor thanked participants for coming, reminded them about the next training session and encouraged them to come again. As participants left and headed towards the car parking area, they talked and said goodbye to one another. On the day of the next training session, patients arrived at 13:00, at the same venue, where the cycle of activities begins again. Of note, social interaction was observed to be common at every stage of the cycle. These included participants' interaction with themselves, family members, exercise instructor, people who managed the facilities and other gym users.

6.2.3 Participants' safety

The exercise instructor's role included ensuring participants' safety during exercise training. He achieved this by performing two assessments. First, participants' heart rate (HR) and oxygen saturation (SpO_2) were measured by non-invasive pulse oximetry before and after each training session. The HR and SpO_2 were performed to monitor for hypoxemia (Rous (2008), an abnormally low concentration of oxygen in the blood. The risk of death posed by oxygen desaturation with exercise in patients with COPD (Casanova, et al., 2008) makes it important for its levels to be monitored before exercise training. Although there are no specific guidelines about SpO_2 during exercise, Rous (2008) suggested that a SpO_2 of >90% should be maintained to avoid oxygen desaturation. Second, the instructor performs a fit-to-exercise checks in which he asked the following questions: *"Have you had something to eat*

and drink before coming to the class? Have you taken your prescriptive medications as directed by your doctor or physician? If you have been prescribed inhalers or asthma puffs do you have them with you today? Do you have any chest infection or anything that might be contagious to others? Are you awaiting further hospital investigation that may be contraindicated for exercise?". These questions were asked to ensure that participants' medical conditions were stable. Participants who have abnormal values of HR and SpO_2 and those who do not provide satisfactory answers to the safety questions were considered unstable and prevented from exercising. In addition, participants who were stable at the start of exercise training session but deteriorated during any of the activity were also stopped and referred back to their surgeries and were not allowed to resume exercise classes without written medical clearance. During cardiovascular and resistance trainings, the participants exercised in their own pace, taking as long recovery breaks as they needed.

6.2.4 Adverse events

Adverse events were not systematically recorded during the 3 month period of this study. This indicates that, overall, the exercise modalities were safe and well tolerated by participants. However, two incidents occurred during data collection, but these were not related to any of the study procedures. The first incident occurred in the fitness gym. A participant had a fall whilst trying to get on a treadmill. She fell because another gym user (who was not part of the study) bumped into her. She had a few cuts and bruises on her right leg but nothing serious. Two personal trainers in the gym responded and provided first aid treatment before the participant was taken to her GP by her son. No accident reporting form was filled. The second incident occurred in another participant's home. About 3 weeks after the first data collection, a participant stopped attending the CEP. When she was followed up telephonically, she self-reported that she had a heart attack at home which prevented her from attending. The first incident did not affect data collection. Although the participant did not attend exercise classes for about 4 weeks, she presented for follow up outcome measurements (at Time Point 2). The second incident affected data collection. The participant opted out of the study because she needed time to relax and convalesce.

6.2.5 Cost to patients

Following referral participants received a one-to-one assessment, screening, goal setting and advice on appropriate exercise options and activities at no cost. Fees for 1Life membership card and Pay As You Go (PAYG) or longer-term membership are also discussed with

participants at their initial assessment. Those who are considered not suitable for leisure centre activities were signposted to free healthy walks or other community programmes available in the local district area. Some were on the £70 per 3 months GP referral gym membership category while others opted for the £3.50 per training session PAYG category. These were already subsidized fixed membership categories and had no further concessions available. It is believed that the total cost to participants included cost of gym membership, travel and money spent on specialised shoes and clothing for exercise, snacks and beverages. The recreation centres appeared to be within close proximity to patients' homes. The average distance from patients' homes was 6.2 miles. Patients did not pay for parking as this was offered free of charge to all service users. These are important factors because cost and access to transportation were identified as barriers to attending a psot-PR exercise programme in a previous study (Desveaux, et al., 2014b). These prompted the participants to recommend subsidising the cost and expanding the number of programme locations. Participants believe that this will make the programmes easily accessible and reduce the burden related to transportation (both time and money)

Section Two

6.3 Quantitative findings

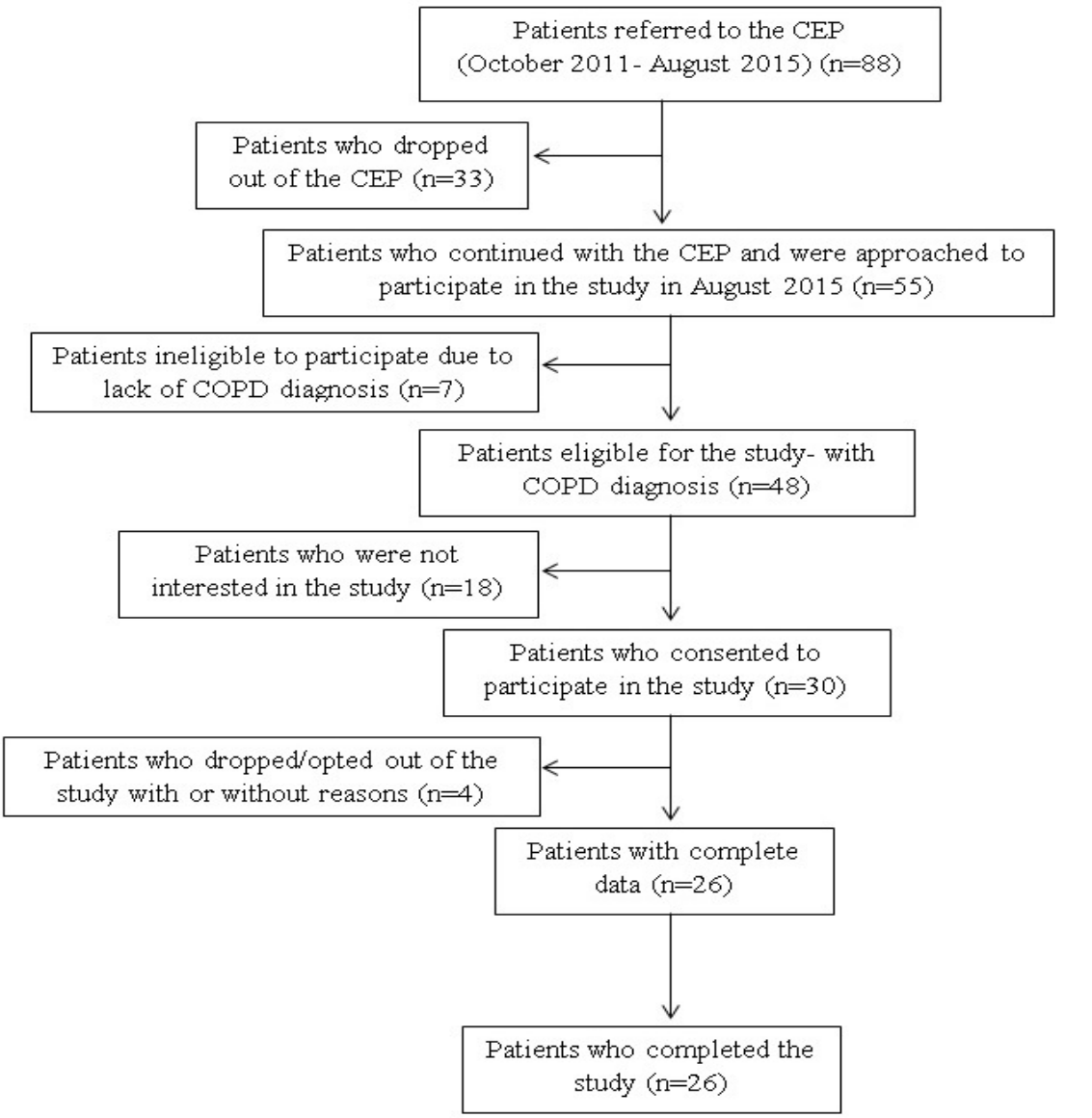
6.3.1 Introduction

This section provides the analyses of the data obtained from the quantitative phase of the study- a 3-month follow-up prospective observational cohort study in which participants levels of daily physical activity were objectively measured (by the PAM AM300 device) along with clinical outcomes such as health status, pulmonary function (FEV_1), exercise capacity and number of hospital admission. Specifically, the section presents a summary of participants' referral to the CEP, recruitment to the study and an overview of participants' characteristics. It also reports on participants' physical activity data and other outcomes at at Time Points 1 and 2. In addition, the section presents results of the statistical analyses of the impact of the CEP and the relationships between participants' levels of daily physical activity and other variables.

6.3.2 Participants' referral and recruitment

A flow chart of patients' referral to the programme and recruitment to this study is shown in Figure 20. In a 4-year period (October 2011–August 2015), 88 patients enrolled in the CEP out of which 33 (38%) dropped out for several reasons- lack of motivation (n=7), death (n=14), COPD and other health related problems (n=6), moved to a different location (n=2), unable to afford (n=2), car accident (n=1) and unknown reasons (1). The remaining 55 patients (62%) continued attending exercise classes out of which 7 did not meet inclusion criteria due to lack of clinical COPD diagnosis. Hence, 48 patients were approached for inclusion. 30 (63%) of these agreed to take part in the study. Of the 30 participants in this study, 4 (13%) dropped out while 26 (87%) participants completed the study. The reasons for drop out included experience of a heart attack and recovering at home (n=1) and relocation (n=3).

Figure 20: Flow chart of patients' referrals to CEP and study recruitment



Abbreviations: CEP= Community-based Exercise Programme; COPD= Chronic Obstructive Pulmonary Disease

6.3.3 Description of participants' characteristics

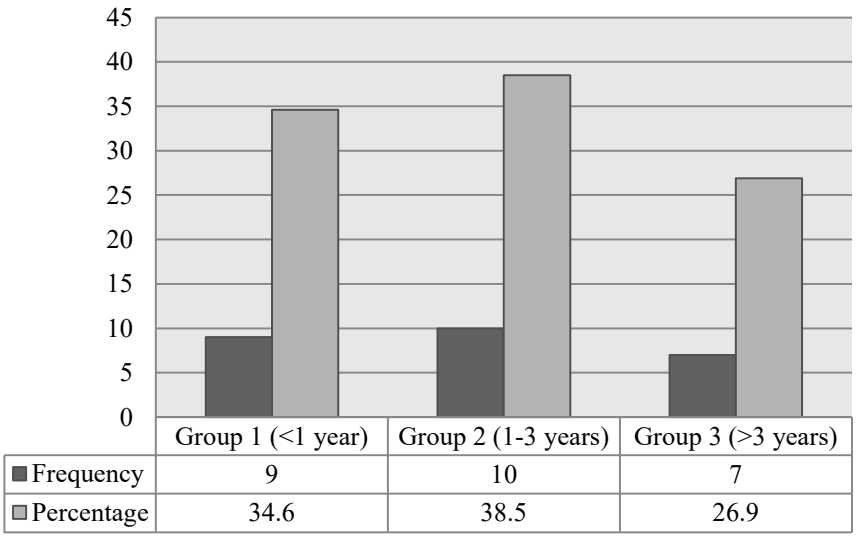
The general characteristics of the twenty six participants are summarised in Table 9. A total of 26 patients with COPD participated in this study. They consisted of 15 females and 11 males, age range from 55 to 89 years (mean 73±7 years). COPD severity, as classified by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guideline using spirometry, was mild (n=6), moderate (n=14) and severe (n=6). More men had severe COPD than women of similar age, but COPD severity appears to progress with increasing age in women than in

men. Participants' Body mass Index (BMI) ranged from 18.20 to 46.41 Kg/m^2 (mean 30±6 Kg/m^2). All 26 participants were Caucasians; majority were married and living with their spouse (n=20); 3 were widowed; 2 were never married and lived alone and 1 was divorced. Majority (n=18) had a history of smoking but have quit; 2 were occasional smokers and 6 had no history of tobacco use. Proximity of the CEP (distance to participants' home) ranged from approximately 1 to 34 miles (mean 6.2 miles). The sample showed variation in level of education, ranging from having no qualification (n=6) to having professional qualification (n=6), GCSE/O'level qualification (n=3) other qualification (n=8) and degree level qualification (n=3). They also varied in the number of years enrolled in the CEP, ranging from <1 year to >3 years. Treatment ranged from use of medications, inhalers and nebulizers to dependence on oxygen therapy.

6.3.4 Participants' duration in CEP

Participants' duration (years) in the CEP was categorised into three groups; Group 1 (<1 year), Group 2 (1-2 years) and Group 3 (>3 years). Figure 21 presents the distribution of the three groups. Participants who have been enrolled in the CEP for 1-3 years comprise the largest group within the population (n=10, 38.5%), followed by those who have enrolled for <1 year (n=9, 34.6%). The proportion of participants who have attended the programme for >3 years comprise the smallest group (n=7, 26.9%).

Figure 21: Distribution of participants by duration in CEP



	Group 1 (<1 year)	Group 2 (1-3 years)	Group 3 (>3 years)
Frequency	9	10	7
Percentage	34.6	38.5	26.9

Table 9: Participants' characteristics

ID	Sex	Age	Marital status	BMI	Ethnic group	Education status	Employment status	Smoking status	FEV1, L (% predicted)	COPD Severity (GOLD Stage)	O_2T	NI use	Years in CEP	Proximity to CEP (miles)
P1	F	89	Single	18.2	White	Prof qual.	Retired	FS	1.13 (75%)	II (Moderate)	No	No	<1	7
P2	F	87	Widowed	33.46	White	Other qual.	Retired	Never	1.03 (43%)	III (Severe)	No	Yes	<1	1
P4	F	80	Married	28.85	White	No qual.	Retired	Never	1.30 (71%)	II (Moderate)	No	No	1-3	6
P5	F	78	Married	28.44	White	Prof qual.	Retired	OS	1.10 (78%)	II (Moderate)	No	Yes	1-3	10
P6	F	77	Married	33.5	White	Degree	Retired	FS	2.07 (80%)	I (Mild)	No	No	<1	1
P7	F	77	Married	34.24	White	GCSE/O'Level	Retired	FS	1.21 (57%)	II (Moderate)	No	No	<1	1
P8	F	74	Married	25.1	White	No qual.	Retired	FS	2.06 (81%)	I (Mild)	No	No	<1	1
P9	F	73	Married	26.67	White	Other qual.	Retired	FS	2.09 (77%)	II (Moderate)	No	Yes	>3	6
P10	F	73	Widowed	27.74	White	No qual.	Retired	OS	1.09 (54%)	II (Moderate)	No	No	<1	4
P11	F	72	Widowed	30.74	White	Other qual.	Retired	FS	1.26 (83%)	I (Mild)	No	No	1-3	1
P12	F	72	Married	38.82	White	Other qual.	Retired	FS	1.42 (78%)	II (Moderate)	No	No	1-3	5
P13	F	63	Married	26.5	White	No qual.	Retired	FS	1.84 (76%)	II (Moderate)	No	Yes	<1	4
P15	F	69	Married	28.25	White	Other qual.	Retired	FS	1.31 (51%)	II (Moderate)	No	No	1-3	1
P16	F	66	Married	27.8	White	GCSE/O'Level	Retired	Never	1.03 (43%)	III (Severe)	No	No	1-3	7
P17	M	79	Married	34.8	White	Prof qual.	Retired	FS	2.33 (78%)	II (Moderate)	Yes	No	1-3	8
P18	M	78	Married	36.6	White	Degree+	Retired	FS	1.52 (55%)	II (Moderate)	Yes	Yes	>3	6
P19	M	73	Single	39.52	White	Other qual.	Retired	FS	1.79 (66%)	II (Moderate)	No	No	>3	12
P20	M	72	Married	23.25	White	Degree+	Part-time	Never	1.11 (34%)	III (Severe)	No	No	1-3	11
P21	M	72	Married	46.41	White	Other qual.	Retired	FS	1.03 (39%)	III (Severe)	Yes	No	>3	4
P22	M	70	Married	32.32	White	O & A Levels	Retired	FS	1.53 (55%)	II (Moderate)	No	Yes	1-3	34
P23	M	68	Married	26.94	White	GCSE/O'Level	Retired	FS	2.53 (80%)	I (Mild)	No	Yes	<1	9
P24	M	66	Divorced	29.1	White	No qual.	Retired	FS	0.98 (33%)	III (Severe)	No	No	>3	1
P25	M	55	Married	28.73	White	Other qual.	Retired	Never	0.98 (33%)	III (Severe)	Yes	No	<1	4
P26	M	67	Married	29.35	White	Prof qual.	Retired	FS	2.09 (77%)	II (Moderate)	No	Yes	1-3	5
P28	F	71	Married	24.86	White	Prof qual.	Retired	Never	1.10 (81%)	I (Mild)	No	No	>3	7
P29	M	73	Married	27.13	White	Prof qual.	Retired	FS	2.23 (81%)	I (Mild)	No	No	1-3	4

Abbreviations: F= female, M= male, FS= Former smoker, OS= Occasional smoker, COPD= Chronic Obstructive Pulmonary Disease, GOLD= the severity of COPD (classified by spirometry) according to the standard of the Global Initiative for Obstructive Lung Disease (GOLD), BMI= body mass index, CEP= community-based exercise programme, O_2T= supplemental oxygen therapy, qual. = qualification, yrs= years, NI= Nebuliser/Inhaler

6.3.5 The impact of the CEP on study variables

The impact of the CEP was examined by identifying the differences in measured variables at time point 1 (T1) and time point 2 (T2).

6.3.5.1 Primary outcome: Participants' levels of daily PA (Average daily PAM score)

A summary of participants' levels of daily PA data (measured by PAM scores) is presented in Table 10. As noted previously (section 5.6.7), a PAM score is a measure of participant's expended energy. It is the ratio between the amount of energy the participant expended while performing PA and the amount of energy expended while at rest, multiplied by 100%. The exact number of scores achieved depended on the intensity of the activity.

Average daily PAM scores increase modestly from 15.1 units at T1 to 16.2 at T2. The median daily PAM score increased slightly but not significantly (1.00) between 14.40 at T1 and 15.40 at T2 (Z= -1.33, p= 0.18) (see Table 11) with a small effect size (r=0.26). Overall, participants' average daily activity did not change over the 3 months.

Table 10: Participants' Physical Activity Characteristics at Time Points 1 and 2

PA Characteristics	T1 M±SD (Range)	T2 M±SD (Range)
Average daily PAM Score	15.1±6 (7.5-36)	16.2±7 (6-36)
Total time spent on PA in the Living Zone (min/day)	470±173 (214-986)	497±199 (165-904)
Total time spent on PA in the Health Zone (min/day)	96±64 (30-332)	107±77 (29-384)
Total time spent on PA in the Sport Zone (min/day)	1.1±2 (0-12)	1.3±2 (0-7)
Total time spent on PA in the Health and Sport Zones (min/day)	96±66	108.6±78
Total time spent on PA in the Living, Health & Sport Zones (min/day)	564±228	606±264
Total energy expenditure (Kcal/day)	1235±484 (620-2801)	1297±509 (471-2776)

Abbreviations: PA= Physical Activity, min= minutes, T1= time point 1, T2= time point 2, M= Mean, SD= Standard Deviation, PAM= Physical Activity Monitor

Table 11: Difference in measured variables at Time Points 1 and 2

Variable	T1 (Median)	T2 (Median)	Statistical test	Result	P-value (2-tailed)	Effect size, r
Primary outcome						
Average daily PAM Score	14.40	15.40	Wilcoxon Signed Rank	Diff= -1, Z= -1.33	0.18	0.26 (small)
	M=15.1	M=16.2				
	R=7.5-36	R=6.0-36				
Secondary outcomes						
Total Energy Expended (Kcal)	M=1235±484	M=1297±509	Paired-samples t-test	t(25)=-0.95, 62Kcal, 95%CI:-196-72	0.35	Eta^2 0.03 (small)
Total time spent on PA (mins)	576	552	Wilcoxon Signed Rank	Diff= -24 min, Z= -1.26	0.209	0.25 (small)
	M=564	M=606				
Health status (SGRQ scores)						
Symptoms	53±19	49±21	Paired-samples t-test	t(25)=1.16, 3.83units (95%CI:-3.00 to 10.70)	0.26	Eta^2 0.05 (moderate)
Activity	67±19	64±22	Paired-samples t-test	t(25)=1.17, 3.36units, 95%CI:-2.70 to 9.81	0.25	Eta^2 0.05 (moderate)
Impact	33±18	29±19	Paired-samples t-test	t(25)=2.25, 4.80units, 95%CI: 0.40 to 9.20	0.03**	Eta^2 0.17 (large)
Total	M=47±16	M=43±18	Paired-samples t-test	t(25)=1.84, 4.05units, 95%CI:-0.50 to 8.6	0.04**	Eta^2 0.12 (large)
FEV_1 (L)	1.37	1.41	Wilcoxon Signed Rank	Diff= 0.04L, Z= -2.68	0.007*	0.53 (small)
FEV1 (%predicted)	64±18 (73%)	65±18 (75%)	Wilcoxon Signed Rank	Diff= 1, Z= -2.73	0.006*	0.54 (large)
6MWD (m)	M=377±109	M=422±87	Paired-samples t-test	t(25)=-4.20, 45m, 95%CI:-68 to -23	<0.0001*	Eta^2 0.41 (large)
Number of Hospital admission	N=56	N=23	Simple percentage	41%		
	2±2	0±2	Wilcoxon Signed Rank	Diff= 2.0, Z= -3.04	0.02**	0.6 (large)

*Difference is significant at the 0.01 level; **Difference is significant at the 0.05 level.

Abbreviations: T1= Time Point 1, T2= Time Point 2, Z= Wilcoxon Signed Rank score, 6MWD= Six minutes walking distance, M= Mean, R= range, L=litres, N= number, PA= physical activity, FEV_1= forced expiratory volume in 1 second, SGRQ= Saint George's Respiratory Questionnaire, Eta^2= Eta Squared statistics, CI= confidence interval, Diff= difference between scores.

6.3.5.2 Secondary outcomes

(i) Total time spent on PA in all zones (Living, Health and Sport)

Participants spent more time on PA in the living zone at Time Point 1 (M= 470±173 minutes/day) and Time Point 2 (M= 497±199/day). This was followed by the health zone in which participants spent an average of 96±64 minutes/day at Time Point 1 and 107±77 minutes/day at Time Point 2. Least time was spent on PA in the sports zone and this remained practically unchanged at Time Point 1 (1.1±2 minutes/day) and at Time Point 2 (1.3±2 minutes/day). The mean time spent on PA in all zones increased by 42 minutes/day. Overall, there was no statistically significant increase in median time spent on physical activity (24 minutes/day) at at Time Point 1 (576 minutes/day) and at Time Point 2 (552 minutes/day) (Z= -1.26, p=0.209) (Table 11).

(ii) Total energy expenditure (TEE in Kcal)

As expected, mean energy expenditure increased minimally by 62 Kcal (see Table 11). There was no statistically significant difference in mean energy expenditure (62Kcal; 95% CI: -196 to 72) between Time Point 1 (1235±484 Kcal) and Time Point 2 (1297±509 Kcal), t(25)= -0.95, p= 0.35 (two-tailed). The effect size was small (0.03) (Table 11).

(iii) Health status

All participants (n=26) completed the SGRQ, which measures health impairment in patients with COPD. Participants' entries were scored according to the recommended procedure. The scores range from 0–100, a score of 100 indicates worst health status. There was a statistically significant difference in mean SGRQ total scores (4.05 units, 95% CI: -0.50 to 8.60) between Time Point 1 (46.72±16 units, n=26) and Time Point 2 (42.67±18 units, n=26), t(25)= 1.84, p=0.04 (two-tailed). The eta squared statistic (0.12) indicated a large effect (Table 11).

(iv) Pulmonary function (FEV_1)

There was a statistically significant increase in the median FEV_1 score (0.04L) between Time Point 1 (1.37L, n=26) and Time Point 2 (1.41L, n=26) (Z= -2.68, p=0.007), with a small effect size (r=0.53) (Table 11).

(v) Exercise capacity (6MWD test scores)

Participants were asked to complete the 6MWD test. The previously described protocol for the test was followed. The mean 6MWD score increased significantly (45.38m, 95% CI:-67.62 to -23.15)

between Time Point 1 (376.85±109m, n=26) and Time Point 2 (422.23±87m, n=26), t(24)= -4.20, p<0.001 (two-tailed). The effect size was large (0.41) (Table 11).

(vi) Number of hospital admission

In total, number of hospital admission reduced by 41% (56 at Time Point 1 compared to 23 at Time Point 2). The median number of hospital admission decreased significantly (2.00) between Time Point 1 (2.00, n=26) and Time Point 2 (0.00, n=26) (Z= -3.04, p=0.02, large effect size, r=0.6) (Table 11).

In summary, the main finding regarding the impact of the CEP is that although participants' daily PA (average daily PAM score) did not change significantly over time, other outcomes such as health status, FEV1 (small changes), 6MWD and number of hospital admission do change over time. As participants spent most time on activities in the living and health zones, their overall level of daily PA- average daily PAM score of 10.10 (after 3 months), equivalent to spending 42 minutes/day) on light-intensity activities (e.g. doing household chores or walking)- is regarded as moderate. The next section establishes what this moderate level of PA is associated with. In other words, it determines if the secondary outcomes improve when participants maintain moderate daily PA (PAM scores) after PR.

6.3.8 The relationship between Primary and Secondary outcomes

Table 12 and 13 presents results of the Pearson Product-moment Correlation matrix for the outcomes measured at Time Points 1 and 2 respectively.

Table 12: Bivariate Correlations for variables measured at Time Point 1

	Variables	1	2	3	4	5	6	7
1	Average daily PAM Score	1.00	.929**	.985**	-.424*	-.033	.327	-.173
2	Total energy expenditure		1.00	.917**	-.403*	.020	.339	-.353
3	Total time spent on PA			1.00	-.483*	.058	.361	-.221
4	Health status (SGRQ total score)				1.00	-.019	-.540**	.531**
5	Pulmonary function (FEV_1)					1.00	.090	-.114
6	Exercise capacity (6MWD test score)						1.00	-.362
7	Number of hospital admission							1.00

**. Correlation is significant at the α= 0.01 level (2-tailed).
*. Correlation is significant at the α= 0.05 level (2-tailed).

Table 13: Bivariate Correlations for variables measured at Time Point 2

	Variables	1	2	3	4	5	6	7
1	Average daily PAM Score	1.00	.942**	.994**	-.523**	.038	.394*	-.394*
2	Total energy expenditure		1.00	.948**	-.508**	.027	.323	-.357
3	Total time spent on PA			1.00	-.553**	.061	.382	-.409*
4	Health status (SGRQ total score)				1.00	-.210	-.654**	.802**
5	Pulmonary function (FEV_1)					1.00	.182	-.296
6	Exercise capacity (6MWD test score)						1.00	-.510**
7	Number of hospital admission							1.00

**. Correlation is significant at the α= 0.01 level (2-tailed).
*. Correlation is significant at the α= 0.05 level (2-tailed)

Table 14: Summary of correlation between data collected at Time Points 1 and 2

	Daily Physical Activity (Average daily PAM Scores)	
Variable	**Correlation at T1**	**Correlation at T2**
Total energy expenditure	0.929**	0.942**
Total time spent on PA	0.985**	0.994**
Health status (SGRQ total score)	-0.424*	-0.523**
Pulmonary function (FEV_1)	-0.033	0.038
Exercise capacity (6MWD test score)	-0.066	0.394*
Number of Hospital admission	-0.173	-0.394*

** Correlation is significant at the α= 0.01 level (2-tailed)
* Correlation is significant at the α= 0.05 level (2-tailed)

6.3.8.1 The Correlation Graph of daily PAM scores versus Secondary Outcomes

Figure 22 shows the correlation graphs or scatterplots of the relationship between daily PA (PAM scores) and secondary outcomes at Time Point 2 (i.e. after 3 months follow-up). As the results clearly show, the regression equation of daily PAM scores vs energy expenditure is y= 66.985x + 213.54; R^2= 0.887 (Figure 22a). This indicated that there was a statistically significant strong positive correlation between the two variables (r= 0.94, n=26, p=0.001), with high levels of average daily PAM scores associated with high energy expenditure. The regression equation of daily PAM scores vs time spent on daily PA is y= 0.6125x + 0.1837; R^2= 0.9876 (Figure 22b), indicating a statistically significant perfect positive correlation between daily PAM scores and total time spent on PA (r= 0.994, n=26, p=0.001). This implies that higher average daily PAM scores associated with higher/more time spent on PA in all activity zones. There appears to be a level of dependency between daily PAM Scores and energy expenditure and total time spent on activity in this analysis. Presumably energy expenditure and time spent in daily PA were part of the scoring of the PAM, hence correlation coefficient of 0.94 and 0.994 respectively. These also hint at positive covariances, in which case they are not independent of the PAM score and can be used interchangeably.

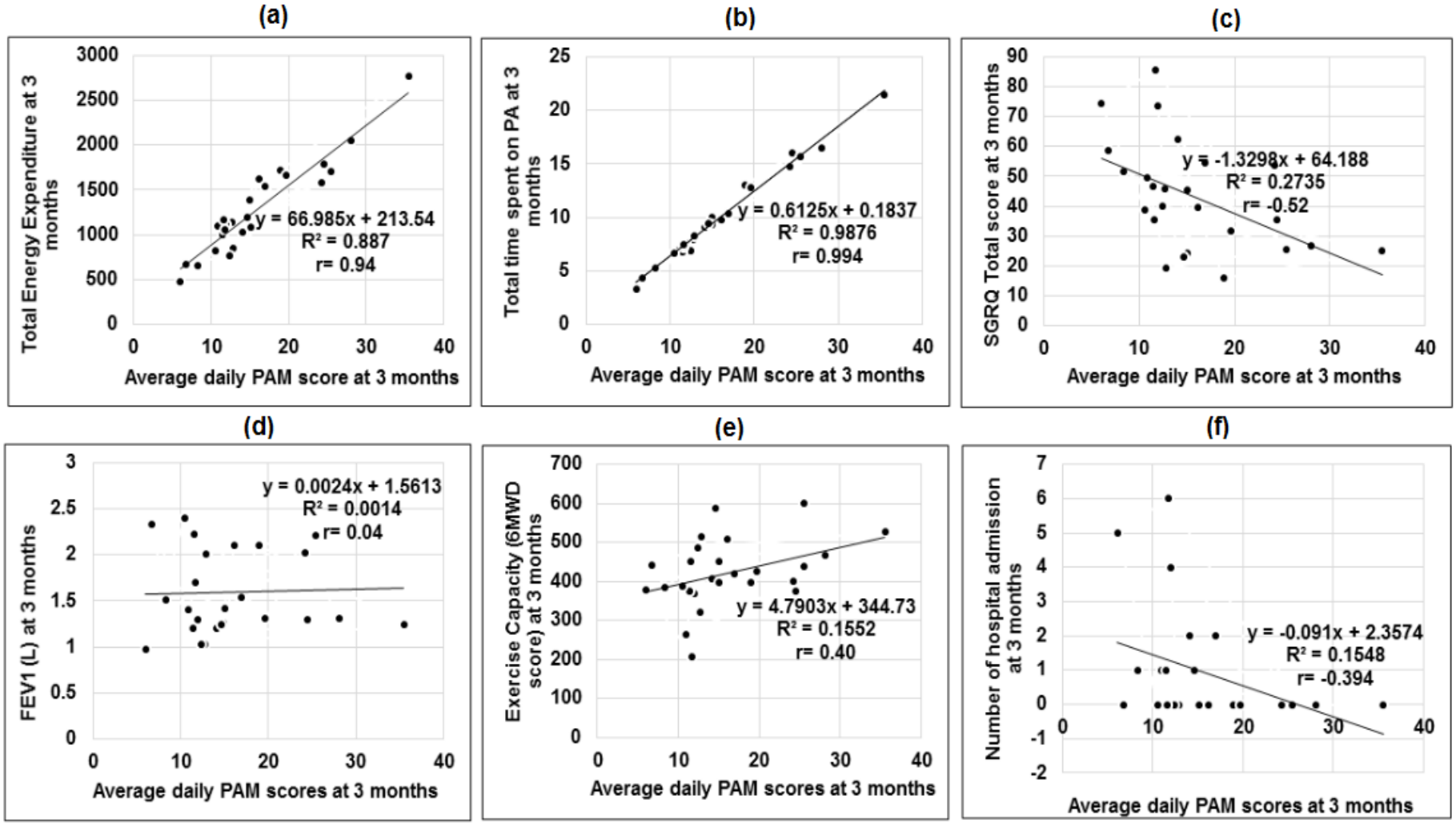
The regression equation of daily PAM scores vs health status (SGRQ total scores) is y= -1.3298x + 64.188; R^2= 0.2735 (Figure 22c). This indicated a strong (large) negative correlation between average daily PAM scores and health status (r= -0.52, n=26, p=0.006), with high levels of average daily PAM scores associated with better HRQoL (reduced SGRQ total scores).

The regression equation of daily PAM scores vs pulmonary function (FEV1 scores) is y= 0.0024x + 1.5613; R^2= 0.0014 (Figure 22d). There appears to be no significant correlation between the two variables (r = 0.04, n=26, p=0.86).

The equation of daily PAM scores vs exercise capacity (6MWD test scores) is y= 4.7903x + 344.73; R^2= 0.1552 (Figure 22e). This showed a statistically significant medium, positive correlation between average daily PAM scores and exercise capacity (r = 0.40, n=26, p=0.046), with high levels of average daily PAM scores associated with high levels of exercise capacity.

The regression equation of daily PAM scores vs number of hospital admission is y= -0.091x + 2.3574; R^2= 0.1548 (Figure 22f). There was a medium, negative correlation between average daily PAM scores and number of hospital admission (r = -0.40, n=26, p=0.047), with reduced number/frequency of hospital admissions associated with high levels of daily PAM.

Figure 22: Correlation Graphs of daily PA versus Secondary Outcomes



6.3.8.7 Correlation between changes in levels of Physical Activity and changes in other outcomes

Table 15 represents the Pearson Product-moment correlation matrix for the changes in outcomes. The correlation analyses indicated that the changes in levels of activity measured by total time spent on PA in all activity zones (living, health and sports) correlated positively with changes in exercise capacity (r= 0.31, *p*= 0.048) and negatively with changes in SGRQ total scores (r= -0.65, *p*= 0.0001). and pulmonary function (*r*= -0.43, *p*= 0.029). The modest negative correlation between changes in levels of PA and changes in pulmonary function (r= -0.43) and number of hospital admission (r= -0.22) did not reach statistically significant level (p>0.05).

Table 15: Correlation between changes in outcomes of interest

	Variables	1	2	3	4	5
1	Changes in total time spent on PA all zones (min.)	1.00	.308*	-.646**	-.429	-.221
2	Changes in Exercise capacity (6MWD)		1.00	-.212	.081	-.268
3	Changes in SGRQ Total score (units/points)			1.00	-.370	.581**
4	Changes in pulmonary function (L)				1.00	-.047
5	Changes in number of hospital admission					1.00

**. Correlation is significant at the α= 0.01 level (2-tailed).
*. Correlation is significant at the α= 0.05 level (2-tailed).

6.3.8.8 Correlation between Primary and Secondary outcomes after controlling for Age and FEV_1 (% predicted)

All analyses were done adjusting for age and FEV1 and it makes little difference. The age and FEV1 of patients with COPD are known to be significant predictors of levels of PA, exercise capacity, health status and number of hospital admissions. In this study, the relationship between variables as shown in Tables 12-14) may, to a large extent, be due to the influence of participants' age and/or FEV1 (% predicted). Hence, their influence on observed relationships between variables was controlled using Partial correlation. A summary of the correlation among variables after controlling for the influence of age and pulmonary function is presented in Table 16. After controlling for age, there was a statistically significant medium, positive partial correlation between average daily PAM scores and exercise capacity (r=0.397, n=26, p=0.046), with high levels of average daily PAM scores associated with increased exercise capacity (6MWD scores). An inspection of the zero order correlation (r=0.394, p=0.046) suggested that controlling for age had very little effect on the strength of the relationship between daily PAM scores and exercise capacity. Similarly, there was a medium, positive partial correlation between average daily PAM scores and exercise capacity, controlling for FEV1 (r=0.333, n=26, p=0.104), with high levels of

average daily PAM scores associated with increased exercise capacity (6MWD scores). An inspection of the zero order correlation (r=0.394) suggested that controlling for FEV1 had very little effect (0.061) on the strength of the relationship without any statistical significance.

There was a statistically significant strong (large), negative partial correlation between average daily PAM scores and SGRQ total scores, controlling for age (r= -0.521, n=26, p=0.008), with high levels of Average daily PAM scores associated with better HRQoL (reduced SGRQ Total scores). An inspection of the zero order correlation (r= -0.523, p=0.006) suggested that controlling for age had very little effect on the strength of the relationship between daily PAM scores and SGRQ total scores. Similarly, after controlling for FEV1, there was still a statistically significant strong (large), negative partial correlation between average daily PAM scores and SGRQ total scores (r= -0.435, n=26, p=0.030), with high levels of daily PAM scores associated with better HRQoL (reduced SGRQ Total scores). The zero order correlation (r= -0.523, p=0.006) suggested that controlling for FEV1 had very little effect (-0.088) on the strength of the relationship.

A medium, negative partial correlation was observed between average daily PAM scores and number of hospital admission, controlling for age (r= -0.402, n=26, p=0.046), with high levels of daily PAM scores associated with reduced number of hospital admissions. The zero order correlation (r= -0.394, p=0.047) suggested that controlling for age had very little effect on the strength of the relationship between these two variables. When the influence of FEV1 was controlled, there was a small, negative partial correlation between average daily PAM scores and number of hospital admission (r= -0.253, n=26, p=0.22), with high levels of daily PAM scores associated with reduced number hospital admissions. The zero order correlation (r= -0.394, p=0.047) suggested that controlling for FEV1 had very little (0.141) decline in the strength of the relationship between these two variables.

Table 16: Correlation among variables after controlling for age and FEV1 (% predicted)

Variables tested	Statistical test	N	Controlling for Age	Controlling for FEV1	Effect size
Daily PAM scores and 6MWD score	Partial correlation	26	r= (0.397*, p= 0.046) Zero-order= (r= 0.394, p= 0.046)	r= (0.333, p= 0.104) Zero-order= (r=0.333, p=0.104)	0.01 (small)
Daily PAM scores and SGRQ total scores	Partial correlation	26	r= (-0.521*, p=0.008) Zero-order= (r= -0.523, p=0.006)	r= (-0.435*, p=0.030) Zero-order= (r= -0.523, p=0.006)	0.09 (small)
Daily PAM scores and number of HA	Partial correlation	26	r= (-0.402*, p=0.046). Zero-order= (r= -0.394, p=0.047)	r= (-0.253, p=0.22) Zero-order= (r= -0.394, p=0.047)	0.14 (small)

*Correlation is significant at the α= 0.05 level (2-tailed).

Abbreviations: 6MWD= Six minutes walking distance, HA= hospital admission, SGRQ= St. George's Respiratory Questionnaire, r= Partial correlation coefficient, N= Number of participants

6.3.9 Predictors of daily Physical Activity

Although the above correlation analysis showed indexes (r) which described the linear relationship between level of daily PA and other variables (i.e. quantified the degree to which they are related), it did not fit a line through the data points. This means that it was not possible to predict the relationship of PA with other variables to identify which independent variables can predict the dependent variable (level of daily PA). Simple linear and multiple regression techniques were used to achieve this objective.

Simple linear regression analyses were first conducted to determine if average daily PAM scores (dependent variable) could be predicted from independent variables (6MWD test scores, SGRQ total scores, FEV1 scores, number of hospital admission, BMI, age, gender and years in CEP) at Time Point 1. Potential predictors of increase in average daily PAM scores significant at $p < 0.05$ in the simple/univariate analyses were retained for multivariate logistic regression analysis. Variables were retained in the final model if they were significant at $p < 0.05$. The results of the regressions at Time Point 1 are presented in Table 17 and Appendix 17. As can be seen in Table 17, at Time Point 1, the relationship of daily PA with all independent variables reflects the results from correlation analyses (see Table 14). A significant proportion of the total variance in average daily PAM scores was associated with two variables; SGRQ total scores (-0.01, 95% CI [-0.02, -0.001], t= -2.24, p= 0.03) and male gender (0.38, 95% CI [0.11, 0.65], t= 2.94, p= 0.007) at Time Point 1. This means that only these tow variables significantly predicted level of daily PA at $p < 0.05$. An illustration of how a simple linear regression equation can be used to make predictions on a participant's level of daily PA is illustrated below:

The simple regression equation is a linear equation of the form:

$$\mathbf{Y = a + bX}$$

Where Y= Level of daily PA (dependent variable)

X= Health status (SGRQ total score)

a= Constant

b= Coefficient

For this dataset, the values of constant (a) and coefficient (b) have been calculated for all variables in the simple and multiple regression analyses (see Appendix 17). The constant and coefficient for the linear relationship between daily PA (Y) and health status (X) are 3.10 and -0.01 respectively. Therefore, the simple linear equation for the relationship between these variables is:

$$\mathbf{Y= 3.10 + (-0.01)(X)}$$

This simple linear equation (Y= 3.10 + -0.01[X]) can be used to predict a participant's level of daily PA (Y) based on the values of his/her SGRQ total score. For example, the predicted level of daily PA (average daily PAM score) for a participant SGRQ total score of 58 will be:

$$\mathbf{Y= 3.10 + (-0.01)\ (58)}$$
$$Y= 3.10 + (-0.58)$$
$$Y= 2.52$$

The two predicators of level of daily PA (SGRQTotal score and male gender) obtained from the simple linear regression models were retained for multivariate logistic regression analysis due to the small simple size (n=26). As can be seen, one variable was retained in the final model because it was significant at $p < 0.05$. Male gender predicted daily PA (Beta= 0.45, t= 2.67, p= 0.014). The adjusted R Square value (0.31) indicated that male gender explained 31% of the variance in daily PA.

The same analytical procedures were applied to data collected at Time Point 2. Results of the regressions at Time Point 2 are also presented in Table 17 and Appendix 17. The relationship of daily PA with all independent variables also reflects findings from correlation analyses (see Table 14). A significant proportion of the total variance in average daily PAM scores was predicted by four variables; SGRQ total scores (-0.01, 95% CI [-0.02, -0.01], t= -3.36, p= 0.003), exercise capacity (0.002, 95% CI [-0.00, 0.004], t= 1.98, $p<0.049$), number of hospital admission (-0.11, 95% CI [-0.21, -0.01], t= -2.34, p= 0.028) and male gender (0.41 95% CI [0.09, 0.73], t= 2.63, p= 0.02). This means that four variables significantly predicted level of daily PA at $p<0.05$.

At Time Point 2, the simple regression equation for the relationship of level of daily PA with, for example, time spent on PA is also a linear equation of the form:

$$\mathbf{Y = a + bX}$$

Where Y= Level of daily PA (dependent variable)

X= Exercise capacity

a= Constant

b= coefficient for exercise capacity

The constant (a) and coefficient (b) for the linear relationship between daily PA (Y) and exercise capacity (X) at Time Point 2 are 1.90 and 0.002 respectively. Therefore, the simple linear equation for the relationship between these variables is:

$$\mathbf{Y= 1.90 + 0.002(X)}$$

For this participant population, exercise capacity increased by an average of 45 meter. If a participant has a 6MWD test score of 525 and increased his/her 6MWD test score by 45m at time point 2, his/her predicted level of daily PA (average daily PAM score) will be calculated as follows:

$$\mathbf{Y= 1.90 + 0.002(X).}$$

$$Y= 1.90 + 0.002(525 + 45)$$

$$Y= 1.90 + 0.002\ (570)$$

$$Y= 1.90 + 1.14= 3.04$$

For the multiple regression analyses at Time Point 2, three stronger predicators of level of daily PA from the simple linear regression models (SGRQTotal score, male gender and number of hospital admission) were retained for the multivariate logistic regression analysis due to the small simple size (n=26). Only one variable (SGRQTotal score) was retained in the final model. Male gender did not significantly predict daily PA (Beta= 0.34, t= 2.07, p=0.061). However, SGRQ total score significantly predicted levels of daily (Beta= -0.47, t= -2.85, p=0.009, $R^2_{adjusted}$= 0.38). The adjusted R Square value (0.38) indicated that participants' health status (SGRQ total scores) explained 38% of the variance in daily PA.

The multiple regression model is a linear equation of the form:

$$\mathbf{Y = a_0 + a_1X_1}$$

Where Y= level of daily PA (dependent variable)

X_1= the stronger predictor (variable) retained in the model (SGRQ total scores)

a_0 = Constant

a_1= Coefficient for the only variable retained in the model (time spent on PA)

The calculated values of a_0, and a_1 are 2.71 and -0.01 respectively. Therefore, the multiple regression equation for the relationship of daily PA with SGRQ total scores at Time Point 2 is:

$$\mathbf{Y= 2.71+ -0.01\ (X_1)}$$

Using this regression model, a participant's level of daily PA can be predicted. For example, the predicted level of daily PA for a participant with SGRQ total score of 48 will be:

$$\mathbf{Y= 2.71 + (-0.01)\ (48)}$$

$$Y= 2.71 + (-0.48)$$

$$Y= 2.23$$

Table 17: Results of Simple and Multiple Regressions Analyses

Simple and Multiple regressions of data at Time Point 1							
	Simple linear regression			**Multiple regression**			
Variables	**Coef (95% CI)**	**t**	**p-value**	**Coef (95% CI)**	**t**	**p-value**	**Beta**
LogPAMT1 (dependent)							
ExcapT1	0.00 (-0.000, 0.002)	1.39	0.18	-	-	-	-
PulmfunT1	-0.02 (-0.35, 0.31)	-0.11	0.92	-	-	-	-
SGRQTotalT1	-0.01 (-0.02, 0.001)	-2.24	0.03	-0.008 (-0.02, 0.001)	-1.95	0.064	-0.33
HadminT1	-0.03 (-0.11, 0.06)	-0.71	0.48	-	-	-	-
BMIT1	-0.02 (-0.05, 0.01)	-1.82	0.08	-	-	-	-
Age	-0.01 (-0.03, 0.02)	-0.44	0.66	-	-	-	-
Gender (Male)	0.38 (0.11, 0.65)	2.94	0.007	0.34 (0.08, 0.60)	2.67	0.014	0.45
YearCEP							
2	0.08 (-0.28, 0.45)	0.48	0.64	-	-	-	-
3	-0.08 (-0.48, 0.32)	-0.42	0.68	-	-	-	-
***Adj R-squared = 0.3142**							
Simple and Multiple regressions of data at Time Point 2							
	Simple linear regression			**Multiple regression**			
Variables	**Coef (95% CI)**	**t**	**p-value**	**Coef (95% CI)**	**t**	**p-value**	**Beta**
LogPAMT2 (dependent)							
ExcapT2	0.002 (-0.00, 0.004)	1.98	0.049	-	-	-	-
PulmfunT2	0.04 (-0.35, 0.44)	0.23	0.82	-	-	-	-
SGRQTotalT2	-0.01 (-0.02, -0.01)	-3.36	0.003	-0.01 (-0.02, -0.003)	-2.85	0.009	-0.47
HadminT2	-0.11 (-0.21, -0.01)	-2.34	0.028	0.02 (-0.10, 0.13)	0.29	0.78	0.02
BMIT2	-0.02 (-0.05, -0.01)	-1.68	0.11	-	-	-	-
Age	0.003 (-0.02, 0.03)	0.27	0.79	-	-	-	-
Gender (Male)	0.41 (0.09, 0.73)	2.63	0.02	0.20 (-0.00-0.59)	2.07	0.061	0.34
YearCEP	-0.05 (-0.028, 0.18	-0.47	0.640	-	-	-	-
***Adj. R-squared = 0.3762**							

Abbreviations: PAMT1= level of PA at Time Point 1, PAMT2= level of PA Time Point 2, ExcapT1= exercise capacity at Time Point 1, ExcapT2= exercise capacity at Time Point 2, PulmfunT1= forced expiratory volume in 1 second at Time Point 1, PulmfunT2= forced expiratory volume in 1 second at Time Point 2, SGRQTotalT1= Saint George's respiratory questionnaire total score at Time Point 1, SGRQTotalT2= Saint George's respiratory questionnaire total score at Time Point 2, HadminT1= number of hospital admission at Time Point 1, HadminT2= number of hospital admission at Time Point 2, BMIT1= body mass index at Time Point 1, BMIT2= body mass index at Time Point 2, YearCEP= number of years in the comminuty-based exercise programme, Coef= regression coefficient, 95% CI= 95% confidence interval, t= t-statistic which is a measure of the precision with which the coeff was measured , Aj. R-square= adjusted R-square statistic which indicates how much of the variance in daily PA was explained by the various predictor variables in the final multivariate model.

6.4 Testing the Hypotheses

To address the research questions outlined in chapter 1 (section 1.5), a framework was proposed and 12 hypotheses were formulated in chapter 3 (section 3.5). These hypotheses are now being tested in this section by using results from the statistical analyses. The results for the path relationships in the proposed model are summarised in Table 18. The reported findings in this table are assessed base on statistical test results and p-values. The standard decision rule of p-value ≤ 0.05 was applied to decide whether or not evidence from the tests supported accepting or rejecting the null hypotheses.

Table 18: Output for the Hypothesized relationships in the Proposed Conceptual Model

S/no	Null hypothesis	Results	Remark
H1	There is no significant statistical difference between participants' daily physical activity (average daily PAM scores) at Time Points 1 and 2	Diff= -1, Z= -1.33, p= 0.18	**Supported**: Evidence supported accepting the null hypothesis.
H2	There is no significant statistical difference between participants' total time spent on physical activity) at Time Points 1 and 2	Diff= -24 mins, Z= -1.26, p= 0.209	**Supported**: Evidence supported accepting the null hypothesis.
H3	There is no significant statistical difference between participants' health status at Time Points 1 and 2	t(25)=1.84, 4.05units (95%CI:-0.50 to 8.6), p= 0.04**	**Not supported**: Evidence supported rejecting the null hypothesis.
H4	There is no significant statistical difference between participants' pulmonary function (FEV_1) at Time Points 1 and 2	Diff= 0.04L, Z= -2.68, p= 0.007*	**Not supported**: Evidence supported rejecting the null hypothesis.
H5	There is no significant statistical difference between participants' exercise capacity (6MWD test scores) at Time Points 1 and 2	t(25)=-4.20, 45m (95%CI:-68 to -23), p<0.0001*	**Not supported**: Evidence supported rejecting the null hypothesis.
H6	There is no significant statistical difference between participants' number of hospital admission at Time Points 1 and 2	Diff= 2.0, Z= -3.04, p= 0.02*	**Not supported**: Evidence supported rejecting the null hypothesis.
H7	There is no negative relationship between daily physical activity (average daily PAM scores) and health status (SGRQ total scores)	r= -.523**, p< 0.01	**Not supported:** Evidence supported rejecting the null hypothesis.
H8	There is no positive relationship between daily physical activity (average daily PAM scores) and pulmonary function	r= .038, p> 0.05	**Supported:** Evidence supported accepting the null hypothesis.
H9	There is no positive relationship between daily physical activity (average daily PAM scores) and exercise capacity	r= .394*, p< 0.05	**Not supported:** Evidence supported rejecting the null hypothesis.
H10	There is no negative relationship between daily physical activity (average daily PAM scores) and number of hospital admission	r= -.394*, p< 0.05	**Not supported:** Evidence supported rejecting the null hypothesis.
H11	There is no significant positive relationship between participants' daily physical activity and time spent on physical activity at Time Points 2	r= .994**, p< 0.01	**Not supported:** Evidence supported rejecting the null hypothesis.
H12	None of the clinical variables (health status, pulmonary function, exercise capacity and number of hospital admission) will significantly predict levels of daily PA at Time Point 2	SGRQ total score strongly predicted levels of daily PA (Beta= -0.47, t= -2.85, p=0.009, $R^2_{adjusted}$= 0.38).	**Not supported:** Evidence supported rejecting the null hypothesis

** Results supported at the α= 0.01 level; *. Results supported at the α= 0.05 level

Abbreviations: Z= Wilcoxon Signed Rank score, t= Paired-samples t-test, r= Pearson's product-moment correlation coefficient, X^2= Kruskal-Wallis test, 6MWD= Six minutes walking distance, M= Mean, L=litres, PA= physical activity, FEV_1= forced expiratory volume in 1 second, SGRQ= Saint George's Respiratory Questionnaire, CI= confidence interval, Diff= difference between scores.

6.5 Summary

The quantitative findings indicate variations in daily physical activity behaviours before and 3 months after participation in the programme. Participation in the intervention was associated with a positive trend towards improvement in levels of physical activity measured by average daily PAM scores, energy expenditure and total time spent on physical activity. However, the observed increase in levels of activity did not reach statistical significance. The quantitative data also demonstrated the impact of the CEP on participants' health status, pulmonary function, exercise capacity and number of hospital admission. There were no statistically important changes in participants' moderate levels of daily PA overtime. However, there were significant improvements in health status, pulmonary function, exercise capacity and decrease in number of hospital admissions.

Finally, the quantitative data revealed the relationship of levels of daily PA with clinical outcomes. Pearson's correlation analyses suggests that level of daily PA was positively associated with time spent on PA, energy expenditure and 6MWD, but negatively associated with SGRQ total scores and number of hospital admission. The relationship between average daily PAM scores and other variables mainly remained after controlling for the influence of participants' age and pulmonary function. Results from simple linear regression analyses corroborated those from Pearson's correlation analyses. However, in a multivariate model, health status and male gender predicted level of daily PA at Time Point 1. At Time Point 2, only health status significantly predicted levels of daily PA.

6.6 Rationale for the qualitative phase of this study

As stated previously, findings from the quantitative data were used to inform the qualitative phase of the study. Three key factors underscored the need for a qualitative study in this project. Firstly, the quantitative data found no statistically significant improvement in levels of daily physical activity following a 3-month participation in the programme even though there were concomitant improvements in exercise capacity and health status. This is consistent with quantitative findings from six previous studies (Coronado, et al., 2003; Steele, et al., 2003a; 2008; Dallas, et al., 2009; Mador, et al., 2011; Egan, et al., 2012) of the impact of PRPs. However, this is the first study to report this finding in the context of a post-PR CEP, which is markedly different from PRP. Hence, the need to explore participants' views of the benefits of the programme and the barriers and enablers of participation.

Secondly, the results also underscore the need to understand the factors influencing PA in this context. It was considered important to explore what helped participants to be able to attend the weekly exercise classes and what made it more difficult for them to attend. An understanding of these factors will have cardinal implications regarding how participants can be supported into long-term CEP following PR.

The next chapter will present the qualitative findings of this study.

CHAPTER SEVEN

FINDINGS: QUALITATIVE PHASE

7.1 Introduction

This chapter provides the results of the qualitative phase of the study. It reports on the main themes that emerged from the semi-structured, face-to-face interviews as well as the elements in each theme. The aim of this study was to validate/confirm and explain part of the quantitative findings in greater depth. Two research questions were asked during the qualitative data collection phase:

(a) What are COPD patients' views of the benefits of the community-based exercise programme to which they were referred after completing PR?

(b) What helps participants to be able to attend the weekly exercise classes and what makes it more difficult for them to attend?

It is important to note that the time frame of the quantitative and qualitative results of the study was different. The interviews were conducted after quantitative data collection and analyses. This was done in order to identify the quantitative findings that needed to be explored further. Whilst the quantitative results (see chapter six) relate to the effect of the CEP over 12 weeks, the qualitative results relate to participants' experience of the programme overall. It was not possible to separate their experiences within 12 weeks because most of the participants have been attending for a long time. The qualitative data were collected through semi-structured in-depth interviews. The interviews confirmed and explained some of the quantitative findings and contributed depth and richness to the entire study. It is also important to note that these data gave the participants a voice about their experiences of the benefits of the programme, factors that influenced their participation and how to improve key components of the programme and strengthen the quantitative findings of this study. The analysis of the interviews focuses on the identification of themes, sub-themes and highlighting the significant elements within each theme. The section begins with a description of participants' characteristics.

7.2 Participants' characteristics

All 26 participants were eligible and consented to participate in interviews. However, after interviewing 12 participants, no new themes were identified and data saturation was reached and therefore no further participants were asked to complete the interview. The characteristics of the 12

participants are summarised in Table 19 and these were generally representative of the overall sample in the quantitative study. The names of participants and research setting were changed to protect their identities.

Table 19: Characteristics of participants in the qualitative study

ID	Sex	Age	Marital status	BMI (Kg/m^2)	Ethnic group	Education status	Employment status	Smoking status	FEV1, L (% predicted)	COPD Severity (GOLD Stage)	O_2T	NI use	Years in CEP	Proximity to CEP (Miles)
P1	F	89	Single	18.2	White	Prof qual.	Retired	FS	1.13 (75%)	II (Moderate)	No	No	<1	7
P5	F	78	Married	28.44	White	Prof qual.	Retired	OS	1.10 (78%)	II (Moderate)	No	Yes	1-3	10
P7	F	77	Married	34.24	White	GCSE/O'Level	Retired	FS	1.21 (57%)	II (Moderate)	No	No	<1	1
P10	F	73	Widowed	27.74	White	No qual.	Retired	OS	1.09 (54%)	II (Moderate)	No	No	<1	4
P11	F	72	Widowed	30.74	White	Other qual.	Retired	FS	1.26 (83%)	I (Mild)	No	No	>3	1
P12	F	72	Married	38.82	White	Other qual.	Retired	FS	1.42 (78%)	II (Moderate)	No	No	1-3	5
P15	F	69	Married	28.25	White	Other qual.	Retired	FS	1.31 (51%)	II (Moderate)	No	No	1-3	1
P17	M	79	Married	34.8	White	Prof qual.	Retired	FS	2.33 (78%)	II (Moderate)	Yes	No	1-3	8
P19	M	73	Single	39.52	White	Other qual.	Retired	FS	1.79 (66%)	II (Moderate)	No	No	>3	12
P20	M	72	Married	23.25	White	Degree+	Part-time	Never	1.11 (34%)	III (Severe)	No	No	1-3	11
P22	M	70	Married	32.32	White	O & A Levels	Retired	FS	1.53 (55%)	II (Moderate)	No	Yes	1-3	4
P23	M	68	Married	26.94	White	GCSE/O'Level	Retired	FS	2.53 (80%)	I (Mild)	No	Yes	<1	9
Mean	-	74.33		30.27					1.79 (66%)					6

Abbreviations: F= female, M= male, FS= Former smoker, OS= Occasional smoker, COPD= Chronic Obstructive Pulmonary Disease, GOLD= the severity of COPD (classified by spirometry) according to the standard of the Global Initiative for Obstructive Lung Disease (GOLD), BMI= body mass index, CEP= community-based exercise programme, O_2T= supplemental oxygen therapy, qual. = qualification, yrs= years, NI= Nebuliser/Inhaler

7.3 Main themes arising from the interviews

Following analysis, a total of five major themes and 27 sub-themes were identified from the data and are presented in Figure 23. The main themes were: (1) referral to the programme (2) perceived benefits (3) enablers and barriers (4) perception of safety; and (5) recommendations for programme improvement. It is worth mentioning that some of the themes and sub-themes exist individually, while others coexist and overlap. This is a typical feature of thematic analysis.

7.3.1 Referral to the programme

Participants were asked who had referred them to the CEP and how they interpreted the reasons for their referral. This main theme incorporates two sub-themes. (a) Sources of referral and (b) Understanding the reasons for referral (why they think they had been referred).

7.3.1.1 Sources of referral

The programme had been set up for older adults with long-term physical health conditions and it accepts referrals from a range of healthcare professionals, for example nurses and physiotherapists from a hospital-based pulmonary rehabilitation programme. The reality was interviewees were referred in one of three ways. 8 out of 12 interviewed came from nurses' or physiotherapists' referrals following participation in a hospital-based pulmonary rehabilitation programme:

It's the nurse at ── the hospital. The nurse told me, said to do it and we filled in a form, giving our telephone number. And then (the exercise instructor) phoned me and then ── I was here. (Tony, P22).

3 out of 12 interviewees were referred by their GPs:

"The doctor said that ── "This is very good for me". So it was the doctor that referred me to this programme, well it was actually the nurse really, it was at the surgery, yes (Lucy, P11).

However, 2 participants were recommended by friends, one turned up and was assessed by the instructor while the other went to her GP and was referred by the GP.

Well, it was a friend actually. Because I've seen her and how well she was doing. ── because ── and I thought to myself well I think I could do with doing that. And I was under the doctor anyway. So I just asked to be ── I approached the doctor and said ── and he said, "Yeah" they will get me on to the programme (Monica, P10).

7.3.1.2 Understanding the reasons for referral

During the discussion on the referrals to the programme, participants were asked if they understood why they were referred to the programme. They stated reasons for referrals have been to prevent breathing problem getting worse and maintain benefits from initial rehabilitation.

7.3.1.3 Stop it getting worse

Preventing breathing getting worse was important to participants. They described how important it was not to give in to the fact that their breathing trouble is incurable but to make the effort and embrace the opportunity to improve it. Participants recognised that to prevent breathing getting worse and slow progress of COPD that they needed to exercise regularly:

I think the point being that ── although COPD was not curable, ── you could like mitigate the progress or slow it down by exercising and building some muscle strength and exercising your, you know, your aerobic facility (Bill, P20).

Consistent with this view, both quantitative and qualitative data demonstrated that participating in the CEP was associated with improvements in pulmonary function and learning skills for coping with breathlessness. Perception of these benefits contributed to regular attendance and success of the programme.

7.3.1.4 Maintain initial benefits

Participants described learning to cope with breathlessness, feeling stronger and improve breathing as a result of participation in an initial hospital-based rehabilitation programme. It is not surprising that people found this given the robust benefits of pulmonary rehabilitation in the literature. Having benefitted from the programme, participants expressed the importance of maintaining these benefits through attending the CEP which provided an opportunity for regular exercise.

For breathing I think, you know, to continue doing the exercises. Because it was helping me, because I was a lot better. I improved when I was at (the local hospital) and to keep it up (Daisy (P12).

With regards to maintaining benefits, the quantitative findings of this study indicated that participants' moderate levels of daily PA at Time Point 1 were maintained but did not change significantly over time. Maintaining moderate levels of daily PA was associated with significant changes in their health status, exercise capacity, pulmonary functions and number of hospital admission within the 3 months of follow-up.

7.3.2 Perceived benefits of the programme

The participants overwhelmingly emphasised the benefits of the CEP. The perceived benefits are discussed under the five sub-themes: (a) Health benefits, (b) Physical benefits, (c) Psychological benefits, (d) Social benefits, and (e) Consistency.

7.3.2.1 Health benefits

The quantitative data showed significant improvements in pulmonary function and the symptom domain of the SGRQ and these are in agreement with the findings from the qualitative interviews. Participants associated their experiences of health benefits to attending the CEP. Because the remodelled airways in patients with COPD are irreversible (Braber, et al., 2010; Soltani, et al., 2010) even after modifying smoking habit, it is expected that patients will continue to experience respiratory symptoms. Although the experiences of participants in this study reflected these, they overwhelmingly agreed that the programme prevented COPD getting worse. The physical health benefits of participating in the programme were recognised by all the participants. In addition, many described their experiences in terms of improvement in general well-being:

I've just found that my wellbeing has been better since I've been coming to the gym than it would normally be (Monica (P10).

For some in the study, the experience of health benefits as a result of attending this programme was related to feeling stronger in themselves, absence of chest infection, coping with breathlessness, doing domestic chores without any breathing problems, getting off antibiotics, the feeling that COPD has not progressed or get any worse and improved breathing (pulmonary function):

I think I was diagnosed with COPD in about 2013 or something. And certainly, I have had ── I just don't feel that it's gone worse ── I mean I feel it hasn't progressed or get any worse at all. ── and if anything, I feel more comfortable now. In fact I had a spirometer test last week, and it was as good as it was three years ago, and in some respect even slightly better. So I'm sure the exercise programme has helped in that respect. And I feel stronger in myself, which I ── again I'm sure it's a good thing, in terms of trying to make sure that COPD doesn't get any ── doesn't get any worse (Bill (P20).

One participant described getting off ambulatory oxygen therapy and coping with breathlessness and directly attributed these to the exercise programme:

They recommended, at (Thompton Town Hospital) that I go ── when I was doing exercises, to go on onto oxygen, which I did. They set all that up for me. I got ── oxygen. Now this was ── it got to be four years ago. [Pause] And ── and from that it's on the shelf. ── because I was using it ──

to walk even up and down because, from where I live to get up to the main road and back, you got to go up inclines. And flat surfaces I'm alright on, inclines I don't get on with very well. ── so I was using it for that. ── there is big cylinder I've got [sic], a bit off with, but I went to the ── the electric one which I've got now. And I used that for ── two three [sic] years I suppose. ── while I was up here, I mean when I came here, ── and I was on the bike one afternoon and I've done 15 minutes on the bike and realised I hadn't switched it on. And I haven't used it since (Michael, P17). I wouldn't have got off oxygen without it [the exercise programme].

I still feel breathless, well, it's part of the course really isn't it? You learn to cope with it. And to cope with it, without oxygen is ── a big plus as well. Because I thought at one point that, that was it [lost hope] *(Michael (P17).*

7.3.2.2 Physical benefits

At a functional level participants described their experience of strengthened skeletal muscles as a result of the exercise programme and this had the added benefits of increased physical fitness. For most participants, the exercise programme was their first experience of exercising in a gym. They related feeling stronger, fitter and better compared to when they were not going to the gym:

I think── according to what I do in the gym, my level of fitness has gone up compared to what it used to be before I started coming here, definitely, yeah, yeah, yes it has gone up (Zoe (P15).

I mean I never did [exercises] ── you know, just the fact of coming to an exercise class ── to the gym twice a week is better than it was. I didn't use to do that. And ── and yeah, yes I feel physically stronger and better (Bill (P20).

Many participants referred to improvements in physical functioning in terms of observations made by friends and family members and abilities to use gym equipment which they previously found difficult to use. One participant explains:

I've been coming here for ── just under 2 years and I know I've improved in the gym. I mean, when I first came here there is no way I could have got on that Cross Trainers, no way. So I know I have improved and I go walking with a friend and some days ── if the weather is good, she will say to me, "You are walking quicker", you know. So ── you know, maybe I haven't noticed it but other people have noticed it (Zoe (P15).

Participants' perception of increased levels of daily PA was supported by the quantitative data when considered in relation to exercise capacity. Because their exercise capacity improved significantly, it is expected that they will be more physically active and this was supported by the quantitative finding of a positive correlation between participants' average daily PA and exercise capacity.

Beside the several references to performance and maintenance of levels of different physical activities, participants also described how the programme was restorative because they were now able to return to hobbies and activities they used to engage in before they were restricted by COPD:

I had given up bowling and I'm back on it now. I bowled for the whole of the winter season. And I'm just waiting for the summer season to start. ── so that's a plus. I have played nine holes of golf. I went out playing with my son and son-in-law. I normally have a buggy because I normally like to play the whole 18 holes. But to get round 18 holes I have to have the buggy. But I still get round 18 holes (Michael (P17).

I think I've made some sort of progress. I'm able to do things, carry on things whereas, like gardening for instance, if I hadn't had these exercises I might just like I can't do it. I can do more of gardening now and carry on doing the things that I've always wanted to do (Ruby (P5).

7.3.2.3 Social benefits (benefits of the social dynamics)

COPD is well known to be a socially inhibiting disease. As with the symptom domain of the SGRQ, the significant improvement in social aspect as measured by the Impacts domain is congruent with outcomes reported by participants. The group nature of the exercise training sessions provided positive social benefits for all participants. It provided some participants the opportunity to meet people with similar conditions:

I think the morale side is very good. Because, you know, you, when ── especially in the winter, and the weather is bad and sometimes you can go ── you can go for days without seeing anybody. This at least makes you get yourself motivated and think, "Oh get up I'm going to just get dressed up and going to the gym". You know, and then you look forward to meeting people (Monica (P10).

Participants highly regarded the camaraderie in the group and how it has been of immense benefit to them. Being part of a group made them aware that they are not alone and that other people have similar problems as them and this positively influenced mutual care and support.

That's very good, being a group thing and meeting people who are similar to yourself. So you don't feel embarrassed or anything like that. You feel on a par. You're not thinking, "Oh (inaudible-5:09) I can't do this" because everybody else is in the same boat as you (Monica (P10).

7.3.2.4 Psychological benefits

A sense of improved psychosocial well-being was an important benefit participants associated with attending the programme. This agrees with the statistically significant negative association between level of PA and psychological wellbeing measured by the Impacts domain of the SGRQ. The most frequently expressed psychosocial benefits were reduced depression, fear and anxiety associated

with being breathless when performing exertional activities, improved motivation and self-confidence.

Some of these benefits appeared to be reflected by four items in the SGRQ tool: (1) 'I get afraid or panic when I cannot get my breath' (2) 'I feel that I am not in control of my chest problem' (3) 'I have become frail or an invalid because of my chest' and (4) 'Exercise is not safe for me'. In addition, the large effect size (Eta^2= 0.17) suggests that the weight of items within the Impacts domain is high and that larger effect size would have been produced if all concepts were validly represented or captured by the instrument. Participants linked these benefits to the group nature or social aspect of the programme which provided the opportunity to get out of their houses, meet and talk to people as well as participate in activities.

I do suffer with depression … I am on medication for depression and that, yeah, yeah. But you see, it's important to come here really because that does help the depression. So coming here definitely helps me overcome depression. Because ── I think talking to people, getting different people's points of view, I think it ── it definitely helps, it definitely helps, yeah (Merlin (P19).

Fear of breathlessness during physical activity is a common problem for people with COPD and is recognised as a major factor for sedentary lifestyle and being trapped in a cycle of inactivity. For many participants, the experience of exerting themselves during training sessions and the realisation that other people with similar conditions have the same experiences, improved their understanding of breathlessness and helped them overcome fear of breathlessness when performing physical activity. This made them feel less frightened and more in control:

It has helped me overcome my fear of breathlessness. Because, you know, you see other people sitting there and they are breathing heavy as well and you know they are going through exactly what you go through. I get out of breath because I do tend to push myself and sometimes I find it very hard to breathe because I just come off the Cross Trainer. That is very hard. I can do that three minutes and I'm gasping for breath. But ── and sometimes it frightens you, because ── before I came on this course if I got breathless like that, I get frightened and ── I start to hyperventilate. So it's a bit of a vicious cycle. But now I know I'm breathing heavy because I'm exercising and it will get back to normal. So it's not so frightening (Zoe (P15).

For many participants, meeting and talking to people in the group provided internal motivation and confidence to do more exercise. Some participants reported having some exercise equipment at home but do not use them due to lack of motivation. They said the people in the programme motivated them and made them do a lot more exercises that they would not do if they were left on their own.

I think if I was left on my own devices I just wouldn't do it. If I didn't have to come here, I don't think I would be doing the exercises at home. No way! (Zoe (P15).

Despite the overwhelming references to the benefits of the programme, some participants still mentioned some of the limitations they experienced as a result of their age and COPD. These included getting tired, inability to use every gym equipment, get up hills, go out for long walks, socialise more frequently, go out at night and play a lot of sports.

It's helping me maintain a level of activity. Yeah, I still get out, I get in the car, I go down, I walk around (Thompton Town), but not all the time, I go in the pub, see my mates, have a beer. Not as much as I used to. I can't do a lot of other things I would like to. I can't go out for long walks with my grandchildren as much as, I would like to. I can't always go out at night, I can't always feel like it (Brendan (P23).

7.3.2.5 Consistency

The major goal of CEPs is to prevent relapse to insufficient levels of PA in daily life and sustain benefits of PRPs. The sub-theme consistency indicated participants' experiences of deterioration in physical ability and COPD symptoms when they stopped attending the exercise classes for any reason and also emphasized the need for regular attendance in order to avoid setbacks:

One thing I do notice with this ── I was recently [sic] had two weeks, no three to four weeks not coming and for whatever reason I wasn't here for a month. I noticed it when I came back that I can't do what I was doing before. So it's very important that you have a consistency. As soon as you don't go in once ── or if you leave it for a week or two, the body falls back. I still haven't got back to what I was doing a month ago in terms of the weight that I was lifting. But it [the programme] is having an effect and is helping keep [sic] me at a level. But you mustn't take the time off that's what I noticed. It's not good, too much time off, you go backward (Brendan (P23).

The quantitative data in this study demonstrated an overall improvement in outcomes and therefore, did not support participants' views regarding experiences of relapse or setbacks associated with not attending regularly. This suggests that the deterioration in outcomes described by participants reflected past experiences and not the reality within the 3-month study period. Nevertheless, the CEP appeared to have been designed to address this problem by ensuring there is consistent or regular exercise training (2 times every week) and regular follow-up of participants by peers and exercise instructor.

7.3.3 Enablers and barriers to PA and attendance

This theme identified issues relating to attendance of the weekly exercise training sessions. The theme was based on participants' comments on what enabled them to attend and what prevented or made it more difficult for them to attend regularly.

7.3.4 Enablers

The following sub-themes highlight the most commonly mentioned factors that significantly enabled regular participation in the programme: (i) Easy access (proximity and owning a car), (ii) Perceived benefits of the programme, (iii) Convenient programme components (iv) Being a retiree (v) Social support (family, peers and exercise instructor), and (vi) Seasons.

7.3.4.1 Ease of access (Proximity and owning a car)

The sub-theme ease of access describes how easy it was for participants to attend exercise classes because they live near the gym. The distance between the location of gym and homes of those interviewed range from 1 to 12 miles (mean 6.08±4 miles). They agreed that the fact that the gym is close to where they live does help make sure they attend on a regular basis. Linked closely to proximity was owning a car, which enabled those who live some miles away from the gym to attend. Despite owning a car, participants recognised that there is a limit to how far they will travel. One participant who drives for 20 minutes to get to the gym, mentioned that he will not attend if he has to travel for 2 hours.

What helps me to attend is my car. I couldn't walk here. Well I could but it would take me a bloody long time and I'll have to stop and, you know. I live about some miles away, yeah, the other side of the Common, on the (Garden Road). My car is the main thing, I don't have to rely on anybody else. That's easy attending. So no problem.

Well, I suppose there must be a limit to how far you'll travel. It's about ── really we drive about 20 minutes. So yeah, the fact that it's close is, yeah, a contribu ── a good factor. ── (Ridgewell) is a little bit closer, but as long as it is ── you know, I won't travel 2 hours or something. But the fact that it's close does help make sure you come on a regular basis (Bill (P20).

7.3.4.2 Perceived benefits

Perceived benefits of the programme encouraged regular attendance. Participants expressed their experiences of the benefits of the programme and attributed their adherence to knowing that it was good for them and that they would have stopped coming if it was not beneficial. Some participants were clear about their dislike for exercising in the gym. They said it is boring and did not enjoy

coming to do the exercises. However, they stated they were committed to doing the exercises because of the benefits:

All I know is that if I didn't do these exercises I will be going downhill faster. The programme is certainly helping. If it wasn't I wouldn't be doing it. Because as I──, I don't enjoy doing it. But then if it wasn't working, I'd sort this ── I'm off. But I still do it (Brendan (P23).

Participants also recognised that doing what they do not like doing required a bit of an effort and that they pushed themselves to do it because of the benefits.

I don't like any of this. [Laughing]. ── it's something that I have to do. So I have to push myself to do it because it is helping. So ── you know, having to make the effort to get in the car to come here, you know ── it's good (Zoe (P15).

It was generally observed that the focus of the programme was at the level of the participants and the exercise instructor influenced participants' beliefs regarding the importance of physical activities and the need to maintain exercise as a component of an effective COPD management strategy. This was further reinforced by peers as they interact within the programme.

7.3.4.3 Convenient and structured programme components

Participants attended the programme because they found the time of day, day of the week and duration of exercise training quite convenient. It was clear that participants were encouraged to attend because of the structured nature of the programme, taking place at a specific place and time. The consistency and structure of the programme components enabled participants to establish a routine, plan and organise their life around the programme.

I think one of the thing [sic] is it's regular. So it's always at a particular point, so you can ── you can ── you know, so you can plan ahead. You know on a Wednesday and on a Friday at mid-day ── it's regular. So it's easy to, you know ── anything else you are doing, you can plan around it. So the fact that it's regular for me it's good (Bill (P20).

7.3.4.4 Retired (having the time)

Eleven out of the twelve participants in this sample were retired and clearly associated being retired with having the time to do the things they want to do and commit to the things they love to do:

Well I'm retired. So I have the time, ── that's basically it. I have the time and I can come. I have the time to come (Amelia (P7).

7.3.4.5 Social support (family, peers and exercise instructor)

A number of social influences encouraged participants to attend exercise classes regularly. Most participants noted the presence of family connections as a key factor that facilitated attendance. Family members included husband, wife and children who encouraged participants to attend and/or supported them to attend when they had problems that would have prevented attendance:

I no longer drive, because I've got dead feet and I can't always feel the pedals. So my husband brings me ── he brings me and collects me. So I've got a very good husband (Amelia (P7)

One participant described how he had benefitted from his wife attending the program with him despite the fact that she does not have COPD. Attendance with partner was perceived as supportive and encouraging with respect to regular attendance:

I come with my wife, you know. So if I ever think, you know, "I can't be bothered this week", she will say, "We'll go anyway" [Laughing]. So the fact that there are two of us involved, if one doesn't quite feel like doing it, the other one says "Come on let's go" and you just help each other (Bill (P20).

The group nature of the programme and friendships were also identified as significant enablers of regular attendance. Attendance was seen as an opportunity to get out of the house, meet with friends and socialise. The following quote exemplify how attendance was facilitated by the opportunity to meet friends:

I think, if you make friends who have got the same as you've got, and you ── it makes you come. Like ── look at (Merlin), I ── I think if I stop, he (Merlin) would stop. I don't know, but I think he would. I like him. But you see he likes to know if I'm here. I like (Merlin), I get on alright with him. I like (Merlin), yeah, he's a good boy, yeah. And (Monica), yeah, (Monica) is my friend. Yeah, I like all the people I meet here. They are all lovely (Daisy (P12).

Linked closely with the group nature of the programme and friendship was support provided by the other participants. This explains why participants kept coming. Some participants explained that peer support would be a solution to inability to attend as a result of transportation problems.

I drive, so I don't have a problem getting here. I ── I think If I did have a problem getting here they [peers] will come, somebody will bring me because they like me coming that much, you know (Monica (P10).

All participants identified the exercise instructor as an important part of their social network. Participants spoke of how well the instructor had engaged and supported them within the programme and this has contributed to their long-term attendance. 8 participants mentioned that they will not attend any training session if they know that the instructor will not be there.

I ── I must admit I don't like to come when I know (the exercise instructor) is not going to be here. I only feel I don't really want to be here if he's not here. [Laughing] (Monica (P10).

This sub-theme also captured participants' comments on the exercise instructor's professional and inter-personal skills which they considered very significant in empowering them. There were several references to his effective communicative and supportive skills, ability to promote self-efficacy, humorous and person-centred approach to exercise training. The instructor was described as being inspirational (motivating and encouraging), always present, patient, supportive, knowledgeable, observant, good, considerate, great, amazing, sensitive, wonderful, fair, punctual, experienced, flexible and caring. It seemed to be critical that participants were happy that the instructor showed an interest in them and understood their condition and personal situations. The instructor's ability to use these qualities to build participants' level of confidence, make the exercise training fun and less daunting appeared to be cardinal to long-term adherence.

I like the exercises in there. I have never been in a gym in my life and I'm 77 years old. That was terrifying, but with (the exercise instructor) there, it's less daunting. I couldn't have done it. I could not have done it without a responsible trainer there. We do need that person there (Amelia (P7).

7.3.4.6 Seasons

Participants expressed how at times weather influenced their wellbeing and attendance of exercise classes. Health status varies seasonally, and people experience better health status in spring/summer than in winter (Miravitlles, et al., 2004). In agreement with this, participants in this study clearly associated winter and summer with their experience of worse and better health outcomes respectively. More frequent attendance of classes was also linked with the summer when they felt better in themselves and more motivated. The following quote from a participant reflects the views of others:

You see, Wednesday and Friday is [sic] good. I mean really, I did come for a couple of times ── twice in the week and I have to say that was in the summer. I find it harder, everything is harder in the winter for me. Arthritis is worse in the winter. Hopefully, as the weather gets better now I want

to try and do two days a week again because I'm ── I'm good in the summer, I'm better in the summer (Monica (P10).

The identified enablers of regular attendance appeared to keep participants in the circle of PA (Figure 19) and enabled them maintain levels of physical activity which the quantitative data observed to be positively associated with exercise capacity and pulmonary function and negatively associated with health status and number of hospital admission.

7.3.5 Barriers

Barriers were what participants cited as factors that specifically made it more difficult for them to attend weekly classes and circumstances that prevented attendance. These were organised into the four sub-themes: (i) family commitments, (ii) Poor physical health, (iii) transport difficulties and (iv) other activities or appointments.

7.3.5.1 Poor physical health

Poor physical health was the most frequently cited factor that significantly impacted on participants' attendance. Participants related this to their experiences of chest infection, arthritis, flu, heavy cold, viral and urinary infections.

[Pause] ── well I think ── I mean the only reason I guess, I didn't come for a couple of weeks, because ── because I wasn't too well. (Inaudible- 14:14) if I had you know, ── sometimes if I get like ── chest infection, something like that, then I won't come. I mean nothing in particular will stop me coming, except if I was not well (Bill (P20)

Oh yeah!. I had ── a viral and urinary ── upset and it took a month and that prevented me from coming (Tony (P22).

7.3.5.2 Family commitments

Family commitments that impacted participants' ability to attend weekly exercise sessions centred on caring for physically unwell partner and attending to children and grandchildren. Participants often prioritised these family commitments over attending exercise classes. However, these did not frequently prevent attendance.

The only time I don't come is if I have to have my children ── my grandchildren. To me ── they are very important to me and ── you know, for instance, if ── they had a particular thing that's

going on at school that they would like me to see in, I think that I have to see it, you know. And so ── they are my priority (Lucy (P11).

7.3.5.3 Transport difficulties

The distance to travel and time taken for some participants to get to the gym were barriers to regular programme attendance. None of the participants come to the exercise classes on public transport. The sub-theme, if my car is broken down, highlights participants' expression of how difficult it would be for them to attend if they did not have a car, if their cars broke down and/or if they had to rely on public transport which is expensive, results in longer travel times and at times inefficient and unreliable.

I drive a car, and it's only about seven miles, six miles from (Strongbow). I couldn't attend unless I come in my car (Mia (P1). Only if my car is broken down I won't come, because I do need my car to come in, yea (Zoe (P15).

7.3.5.4 Other activities or appointments

Other barriers mentioned by participants were circumstances that got in the way of attendance and these included, engaging in hobbies such as painting and decorating, part-time job, going on holidays and attending hospital appointments and funerals.

… I mean sometimes I don't come it's because ── I've been decorating and still putting the paints on, so I couldn't come. I was decorating, and for a long time I come twice a week. I've been decorating for the last month (Tony (P22).

I still do work part-time, so occasionally I need to work say on Wednesday, which means maybe that particular Wednesday I can't come (Bill (P20)

The barriers to regular attendance conveyed messages about what prevented them from remaining in the circle of PA (Figure 10), hence, reducing levels of activity. They also represent participants' views about what contributed to their experiences of relapse or setbacks associated with not attending regularly. Only one of the barriers, transport difficulties, was completely addressed by the CEP. Participants did not experience difficulties attending due to owning a car and peer support in addition to programme being delivered in a centralised location not too far (average 6.2 miles) from where participants resided. None of the components of the CEP addressed three barriers- poor physical health, family and other commitments that prevented participants from attending regularly.

However, regular visits and telephone follow-up by peers and exercise instructor supported participants who may have been absent from exercise classes appeared to contribute to subsequent attendance.

7.3.6 Perception of safety

Participants described how it was important to feel safe within the CEP. There were two sub-themes within this main theme, which were factors participants attributed to their perception of safety. These included: (i) Being supported and supervised, and (ii) Self-protective safety measures.

7.3.6.1 Being supported and supervised

Participants described how daunting and unsafe it felt for them to come to terms with the reality of having to exercise in a gym. They expressed how daunting and unsafe it can be for them to use the exercise equipment. One participant explains:

I feel safe… but ── but not quite as safe as we did before they put on those new machines. Some of them are ── not quite so user friendly … For example, the Treadmill ── the Treadmill gets so loose down to the side and so when you finish, you got to turn and you got to get off it. And it's a big step down and I'm always frightened that I'm going to fall off it, and fall down. One of the Rowing machines I bashed my leg on about weeks ago and it's still not healed. It's nasty (Mia (P1).

Most of the participants described similar experiences because it was their first time exercising in a gym. However, they also explained how the instructor made exercising fun, less daunting and safe. Participants clearly associated their feeling of safety with having been regularly supported and supervised by the exercise instructor. The instructor's supportive and supervisory roles included fixing and showing how to work all the equipment, helping those who can't do the things too well, answering questions, checking vital signs (oxygen saturation) before and after every training session, keeps an eye on everyone, moving around and checking on people.

What I like best is having being supervised. Because ── you've always got that person if something did happen, you've got someone there. Otherwise you don't know what to do, do you? (The exercise instructor) makes me feel safe. The trainer makes me feel safe (Amelia (P7).

Feeling safe was also related to support from peers and other gym users who can be helpful when they need help with the machines and or when there is any unpleasant or adverse event.

Other people are around and so if anything did happen, there is somebody there. There was ── there was a situation where ── we had a guy here, and he fell and cut his head, no, the back of his

hand. And he was looked after ── you know by people in here. So if there is a problem, you can feel ── you can feel comfortable somebody good will you know, take control of it and get things sorted out (Bill (P20).

For some participants, the support, motivation and supervision provided by the exercise instructor inspired confidence in their ability to subsequently exercise and use gym equipment with minimal or no supervision. The association of safety with self-confidence in using exercise equipment without being fully supervised was recognised by all the participants.

I feel very, very safe, because when ── when ── the Easter holiday was on, we could just come out on our own. I did come out on my own, just down on the Treadmill and other machines without being supervised. Yeah, yeah, so it's pretty safe up here (Merlin (P19).

7.3.6.2 Self-protective safety measures

Taking personal responsibility for own safety was important to all the participants. They described how important it is for them to adopt self-protective measures that minimised risk of injuries and breathlessness during exercise sessions and whilst performing other physical activities. Participants frequently related feeling safe with not overdoing the activity and doing it at their own pace.

I can make my bed, but I have to pace myself. I can cook a meal, but I have to go at a certain pace. So, I'm ── I'm still living, doing things, but I have to balance them and curtail and not go silly (Brendan (P23).

In addition to not overdoing activity and performing activities at own pace, participants clearly attributed feeling safe within the programme to flexibility and availability of various exercise equipment which promoted use of certain equipment that they liked to use. There was a sense of the importance of the instructor being very understanding, promoting choice, providing guidance and not forcing them to go on all equipment.

You have the choice of equipment that you can use, that benefits you, that you either like or don't like, that suits you or doesn't suit you. ── and that's probably part of it. It's flexible, it's not totally right rigid in there, the warm-up warm-down. But you've got a bit of choice and you've got guidance from (the exercise instructor) (Brendan (P23).

7.3.7 Recommendations for programme improvement

This theme related to participants' comments on how the programme can be improved. The most frequently mentioned recommendation was having a purpose-built unit with the proper sets of

exercise equipment for people with COPD following primary PR. The underlying reasons for this was a feeling that the commercial gyms are sometimes crowded with kids from a nearby school and that they do not have the proper equipment they should be using, considering their age and conditions. One participant mentioned that the purpose-built unit would enable them to use the right set of equipment to work on their chest, while two participants were of the view that the unit would help them exercise in a less crowded place and enable the exercise instructor and the people organising the programme to be more flexible, in terms of not having to always fit in with other classes at the gyms.

I don't see that you could ── change that very much in the situation that it is, other than having a purpose built unit to go to, which has got the ── proper equipment to suit our conditions and the space to do all the other work as well. There should be a unit dedicated to this. You want a proper unit with the proper equipment. Because according to (the exercise instructor), that's not the proper equipment we should be using. I mean, I would prefer more equipment that give you ── more chest [sic] you know, to keep, it is the chest you are working on after all (Michael (P17).

In addition to references to the benefits of having a purpose-built facility, participants also identified the challenges associated with setting it up. These included cost and having dedicated people to run it.

Well, I think having a purpose built facility just for people with COPD ── and the elderly with other sorts of conditions may make a difference. It will help a little bit I suppose. I guess, it will be quite helpful and I guess it will be quite expensive to set up on its own ── your own place. ── I suppose, it would, it would sometimes, yeah, a little benefits sometimes, but I'm not sure of its extra cost, I don't know (Bill (P20)

With regards to one of the programme components (time of day that the exercise sessions took place), it was clear that the participants were mostly pleased with the afternoon sessions. However, two participants reported that they prefer morning sessions:

The only thing I would have thought is the timing. It's right in the middle of the day, which sort of takes up ── sort of you know ── it sort of takes up the whole day, you know what I mean? If it was like 10:30 in the morning, then you finish by lunch time, then you know your afternoon was [sic] free to do something else (Lucy (P11).

With regards to exercise modalities, 11 out of the participants said they liked the studio breathing, seated warm-up and cool down exercises (more or less) than using gym equipment. Hence they felt strongly that the seated warm-up and cool down exercises should be continued.

The studio exercises. I would recommend we keep those. Because we can all do those and haven't learned them, we can do those at home, ok, which I've been doing in the past four ── we can sit in our arm chairs at home and do these exercises. ── I quite like the equipment I use, which is basically just the weights drawing them up to my chest. ── So but I would definitely keep the studio good. If I had a choice, I would keep the studio good (Amelia (P7).

Several participants described how pleased they were with the programme and spoke very positively of the good organising and programme components (time of exercise sessions, exercise modalities, frequency and duration). They promised to keep attending and recommended expanding the number of locations in which the program was held for the benefit of others:

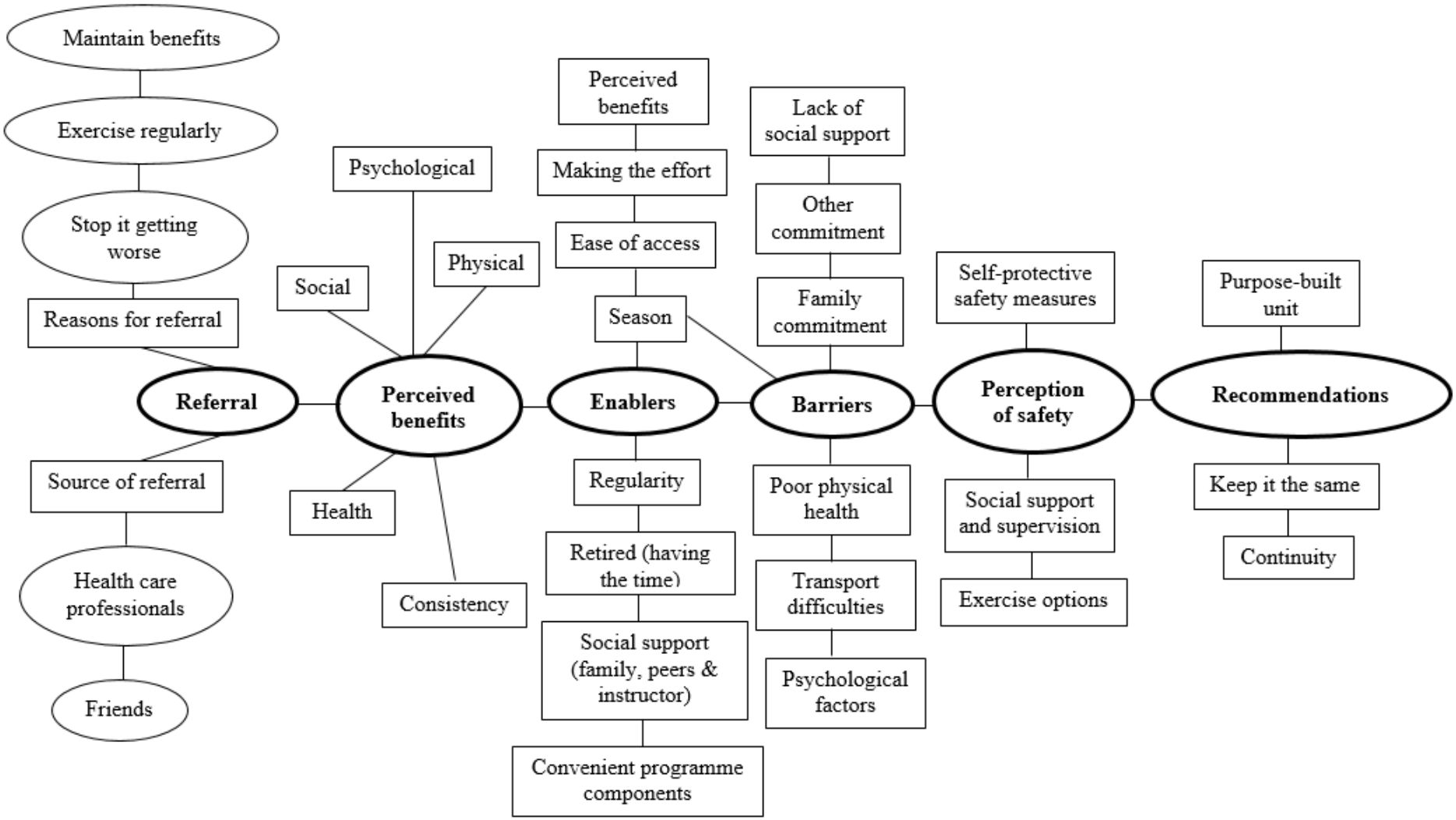
I think it [the exercise programme] works very, very well and I think that people at (Thompton Town) are lucky that they were there, but I don't know if everybody does it all over the place. It's good. Well done (the exercise instructor)! (Brendan (P23).

I think it's ── more people ought to go to it who have breathing problems (Tony (P22)

All participants spoke clearly about their desire for the programme to keep going and not be cut under budget. They considered the programme an essential for people with breathing problems. One participant described how angry she will feel if the programme is discontinued:

I think it's ── a wonderful programme. I think ── [sigh] lets put it this way, I think I'll go mad if somebody said to me next week, it's not happening anymore you can't come. So you know, at the moment, I love it, I love it, you know (Monica (P10).

Figure 23: Theme and Subthemes from interview data



7.4 Integration of Quantitative and Qualitative findings

The quantitative and qualitative data in this study were analysed separately and then integrated using a joint display approach (Appendix 18). Guetterman, Fetters and Creswell (2015) considered this as an appropriate approach and supported its use in an explanatory mixed methods study design. As mentioned earlier, the collected quantitative data was used to provide the theoretical drive for the qualitative phase of the study. Conversely, the qualitative phase validated and explained the numerical data obtained from the quantitative phase. Overall, most of the qualitative findings were consistent with the quantitative results, indicating that participating in the CEP improved levels of daily PA and clinical outcomes. Whereas the quantitative findings indicated the extent to which outcomes improved, the qualitative findings provided further information regarding: (a) how the CEP brought about the observed improvements (b) why there is no statistically significant improvement in levels of daily PA (c) additional benefits experienced by the participants, and (d) recommendations for programme improvement.

The quantitative data indicated that certain participants benefitted more than others. Mean score was computed to reflect overall improvement for each outcome (change in measured outcome). Two categories of changes were developed (low and high scores) for each outcome. Participants' scores were categorised as low and high if they were lesser and greater than the mean scores respectively. The joint display has 5 outcomes (daily PA, exercise capacity, health status, pulmonary function and number of hospital admission). Each outcome has a row for low score and another row for high score. In addition, it presents the experiences of participants that fit these two categories (Appendix 18).

There were differences in patterns of communication and relating between participants who scored low and high on measured outcomes. These observations were not unusual. They provided insights into how participants' characteristics and attitudes may influence their experience of benefits of the programme. For example, participants with low daily PAM, 6MWD and SGRQ total scores and high number of hospital admission were more likely to: (a) report more barriers to PA and attending weekly exercise classes (b) be ambivalent about their physical fitness, (c) exercise less frequently, (d) engaged more in low-intensity activities, and (e) verbalised preference for seated warm-up and cool-down exercise stretches. In contrast, participants with high daily PAM, 6MWD and SGRQ total scores and low number of hospital admission tended to report less barriers to PA, engaged more frequently with the service and appeared to have benefitted more from it. They engaged more in moderate-intensity PA, enjoyed both seated warm-up/cool-down exercise stretches and using exercise equipment and described more perceived benefits with a strong sense of determination to

exercise regularly in order to avoid deterioration. Surprisingly, high-scoring participants described not exercising at home and associated this with lack of motivation.

This data integration expanded understanding of why there was inconsistency between quantitative and qualitative data relating to improvement in levels of daily PA. While quantitative data showed no statistically significant improvement in levels of daily PA, participants reported improvements in their levels of daily activities. Three reasons were given for this inconsistency. First, participants experienced improvements in their exercise capacity and physical fitness and mostly translated these into engaging in low and moderate-intensity activities (e.g. walking to and from the local shops and pubs, playing games with grandchildren, walking their dogs, running a house, driving a car, visiting friends, bell ringing, gardening, painting and decorating, climbing stairs, DIYs and completing activities of daily living such as making beds and cooking). It is possible that the activity monitors worn by participants were not sensitive enough to capture some of the activities performed by participants, especially those involving upper extremities, e.g. church bell ringing, gardening, driving, making a bed, bathing and showering, dressing, painting and decorating.

Second, participants said they avoided or stopped engaging in high/vigorous-intensity sporting activities due to their age and limitations caused by COPD. Finally, all participants (n=12) were concerned about their personal safety and mentioned not over-doing activities and doing it at their own pace as some of the self-protective measures they adopted to minimise risk of injuries and breathlessness. Exercise capacity is positively associated with physical functioning in people with COPD. Despite improvement in this outcome, as evident in the qualitative data and corroborated by the quantitative results, participants did not translate this into high levels of daily activity due to safety concerns.

One of the participants' characteristics and attitudes that influenced experience of benefits of the programme was ability to support each other. Although social support was observed in both low and high-scoring participants, high-scoring participants tended to emphasise the benefits of social support and were notably appreciative of the support from their peers and the interpersonal and empowering skills of the exercise instructor. Unlike the Impact domain of SGRQ which does not address disease-specific social isolation and the significance of social support, the qualitative data highlighted the importance of being socially connected. They expressed that social contacts facilitated regular attendance and were sources of information, peer support, recognition, motivation and encouragement, self-confidence, mutual care, and safety. Participants' views were in agreement with findings from general observation of the programme during recruitment and data

collection process in which social interaction was observed to be a cardinal aspect of the CEP (see Figure 19). This might partly be explained by the fact that all participants have previously completed a hospital-based pulmonary rehabilitation and recognised the need to stay connected with peers and healthcare professionals to avoid being socially isolated because of COPD.

7.5 Summary

This chapter has presented findings from the qualitative phase of the study. Data were collected through semi-structure interviews with 12 participants. Interview data were thematically analysed and interpreted as a means of confirming and providing further explanation to some of the quantitative findings. Five major themes were identified from the data; referral to the programme, perceived benefits of the programme, enablers and barriers to attendance, perception of safety and recommendations for programme improvement. Majority of participants were referred by physiotherapists and nurses after they completed an 8-week hospital-based PR programme. All participants understood that they were referred in order to prevent their breathing problems getting worse and maintain benefits from initial rehabilitation.

The programme was perceived to be physically, psychologically and socially beneficial and participants emphasised the need for regular attendance in order to avoid setbacks. Sustaining benefits was associated with regular attendance which was enabled by seven factors (ease of access, perceived benefits, convenient programme components, regularity, being retired, feeling safe, social support and the seasons) and hindered by four factors (poor physical health, family commitments, transport issues, and other activities or appointments). Feeling safe was considered important by all the participants and they attributed this to being supported and supervised by the exercise instructor, availability of exercise options and adopting self-protective safety measures, notably not overdoing the activity and doing it at their own pace. Overall, participants were pleased with the programme design but recommended having a purpose-built facility for exercise after completing initial PR, continuing with the studio warm-up and cool-down exercises and that more people with breathing problems should come to it.

The chapter also integrated the quantitative and qualitative findings. This provided insights into how participants' characteristics and attitudes may influenced their experiences of benefits of the programme and also expanded understanding of why participants did not significantly improve their levels of daily activities. The findings of this study are discussed in chapter 8.

CHAPTER EIGHT

DISCUSSION OF FINDINGS

8.1 Introduction

The major findings of this study were presented in chapters six and seven. This chapter places the findings (original contributions to knowledge), according to research questions, in a larger context using existing literature. Discussion concerning the five research questions and additional findings of the study are presented.

8.2 Discussion relating to the first three Research Questions (quantitative findings)

Improving levels of daily PA and other clinical outcomes is an important goal of COPD management (Vestbo, et al., 2013). One of the aims of this study was to investigate whether participating in a CEP improves participants' daily activity and outcomes such as health status, pulmonary function, exercise capacity and number of hospital admission in people with COPD after completing an 8-week hospital-based PRP. Accordingly, the study was guided by the following research questions:

(a) Does participation in a Community-based Exercise Programme improve clinical outcomes in people with COPD following pulmonary rehabilitation?

(b) Is there a relationship between free living daily PA and measures of health status and hospital admission in people with COPD following pulmonary rehabilitation and participation in a community-based Exercise Programme?

(c) Can any of the clinical variables such as health status, pulmonary function, exercise capacity and number of hospital admission predict levels of daily PA following pulmonary rehabilitation?

Current knowledge is that increased levels of daily PA is associated with improvement of 62m in 6MWD, 2.31 and 15.55 points increase in SGRQ and CRDQ total scores, respectively, 1.3% improvement in FEV_1 following PR. However, participants' levels of daily PA were mostly measured by self-report and activity questionnaires. Objective and accurate measurement of levels of daily PA is increasingly becoming valuable for determining the extent of disability in people

with COPD and is recommended for evaluating the effectiveness of interventions for managing COPD (Vestbo, et al., 2013; Watz, et al., 2014). Accelerometer-based devices are the most accepted means of measuring levels of daily PA (Troosters, et al., 2010; Pitta, et al., 2005a; 2005b; 2006a; 2006b). The original contribution of this thesis is the objective measurement of free living daily PA and its relationship with health status, exercise capacity, FEV1 and number of hospital admission in the post-rehabilitation phase of COPD management. The study used PAM AM300 devices, which are inexpensive, less time-consuming and more practical monitors to quantify daily PA in people with COPD attending a CEP. The effects of a CEP on daily PA and other clinical outcomes were investigated and the study contributes the following five original new knowledge.

First, participants' levels of daily PA improved moderately (equivalent to 42 minutes/day on light and/or moderate-intensity activities) but not significantly. This is consistent with previous studies which reported about 1-7% improvements ($p>0.05$) in daily activity (Steele, et al., Pitta, et al., 2008; Coronado, et al., 2003). Cindy et al (2012) suggested that the capacity of an exercise programme to produce a significant increase in daily PA may be influenced by methodological factors such as nature of the programme, method of PA assessment, duration and frequency of training session, as well as clinical stability of participants over the duration of the exercise programme. With respect to method of PA assessment, accelerometers were used in this study. As 60% of studies that utilised accelerometers to measure PA reported significant improvement in levels of PA (Cindy, et al., 2012), it was expected that their use in this study will yield a similar result. The modest and non-significant improvement in daily PA observed in this study may be due to differences between this study and others reviewed by Cindy, et al (2012), in terms of the nature of rehabilitation programme, patients' characteristics and methodological issues, notably sensitivity of the activity monitors and duration of the CEP.

With regards to duration of the intervention, Pitta et al (2008) suggested that participating in an exercise programme for a short time (3 months) will not significantly improve levels of PA in people with COPD and that participants will significantly improve their levels of PA if the programme lasts for about 6 months (20±36%; $p=0.008$). When Pitta et al (2008) found that their rehabilitation programme did not produce a significant improvement in participant's levels of PA (change in walking time) despite observing significant improvements in functional exercise capacity and other outcomes after 3 months, they hypothesized that increasing levels of PA in people with COPD require participation in rehabilitation programmes for >3 months. They found that the effect size for walking time after 3 and 6 months of rehabilitation were 0.24 (95% CI, -0.32 to 0.79) and 0.53 (95% CI, 0.00 to 1.05) respectively. It can be argued that if participants in this

study had been follow-up for ≥6 months, significant improvements in levels of daily PA would have been observed.

The frequency of exercise training also contributes to improvement in outcomes. Levels of PA increased significantly in previous studies in which participants engaged in exercise training 3 times/week for ≥8 weeks. In contrast, there was no significant improvement in participants' level of PA in 80% of studies in which participants trained 2 times/week (Cindy, et al., 2012). In the present study, participants attended exercise training for an average of 1.5 times/week, hence, it is not surprising that their level of PA did not increase significantly. These suggest that people with COPD need to frequently engage in exercise training (≥3 times/week) to significantly increase their levels of PA.

The influence of clinical stability of participants on measured clinical outcomes was not reported in this study. Nevertheless, this influence was reported in previous studies. The studies by Steele et al (2010) and Pitta et al (2006) suggests that levels of PA deteriorated in participants who were clinically unstable, defined as experience of ≥1 acute exacerbations during the follow-up period. Notably, this decline in levels of PA persisted for several weeks in the study by Pitta et al (2006). However, deteriorations in levels of PA (walking time in daily life and 6MWD scores) due to severe acute exacerbation requiring hospital admission were not very significant when patients participated in a rehabilitation programme that lasted for six months (Pitta et al 2008), suggesting that longer duration interventions even out the influence of clinical stability.

Second, participants' exercise capacity (6MWD), health status (SGRQ total score), and FEV1 improved significantly by 45.38m (95% CI:-67.62 to -23.15, $p<0.001$), 4.01 units (95% CI: -0.50 to 8.60, $p=0.04$) and 0.04L ($p=0.007$) respectively, while number of hospital admission reduced by 41% ($Z= -3.04$, $n=26$, $p=0.02$). The significant improvement in 6MWD observed in this study is consistent with results from other a systematic review (Beachamp, et al., 2013) and is clinically important. In research and clinical practice, the 6MWD test has become the principal method of assessing physical fitness and exercise tolerance in people with COPD (Goldstein 1990; Watz, et al., 2014). Physicians and rehabilitation specialists are now able to easily measure 6MWD of their service users using the internationally recommended protocol (ATS, 2002) which is very well tolerated by people with COPD (Liesker, et al., 2002; Amardottir, et al., 2007; Bradley, et al., 2007). COPD has a strong link with reduced 6MWD. In the study by Garcia-Aymerich, et al. (2006) 6MWD was less by 36m in people with COPD compared with age-matched healthy individuals. 6MWD reduced by 26m every year in people with COPD in a different study (Pinto-

Plata, et al., 2004). Studies report that 6MWD independently predicted mortality in people with COPD (Oga, et al., 2003; Pinto-Plata, et al., 2004; Casanova, et al., 2007). A ≥30m reduction in 6MWD increased risk of death in people with COPD (Pinto-Plata, et al., 2004; Casanova, et al., 2007). Reducing COPD-related morbidity and mortality is a goal of COPD management (Vestbo, et al., 2013). This study shows that participation in a post-PR CEP improved participants' mean 6MWD by approximately 45m at 3 months. Aside 6MWD, health status is also an important outcome measure in COPD management (Vestbo, et al., 2013). In this study, health status (SGRQ total score) improved significantly following participation in the CEP for 3 months. This result is similar to those reported in an earlier study with similar duration of exercise programme (Pitta, et al., 2008). COPD has considerable impact on health status and mortality. There is evidence that high SGRQ total scores (poor health status) increased the risks for hospital readmission and mortality (Garcia-Aymerich, et al 2006; Almagro, et al., 2002; Antonelli-Incalzi, et al., 2009). This makes improving health status another goal of COPD management (Vestbo, et al., 2013). In contrast to previous work (Beuchamp, et al., 2013), this study reported on the effect of CEPs on hospital admission. It found a 41% reduction in number of hospital admission. The relatively short follow up period (3 months) may have contiubted this observation. Besides, the significant improvement in health status may have influenced reduction in number of hospital admission as the two variables are known to be positively associated (Garcia-Aymerich, et al., 2003; 2006; 2008; Pitta, et al., 2006b; Benzo, et al., 2010; Garcia-Rio et al., 2012).

The third contribution to knowledge is the demonstration of correlation, at the end of the 3 months follow-up, between daily activity and other outcomes. Daily PA correlated positively with 6MWD ($r=0.40$, $p=0.046$) and negatively with HRQoL ($r= -0.52$, $p=0.006$) and number of hospital admission ($r= -0.394$, $p<0.05$) but no correlation with FEV_1 ($r= 0.038$, ns). Similar results were reported in earlier studies on the pre-PR relationship of levels of PA with clinical outcomes. For example, daily PA negatively correlated with health status test scores in five previous studies (Garcia-Aymerich, et al., 2004; McGlone, et al., 2006; Hernandes, et al., 2009; Esteban, et al., 2010; Arne, et al., 2011). Two of these studies reported modest correlation coefficient ($r= -0.30$, $p<0.05$) (McGlone, et al., 2006; Hernandes, et al., 2009). This means that low levels of daily PA is associated with poor health status (HR, 0.93, 95% CI, 0.90-0.96) as observed by Garcia-Aymerich, et al. (2004) and high levels of PA is linked with high health status (OR, 7.78; 95% CI, 4.66-12.97) as reported by Arne, et al. (2011). The post-PR result of the relationship of daily PA with health status ($r= -0.424$, $p<0.05$) observed in the current study also corroborates these previous results. Sufficient to say that this is also the case for 6MWD where positive correlation with daily activity

was reported (Pitta, et al., 2005a; Garcia-Aymerich, et al., 2009; Watz, et al., 2009; Hernandes, et al., 2009; Garcia-Rio, et al., 2009; van Gestel, et al., 2012).

This study observed a significant negative correlation between daily PA and number of hospital admission (r= -0.394, p<0.05). This suggests that in the post-PR phase of COPD management, increasing participants' levels of daily PA can reduce number of hospital admission. This result is in agreement with earlier findings in participants prior to PR (Garcia- Aymerich, et al., 2003; 2006; 2008; Pitta, et al., 2006; Benzo, et al., 2010; Garcia-Rio, et al., 2012). The dose of daily PA associated with reduced number of hospital admission is of clinical significance. The recommended level of PA for people with COPD by the ACSM is 30 minutes/day of moderate activity such as walking (ACSM, 2013). Garcia-Aymerich, et al. (2003) reported that moderate level of daily PA (equivalent to walking 2 hours/week) reduced the risk of hospital admission by 30-40% among 2,386 people with COPD recruited from Copenhagen. In a different setting (Barcelona), reduced risk of hospital admission was found in participants who walked 1 hour/day (Garcia-Aymerich, et al., 2006). Following discharge from hospital, Garcia- Aymerich, et al. (2003) found that low level of daily PA (equivalent to walking <1 hour/day) was a significant risk factor for hospital readmission in people with COPD. According to Benzo, et al. (2010), ≥2h/week of activity reduced number of hospital admission (OR, 0.60; 95% CI 0.41–0.88; p=0.01). The current study found that, levels of daily PA was negatively associated with number of hospital admission (r= -0.394, p<0.05). However, a change in moderate levels of daily PA (42 minutes/day) was not significantly associated with a change (41% reduction) in number of hospital admission (r= -0.22, *p*= 0.28). The differences in percentage reduction in the number of hospital admissions reported in the present and earlier studies may be due to difference relating to environment, climate, study design, length of follow-up, and participants' phase of disease management (pre or post rehabilitation). Some of these differences are also likely to account for different patterns of daily PA and give an indication of the external validity of the associations reported in the studies. These results suggest that the burden of COPD can be reduced by actively encouraging and supporting people with COPD to be more physically active and participate in CEP following initial PR. Interestingly, participants' average level of daily PA was considerably more than the 30 minutes per day of moderate activity recommended for health in people with COPD (ACSM, 2013).

In the correlation and regression analyses, the relationships of daily PA with severity of COPD (FEV_1) were not statistically significant (r= 0.038, ns), suggesting that degree of participants' airflow limitation and disease severity is not an indicator of impairment in level of daily PA. In the general population, a high level of daily PA is associated with a slower deterioration in FEV_1

(Jakes, et al., 2002; Pelkonen, et al., 2003). With regards to the relationship between PA and FEV_1 in people with COPD, previous research is equivocal. Two studies published by Garcia-Aymerich, et al. (2004) and Hernandes, et al. (2009) found that daily PA correlated with 6MWD and health status but had no association with FEV_1. In other studies of the correlates of PA, Pitta, et al. (2005a; 2008) found modest correlations between daily PA and FEV_1 ($r= 0.30$, $p<0.05$). Modest correlations ($r= 0.4$, $p<0.01$) between these variables were also reported in the studies by McGlone, et al. (2006) and Watz, et al. (2009). Methodological issues such as sample size, methods of assessing daily PA and FEV_1, duration of follow-up may have contributed to these inconsistencies. Nevertheless, other researchers identified FEV_1 as a determinant of health status that has a negative correlation with number of hospital admission in people with COPD (Tsiligianni, et al 2011; Bridevaux, et al., 2008).

In the pre-rehabilitation phase of COPD management, 6MWD, HRQoL and hospital admission are important correlates of physical activity (Esteban, et al., 2010; Arne, et al., 2011; Pitta, et al., 2005a; Garcia-Aymerich, et al., 2003, 2006, 2009; Benzo, et al., 2010; Garcia-Rio, et al., 2012), suggesting that improvement in levels of activity can be explained by improvements in 6MWD, HRQoL and reduction in hospital admission. Results from this study show that these findings still apply in the post-rehabilitation phase. In contrast, the data suggest that the moderate and statistically insignificant improvement in daily PA cannot be explained by the lack of improvements in other outcomes since 6MWD (the main predictor of daily activity) (Pitt, et al., 2005a; Garcia-Rio, et al., 2009; van Gestel, et al., 2012) and SGRQ scores improved and hospital admission reduced significantly over 3 months. On one hand, the CEP adequately improved participants' capacity to perform daily activities, reduced COPD symptoms and hospital admission and other barriers to daily PA. On the other hand, participants did not immediately translate the observed benefits of the programme into being more physically active in daily life. This suggests that improving 6MWD, health status and reducing hospital admission is not enough to make participants more physically active in daily life. It appears that people in the post-rehabilitation phase of COPD management will require other psychological factors (e.g. setting daily PA goals, incentives), environmental factors (e.g. season, safety) and other factors in order to significantly increase levels of daily PA.

The fourth contribution to knowledge relates to the demonstration of the clinical relevance of moderate improvement in levels of daily PA over the 3-month follow up period. This was considered by observing whether or not the moderate change in daily PA correlated with changes in other measured outcomes. It was found that moderate improvement in daily PA correlated

positively with changes in 6MWD (r=0.31, p=0.048) and negatively with changes in HRQoL (r= -0.65, *p*=0.0001). This has clinical relevance when considered in the context of their Minimal Clinically Important Difference (MCID) for people with COPD. Jaeschke, Singer and Guyatt (1989 p. 23) defined the MCID as *"... the smallest difference in a score in the domain of interest which patients perceive as beneficial and which would mandate, in the absence of troublesome side effects and excessive costs, a change in the patient's management"*. Puhan, et al. (2008) and Holland, et al. (2010) established that 6MWD test scores should change by approximately 25m and 35m respectively for people with moderate to severe COPD in order to represent an important effect. The 45m improvement shown in this present study exceeds the MCIDs for the 6MWD. Similarly, the 4.01 unit improvement in mean SGRQ total score observed in this study is of clinical importance because it equals the MCID value for HRQoL in persons with COPD (Jones, 2005), representing a significant change.

Finally, the sudy identified a clinical outcome that predicted levels of daily PA post-PR. In previous studies, 6MWD was the most important predictor of daily activity (Pitt, et al., 2005a; Garcia-Rio, et al., 2009; van Gestel, et al., 2012). In contrast to the multivariate models pre-PR (Garcia-Rio, et al., 2009), 6MWD was not retained in the final multivariate model post-PR, suggesting that 6MWD test scores cannot reliably predict levels of daily PA. Health status (HRQoL) was the only predictor of daily activity in this study (Beta= -0.47, t= -2.85, p=0.009, $R^2_{adjusted}$=0.38). This result is concurrent with other pre-rehabilitation studies in which health status and/or its indicators (e.g. dynamic hyperinflation, change in end-expiratory lung volume and the GOLD severity classification) predicted daily PA (Garcia-Aymerich, et al., 2004; Garcia-Rio, et al., 2009; Watz, et al., 2008; Sandland, et al., 2005). Nevertheless, the exact contributions of health status were not specified in these studies. For example, the 84% reduction in levels of daily PA in people with moderate to severe COPD reported by Garcia-Rio, et al (2009) was due to a combination of three factors- the development of dynamic hyperinflation, change in end-expiratory lung volume, and lower 6MWD scores. In the present study, health status alone accounted for 38% of participants' daily PA, suggesting that other factors contribute to daily activity in the post-rehabilitation phase of COPD management. This result highlights the importance of assessing and helping patients' maintain their health status using effective strategies in order to be physically active and achieve COPD management goals as previously recommended by Tsiligianni, et al (2011), Vestbo, et al (2013) and Watz, et al (2014).

In summary, this study found that, participating in a CEP after completing an initial hospital-based PR improves moderate levels of daily PA, significantly improves health status, exercise capacity

and FEV_1 and reduced number of hospital admission. The relationships between increase levels of PA (measured by PA questionnaires) and improvements in clinical outcomes (6MWD and HRQoL) still apply with objectively measured free living PA data, but not with pulmonary function. Of the outcomes assessed in this study, only health status scores (SGRQ total scores) significantly predicted levels of daily PA in the post-PR phase of COPD management. However, health status only accounted for approximately 38% of variance in daily PA, suggesting that other factors contribute to daily PA.

The mechanisms by which regular daily PA produces benefits and relationships with clinical outcomes in people with COPD are unknown. Some authors have provided biological explanation linking these to increase exercise tolerance, reversal of skeletal muscle weakness, fatigue (Wust, et al., 2008; Seymour, et al., 2010) and systemic inflammation (Barnes and Celli 2009; Troosters, et al., 2010). Regular PA strengthens skeletal muscles (Garcia-Aymerich, et al., 2009; Waschki, et al., 2012) and this was associated with increased exercise capacity and reduction in number of hospital admission (Puhan, et al., 2005; 2011; Pitta, et al., 2006b). At the cellular level, Sala, et al. (1999) showed that exercise training improves energy transformation by skeletal muscles in people with COPD and this was thought to reduce symptoms by reducing the production of lactate during physical exertion. Researchers such as Troosters, et al. (2010) and Rabinovich, et al. (2013) demonstrated that exposure to moderate-intensity resistance exercise training produce significant anti-inflammatory and anti-oxidant effects (as indicated by levels of C-reactive protein and tumour necrosis factor alpha) in people with moderate to severe COPD. Explaining the mechanism underlying the relationship of daily PA with clinical outcomes is beyond the scope of the present study, nevertheless, the study explored factors that influenced the observed relationships. These were outlined in section 7.3.3 and are discussed in the following section.

8.3 Discussion relating to the last two Research Questions (qualitative findings)

One of the aims of this study was to explore participants' views of the benefits of the CEP as well as barriers and facilitators of adherence to the programme. Accordingly, the qualitative study was guided by two research questions:

- What are COPD patients' views of the benefits of the community-based exercise programme to which they were referred after completing pulmonary rehabilitation?

- What helps COPD patients to be able to attend the weekly exercise classes and what makes it more difficult for them to attend?

When these questions were addressed using face-to-face semi-structured interviews, participants' positive perceptions of the benefits of the programme were highlighted in addition to uncovering of factors that facilitated and acted as barriers to regular attendance. The following is the discussion of findings relating to benefits of the programme, factors that enabled regular attendance and those that affected programme adherence. There were six original contributions to knowledge from the qualitative study:

(a) The programme was associated with health, physical, psychological and social benefits.

(b) One previously identified barrier (changing physical health) to physical activity still apply. Other barriers such as lack of motivation, fear and social isolation did not apply because they were addressed by the group nature of the CEP which provided consistent social support and opportunity for interaction. Three new barriers were identified in this study; transport difficulties, family commitments, and engaging in other activities.

(c) The facilitators/enablers of daily PA and regular participation in programmes (healthcare professionals, social supporters, motivation and encouragement, reduced fear and seeing benefits) still apply. Six new facilitators emerged from this study; easy access (proximity and owning a car), perceived benefits of the programme, convenient programme components, being a retiree, social support (family, peers and exercise instructor), and seasons.

(d) Lack of motivation was associated with not exercising at home despite having different home exercise equipment.

(e) Deterioration in perceived benefits was associated with irregular programme attendance or lack of consistency.

(f) Feeling safe within the programme

This study is unique because it examines the views of patients with COPD attending a post-PR supervised CEP. The participants in the programme articulated several health, physical, psychological and social benefits of the programme citing absence of chest infection, coping with breathlessness, improved breathing, getting off antibiotics and ambulatory oxygen therapy, strengthened skeletal muscles, feeling stronger and fitter, maintenance of levels of physical activities, reduced depression, fear and anxiety associated with being breathless when performing

exertional activities, improved motivation and self-confidence as well as meeting people with similar conditions. These results are consistent with those reported by Desveaux, et al. (2014b). What this study adds is that, in addition to the overwhelming endorsement of these benefits, participants emphasized the need for regular attendance in order to avoid experiences of deterioration in physical ability and COPD symptoms.

Consistent with the results from the study by Desveaux, et al. (2014b), this study found more references to facilitators than barriers to programme attendance, indicating their positive experience in the CEP. As a result of their positive experiences in the program, participants expressed their desire for the programme to continue, commitment to keep attending and recommended it to people with similar conditions. Unlike in the study by Desveaux, et al. (2014b) in which participants' recommendations for programme improvement mostly addressed the burdens associated with the programme (e.g. negative aspects of the overall design, access during winter months, cost and proximity), participants in this study did not perceive any of these burdens. They were mostly satisfied with the overall programme design and components of the programme which they recommended to keep the same. Participants mostly recommended having a purpose-built facility with the proper sets of exercise equipment, considering their age and conditions.

The five barriers to increase levels of daily PA and circumstances that prevented attendance of weekly exercise classes were mostly unrelated to the programme itself. They were similar to those highlighted in previous studies (Keating, Lee and Holland, 2011; Hellem, Bruusgaard and Bergland, 2012; Thorpe, Johnston and Kumar, 2012) and included poor physical health, transport difficulties, family commitments and other commitments such as going on holidays. Deterioration in physical health was the most frequently cited barrier. This is expected in people with moderate to severe COPD given the chronicity of the disease and its negative impact on people as well as the fact that post-PR CEPs cannot completely stop the progressive deterioration in COPD symptoms. This also gives credence to the fact that the current study reflects real life events in a long-term CEP. Other barriers identified by other researchers included depression and lack of perceived benefits (Keating, Lee and Holland, 2011). Surprisingly, lack of motivation did not emerge as a barrier to programme attendance in this study as previously identified by Thorpe, Johnston and Kumar (2012). It was mainly associated with not exercising at home despite participants having home exercise equipment and the capacity to do so.

Sabit, et al. (2008) found that longer travel time was an independent correlate of poor attendance and that proximity of a PR programme to participants' homes was of borderline statistical

importance. Transport difficulty is a common concern for people with COPD attending rehabilitation programmes. This is probably because many of them have physical health problems which make them unfit to drive. Without using personal or family transport, the only alternative for people is to depend on expensive private taxis or hospital transport, which can be expensive, inefficient, unreliable and increase travel time. A longer travel time may be very inconveniencing and stressful especially to people with physical health problems and disabilities. The problem of lack of transportation is worsened by the fact that CEPs are not widely available in the UK because approximately 64% of 160 PRPs do not provide follow on care for participants after completing PR (BTS, 2002), prompting recommendations for more services by researchers and organisations that provide guidance and advice to improve health and social care (NICE, 2011; Bolton, et al., 2013). Although recent results of rehabilitation and post-PR programmes' survey in the UK are lacking, personal experience is that existing number is inadequate. This means that people will have to travel far in order to attend programmes. Participants reported fewer barriers because the exercise instructor and peers supported them to overcome barriers such as fear of breathlessness and lack of motivation and this appeared to have improved their level of activity. In keeping with the ''Perceived Barriers'' construct of the Health Belief Model (Hochbaum, Rosenstock and Kegels, 1952), participants who perceived fewer barriers to their course of action are expected to be more likely to increase their levels of activity.

The six (6) reported factors that positively facilitated increase activity participation and regular attendance were; easy access (proximity and owning a car), perceived benefits of the programme, convenient programme components, being a retiree, social support (family, peers and exercise instructor), and seasons. Easy access to the programme was an interesting finding because of its previous association with reduced PA (Sabit, et al., 2008). As this CEP was easily accessible to all participants, attendance and increase activity were facilitated. Although some of the identified facilitators have previously been mentioned in an earlier study (Desveaux, et al., 2014b), it is worth mentioning that some facilitators highlighted by other studies emerged as perceived benefits in the present study. For example, while motivation, encouragement and social support were identified as primary facilitators (O'Shea, Taylor and Paratz, 2007; Wang, et al., 2013), participants in this study perceived these as some of the benefits of the programme. Nevertheless, perceived benefits also emerged as important facilitators of attendance in this study. This underscores the individual, coexisting and overlapping nature of the facilitators and benefits of rehabilitation programmes for people with COPD.

Results from earlier studies suggested that participants are very much inclined not to adhere to interventions if they do not perceive the benefit(s) of the interventions (Christensen and Johnson, 2002). Perceived benefits facilitated increase activity participation with the CEP. Most participants said, despite not enjoying exercising at the gym and finding it boring, they attended exercise classes because of the benefits they gained from it. This is in agreement with results from the study by Stewart, et al. (2014) and highlights the importance of the role of perceived benefits in maintaining daily PA behaviours. This also suggests that a reinforcement of participants' belief in the benefits of PA can help them become more physically active, again in agreement with the ''Perceived Benefits of Taking Action'' construct of the Health Belief Model (Hochbaum, Rosenstock and Kegels, 1952).

Motivation and encouragement from participants' social network (peers and instructor) appeared to be crucial. The social support enabled participants to better understand reasons for breathlessness and how to cope with it when performing PA. Seeing people similar to oneself completing exercise protocols inspired personal belief in their ability to do the same. This efficacy belief has earlier been referred to as modelled attainment (Bandura, 1997). People with COPD have been able to cope with behavioural changes and positive lifestyle changes following pulmonary rehabilitation due to support from their peers (Stewart, et al., 2014). In addition to other factors, perceived social support through camaraderie in group exercise facilitated long-term concordance in this study as in other studies (Lewis and Cramp, 2010; Thorpe, Johnston and Kumar, 2012).

Deterioration in perceived benefits was associated with irregular programme attendance or lack of consistency. The sub-theme consistency indicated participants' experiences of deterioration in physical ability and COPD symptoms when they stopped attending the exercise classes for any reason and also emphasized the need for regular attendance in order to avoid relapse to insufficient levels of physical activity in daily life and decline in benefits of PRP is the major goal of CEPs. This result is supported by quantitative studies that reported decline in clinical outcomes following PR (Verrill, et al 2005; Heppner, et al., 2006; Karapolat, et al., 2007). To my knowledge this is the first qualitative study to corroborate findings from quantitative studies in relation to deterioration in benefits. It should be noted that the decline in benefits reported in quantitative studies was observed 3-12 months after cessation of the programmes and this provided evidence for the recommendation of CEPs by clinical guidelines (Nici, et al., 2006; Vestbo, et al., 2013; WHO, 2013). Result from the present study shows that it is possible for participants to experience deterioration within an on-going CEP due to irregular attendance. This result therefore emphasises the significance of keeping

participants motivated and supported to overcome perceived barriers to regular PA and attendance of programmes that aim to maintain benefits of PR.

Feeling safe appeared to be an important issue for all participants in the present study. Concerns about personal safety were previously cited as barriers to attending rehabilitation programmes with exercise training component (O'Shea, Taylor and Paratz, 2007; Wang, et al., 2013; Desveaux, et al., 2014b), leading to participants suggesting several recommendations on how to enhance safety. Unlike these studies, participants in the present study reported feeling safe in this programme and related this to been regularly supported and supervised by the exercise instructor, the presence of their peers, not being forced to use all exercise equipment, not overdoing the exercise and doing it at their own pace. Although participants spoke strongly about feeling safe, they did not specifically associate this with long-term adherence.

8.4 Discrepancy between quantitative and qualitative findings

There was inconsistency between quantitative and qualitative data relating to improvement in levels of daily PA. While quantitative data showed no statistically significant improvement in levels of daily PA, participants reported improvements in daily PA. Three reasons might explain this inconsistency. First, it is possible that the accelerometer-based devices (PAM AM300) discriminated between PA intensities and detected activities of moderate and/or vigorous intensities like brisk walking, jogging, climbing stairs and running, which are simply performed less frequently by most of these participants, probably because they have modified their environment and the type of activities they engage in due to the limitations caused by COPD. As mentioned by Pitta, et al. (2006b), accelerometers may not accurately detect intensities of PA mainly involving the upper limbs e.g. gardening, painting and church bell ringing as well as they do for activities using the lower limbs. This hypothesis is supported by the results that participants in this study spent more time in the living and health zones (engaging moderate-intensity activities) than in the sports zones, which is characterized by vigorous-intensity activities. Therefore, most of the participants' daily activities may not have been detected or scored by PAM AM300 devices. Second, it is plausible that activities that are valuable to participants were not detected by the monitors. When participants described their experiences of the effects of the programme on physical function, there were more references to improvement of daily PA in the living zone e.g. running a house, driving a car, visiting friends (socialising), gardening, painting and decorating, DIYs and completing activities of daily living (e.g. making beds and cooking). Improvement in ability to engage in these activities can be a sign of increased exercise capacity and health status as demonstrated in this study. Finally, the participants may have benefitted from an initial PR

(Beauchamp, et al., 2013; Vestbo, et al., 2013), which includes increase levels of daily PA, therefore a significant increase in physical functioning was not expected.

8.5 Additional new knowledge

This study also contributes the following new knowledge to existing COPD literature:

- PR programmes have been well characterised (Desveaux et al 2014a, Yohannes and Connolly 2004). This is the first study that characterise a CEP. The feature of this CEP included (a) low-cost access, (b) co-ordination and supervision by a non-healthcare professional (an exercise instructor), (c) a six-stage cycle of physical activity, (d) tolerable exercise modalities which include 24 seated warm-up and cool-down exercises, 5 cardiovascular, 12 resistance training exercises and (e) social interaction (see section 6.2).

- Feeling safe was considered important by all the participants and they attributed this to being supported and supervised by the exercise instructor, availability of exercise options, not being forced to use all exercise equipment and adopting self-protective safety measures, notably not overdoing the activity and doing it at their own pace.

- The lack of motivation which was associated with not exercising at home despite having different home exercise equipment has an important implication for home-based PR and CEPs.

- Participants typically followed a distinct six-stage cycle of PA within the CEP and this suggests how they avoided reverting to sedentary lifestyles and a previously described vicious cycle of physical inactivity pre-PR (Troosters, et al., 2013; Corhay, et al., 2014). These two cycles of PA appears to be mutually exclusive

- Experiences of deterioration in perceived benefits were associated with irregular attendance within an on-going CEP.

These new contributions to knowledge have important implications for future research, rehabilitation professionals and the health care system as highlighted in section 9.2.

8.6 Discussion relating to Additional Findings of the Study

This section discusses the unique features of the CEP that were uncovered through information obtained from documents relating to the programme and general observation during the recruitment and data collection process. Although these findings are not in general critical to answering any of the research questions, they have practice implications in addition to providing context needed to understand the findings of the study.

Considering the natural deterioration in clinical outcomes following PR, it is currently recommended for all providers of PR services in the UK to ensure that people with COPD are facilitated into CEPs after completing PR (NICE, 2011; Bolton, et al., 2013). Although recent results of PR survey in the UK are lacking, a previous survey (BTS, 2002) conducted by the BLF and the BTS in October 2002 found that only 55 (36%) of the 160 PR programmes provided follow on care for people with COPD after completing PR. This reflects inequalities in service provision and may prevent people with COPD from achieving the goal of improving their well-being. Tackling such inequalities is essential to improving outcomes and additional resources will be needed to implement and scale-up recommendations. This requires knowledge on how to set up rehabilitation programmes. PR programmes have been well characterised (Desveaux, et al., 2014a; Yohannes and Connolly, 2004), but no study has been found that characterise any post-PR CEP. Published studies only include brief information regarding setting, supervision, frequency, intensity, duration and types of exercise training completed in the CEP (Cooke, et al., 2009; Beauchamp, et al., 2013; Moullec, et al., 2008). It is imperative for the key features of this CEP to be discussed. This may help improve understanding of the provision and design of existing and future CEP.

It was identified that the CEP was provided by a local Council in partnership with a lifestyle and facility management company. The programme, which was offered in a typical fitness gym, was characterised by low-cost access, supervision by a non-healthcare professional (an exercise instructor), 24 seated warm-up and cool-down exercises, 5 cardiovascular, 12 resistance training exercises, a six-stage cycle of PA and social interaction.

The cost of accessing PA intervention, for example gym membership prices, is an important consideration for potential participants and can prevent people from exercising regularly. Although participants paid £3.50 each for an exercise training session, none of them cited this as a barrier to regular attendance. In a previous study (Bethancourt, et al., 2014), low-cost access was also identified as an important facilitator of increased levels of PA among healthy older adults. Two

systematic reviews of barriers and facilitators of PA in people with COPD have also not reported cost as a barrier. These suggest that access to affordable PA intervention facilitates activity participation in the post-PR phase of COPD management.

Guell, et al., (2008) highlighted the need for participants' supervision to ensure success of CEPs. They suggested following up participants in home-based programme through telephone calls and occasional visits by supervisors. This approach produced positive benefits in studies by Moullec, et al. (2008) and Cooke, et al. (2009). However, it is possible that follow-up will not effectively change participants' behaviour. This assumption is supported by an observation from a more recent study (Soicher, et al., 2012) which found that participants returned to their pre-rehabilitation behaviour patterns despite being followed-up through bimonthly phone calls. It is believed that the need for regular follow-up and supervision of participants in home-based exercise programmes, as suggested by Guell, et al. (2008), may be associated with economic burden for providers of the service. It is also unclear the degree of professional supervision that is needed for supporting participants. Some researchers have reported that people with COPD appreciate having regular contacts with physiotherapists who are able to tailor exercise programmes to their individual needs (Hellem, Bruusgaard and Bergland, 2012; Desveaux, et al., 2014b). Spruit, et al. (2004) highlighted the importance of the guidance of physiotherapists who have broad knowledge of different exercises for people with pulmonary diseases. Other researchers have recognised that close supervision by a team of health care professions, especially physiotherapists and nurses, is associated with overall success of PR and post-PR exercise programmes (Beauchamp, et al., 2013; Hellem, Bruusgaard and Bergland, 2012; Desveaux, et al., 2014b).

In the present study, a trained exercise instructor co-ordinated the CEP and supervised participants during exercise training. This means that a CEP does not essentially have to be provided by the health care system and coordinated or supervised by healthcare professionals (physiotherapists). This result is a new contribution to knowledge and differs somewhat from studies in two recent systematic reviews conducted by Beauchamp, et al. (2013) and Desveaux, et al. (2014a) in which follow-up programmes were mostly supervised by healthcare professionals, notably physiotherapists and respiratory nurses. Guell, et al. (2008) were of the view that the major factor to be considered is for the individual to have some knowledge on different exercise modalities and be able to teach people with COPD how to safely perform the exercises. Unlike in a previous study (Bethancour, et al., 2014) where lack of professional guidance and support was recognised as a barrier to activity participation, participants in the present study emphasised the significance of the exercise instructor's professional, inter-personal and empowering skills which they said increased

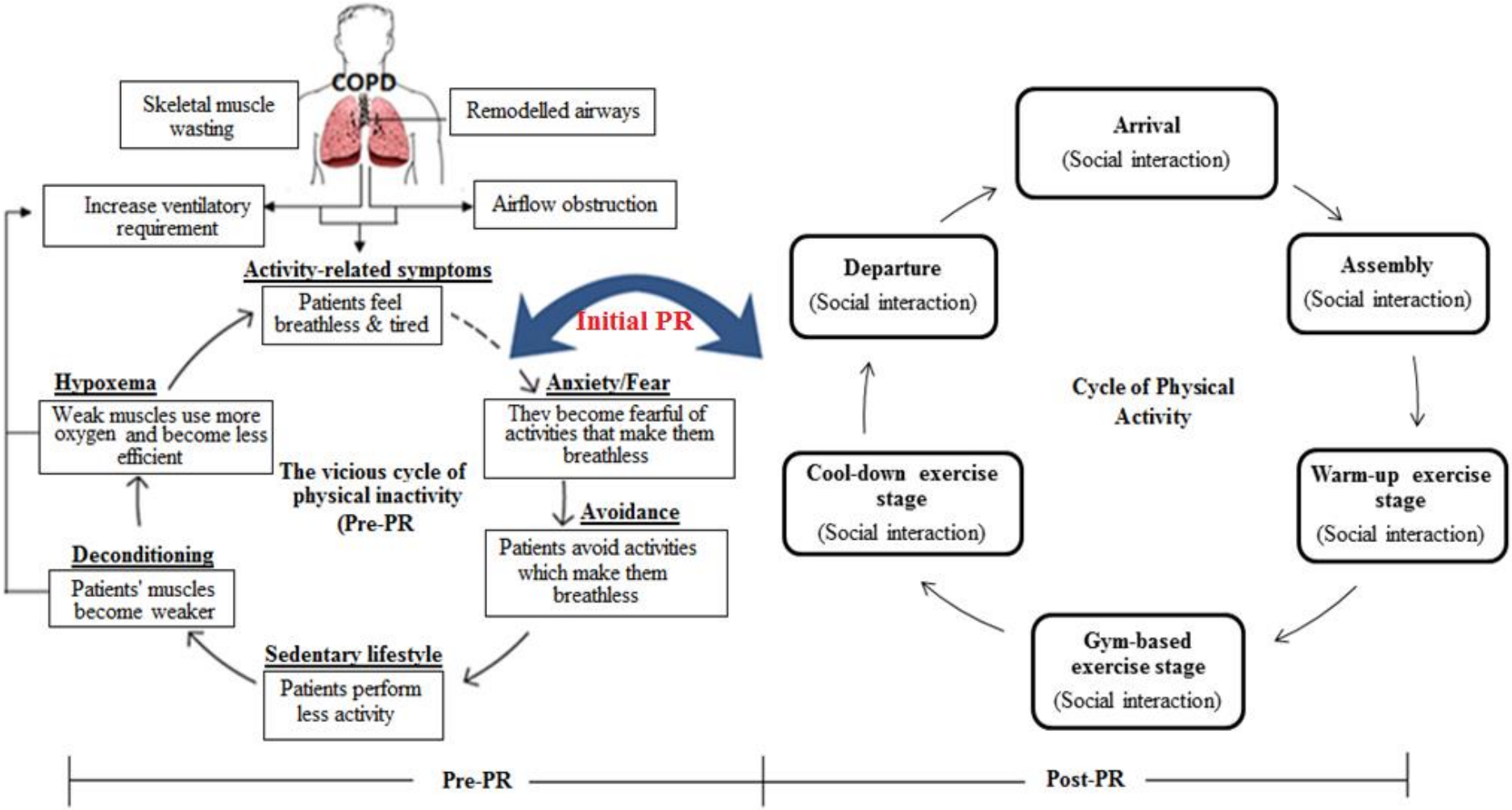
their level of confidence, made the exercise training fun and less daunting and promoted long-term adherence. Most of these skills have previously been identified in teams of health care professionals supervising rehabilitation and post-PR exercise programmes (Beauchamp, et al., 2013; Hellem, Bruusgaard and Bergland, 2012; Desveaux, et al., 2014a; 2014b). This indicates that the skills needed to empower participants and facilitate adherence to long-term post-PR CEPs can be developed by non-healthcare professionals with cost-effectiveness implication.

Non-healthcare professional support through inspiration (motivation and encouragement), building self-confidence and optimism, recognising and understanding participants' condition enabled them to think positively. This appears to agree with the theory of empowerment espoused by Walseth and Malterud (2004). According to this theory, professionals empower their service users by supporting and helping them set objectives to be achieved and adapting the objectives to their individual capacity using available resources. Having an awareness of participants' conditions, the professional does not push them beyond their limits but advises and motivating them to do as much as they can to participate actively. Walseth and Malterud (2004) also recognised that empowering people requires effort, patience, and long-term participation in a programme. Hellem, Bruusgaard and Bergland (2012) explained that because physiotherapists work with their clients in an advisory capacity and treat them over a period of time, they are able to provide an environment where positive feelings, bodily experiences, thoughts and cognitive processing are developed. Another important outcome from this interview was that the participants perceived that their exercise instructor understood them, was interested in their wellbeing, enthusiastic and knowledgeable about COPD and exercises for those with disease. Participants in a previous study have expressed that it is difficult for them to find healthcare professionals in the primary health service that will approach them with interest, understanding, and enthusiasm (Hellem, Bruusgaard and Bergland, 2012). Results from this study support the view that when non-healthcare professionals show interest, understanding and enthusiasm in participants' ongoing exercise needs the probability increases that the participants will engage and adhere to the programme for as long as it lasts.

The general observation that participants typically followed a distinct six-stage cycle of PA within the CEP is a new contribution to knowledge and appears to suggest how they avoided reverting to sedentary lifestyles and the vicious cycle of physical inactivity following PR. As noted earlier, people with COPD are less physically active in daily life than those without the disease (Pitta, et al., 2005a; Hernandes, et al., 2009; Vorrink, et al., 2011) and people with other chronic conditions (Arne, et al., 2009). Troosters, et al. (2013) and Corhay, et al. (2014) described a vicious cycle of physical inactivity model which explains why people with COPD may become inactive (see section

2.8.4). Because participants become more physically active after participating in PR programmes (Walker, et al., 2008; Sewell, et al., 2005; Mercken, et al., 2005; Pitta, et al., 2008), it can be said that PR breaks or liberates participants from the pre-PR vicious cycle of PA. Due to the findings that initial benefits from PR diminish significantly 3-24 months after programme completion (Heppner, et al., 2006; Karapolit, et al., 2007; Verrill, et al., 2005), it can be argued that participants will very much be inclined to return to the vicious cycle if they are not facilitated into long-term post-PR exercise programmes. Participants' entry into the six-stage cycle of PA (see section 6.2.2) is thought to have prevented them reverting again to the vicious cycle of inactivity in which they were prior to PR, thus, suggesting that the vicious cycle of physical inactivity, described by Troosters, et al. (2013) and Corhay, et al., (2014) and the cycle of PA observed in this study are mutually exclusive as illustrated in Figure 24. More importantly, every stage of the observed cycle of activity was characterised by social interaction between participants, exercise instructor, family members, and other users of the gyms. This is consistent with results from another previous study (Thorpe, Johnston and Kumar, 2012). The qualitative results found that social interaction within this CEP contributed to perceived benefits and facilitated regular attendance and PA participation.

Figure 24: Mutually Exclusive Cycles of Physical Inactivity and Activity in COPD



Exercise training continues to be the principal component of all PR and post-PR CEPs (Beauchamp, et al., 2013; Moullec, et al., 2008; Desveaux, et al., 2014a). The mode, intensity, frequency and duration of training are of vital consideration in designing programmes. Burtin, et al. (2012) showed that it is feasible for people with moderate to severe COPD to perform high-intensity exercise training e.g. 60-70% maximal workload during cycling and 75% of mean walking speed during 6MWD. These improved exercise capacity and HRQoL, probably better than low-intensity training observed by Baumann, et al. (2012). Because these observations were mostly from PR programmes which lasted between 12-26 weeks, the findings cannot be generalised to participants in long-term post-PR programmes. In addition, participants in long-term programmes may not adhere to high-intensity exercise training.

Although there are recommendations for physical training modalities in PR settings (Nici, et al., 2006), as of yet, there is no consensus on the optimal training modalities, intensity, frequency and duration needed to sustain or further improve initial benefits of PR in post-PR intervention settings. Current practice, especially in research settings, is more inclined to peripheral muscle training, probably due to its association with significant improvement in exercise performance and HRQoL (Beauchamp, et al., 2013). Current PR exercise specification (Nici, et al., 2006) may not work for many participants attending long-term post-PR programmes. In addition, using a one-size-fits-all approach can jeopardize adherence to the regimen. Hence, it is imperative to encourage innovative ideas and approaches to provide a greater range of exercise options as far as possible and practicable. People need choice and models that are new and effective should help to facilitate this. More studies are needed to understand ways in which training modalities are incorporated into post-PR exercise programmes. This study made an important contribution in this regard.

Similar to most other studies included in a recent systematic review (Beauchamp, et al., 2013), supervised exercise training was a key component of this CEP. This included 24 seated warm-up and cool-down exercises, 5 cardiovascular and 12 resistance exercises as well as seated breathing exercises. The intensities, frequencies and durations of these exercise modalities were relative to each participant and his/her current fitness level and appeared consistent with more recent practical recommendations for people with COPD (Gloeckl, et al., 2012). The value of this is that it can assist rehabilitation professionals in delivering services. Unlike other studies (Beauchamp, et al., 2013), the present study found that the CEP programme did not have education and psychological counselling sessions. It is the authors' view that this may be due to the need to minimize total staff costs. However, the group and social nature of the programme appeared to have compensated for

this. It offered participants the opportunity to derive motivation, emotional comfort, moral support, encouragement and valuable information from the experiences of others

8.7 Summary

This chapter has presented a discussion relating to the three research questions and additional findings of the study. The next chapter concludes this thesis. It offers a brief discussion of the implications of findings for practice, strengths and limitations of the study. Finally, recommendations for future research are offered.

CHAPTER NINE

IMPLICATIONS, RECOMMENDATIONS AND CONCLUSION

9.1 Introduction

This is the concluding chapter of this thesis. It discusses the implications of findings for practice, the strengths and limitations of the study and suggested areas where future studies are warranted.

9.2 Implications for Practice

The findings from this study have several implications for clinical practice. First, it found that moderate levels of daily PA in the post-rehabilitation phase of COPD management is only partially explained by health status (38%). This result is relevant to participants' on-going COPD management. The Other than exercise capacity and health status, the PA that a person does throughout his/her daily life can be influenced by several other factors such as psychological, behavioural, social, and personality factors. Considering the statistical and clinical relevance of the relationship of moderate levels of daily PA with clinical outcomes observed in this study and that health status predicted daily PA, it is important for rehabilitation professionals to make routine assessment of participants' health status an important priority. Generic and COPD-specific questionnaires should be used to measure health status as they can provide information on participants' health status compared to physiological markers of health such as blood pressure, body temperature, oxygen saturation, pulse, heart rate, arterial blood gas tensions, etc.

Second, the finding that participants spent 42 minutes/day on moderate-intensity activities is important. As this level is higher than the recommended level for people with COPD, it evidences the effectiveness of the CEP. Moderate-intensity PA, particularly walking, was previously identified as the most vital and frequently performed type of PA among elderly population (Buman, et al., 2010; Westerterp, 2008) and when performed regularly by community-dwelling older adults with different chronic conditions, it was shown to be associated with reduced morbidity and mortality (Buman, et al., 2010). Its significant positive correlation with 6MWD and negative correlations SGRQ total scores and number of hospital admission as shown in the present study, support its recommendation in the post-PR phase of COPD management. Considering participants' age, limitations caused by COPD and high risk of drop-out associated with high-intensity programmes, promoting light-intensity PA in daily life should be a goal of CEPs.

Third, the qualitative outcomes of this study demonstrated that research tools (e.g. activity monitor and SGRQ) were unable to fully capture participants' experiences of the benefits of CEPs. Consistent with previous studies (Monninkoff, et al., 2004), this study identified some aspects of health status that participants considered valuable but were inadequately represented by disease-specific SGRQ. These included physical and psychological benefits of the programme; getting off antibiotics and ambulatory oxygen therapy, motivation and self-confidence, feeling safe and social isolation. In order to maximise health status in people with COPD, McCathie, Spence and Tate (2002) emphasised the need to address and assess psychological factors. Accordingly, it makes sense to recommend an adjustment to be made to disease-specific instruments for measuring health status with an inclusion and weighting of items that reflect these physical, psychological and social concepts.

Fourth, Monninkhoff, et al. (2004) suggested that the 'operationalisation of SGRQ items' should be improved by integrating additional stimuli (e.g. cycling) that are of value to people with COPD. This study provides additional support to this suggestion by identifying other stimuli (PAs such as DIYs, climbing stairs and Activities of Daily Living) which participants considered valuable. Adding more stimuli will also require adjustments to the weights given to the different domains of the instrument so that participants' values are sufficiently represented.

Fifth, the lack of motivation which was associated with not exercising at home despite having different home exercise equipment has an important implication for home-based PR and CEPs. A systematic review conducted by Vieira, Maltais, and Bourbeau (2010) suggests that benefits from home-based PR are similar to those produced by hospital-based programmes. Evidence of the comparative effectiveness of post-PR home vs community-based exercise programmes is lacking, findings from this CEP are similar to the improvements in exercise capacity, levels of daily activities, health status and reduce hospital admissions and psychological stress reported in a home-based programmes (Moullec, et al., 2008; Cooke, et al., 2009). This appears to support the recommendation for people with COPD to exercise at home (Vestbo, et al., 2013; Guell et al., 2008). Although home-based rehabilitation programmes are feasible and effective (Liu, et al., 2013; Cooke, et al., 2009), it is noticeable that the views of participants in these studies were not examined, perhaps due to the quantitative nature of the study design. From the interviews of participants in the present study, it was found that majority of the participants said they would not be doing the exercises at home despite having different home exercise equipment and associated this with lack of motivation. This suggests that home-based exercise programmes may not effectively sustain or improve benefits from PRP mainly due to lack of adherence to exercise

protocols. The previously mentioned psychological benefits cited by participants in this and others (Stewart, et al., 2014) e.g. self-confidence, efficacy beliefs, motivation and encouragement inspired by the exercise instructor and peers within the programme helped participants exercise regularly.

Sixth, it is assumed that co-ordination and supervision by a non-healthcare professional may have a low cost implication to service providers. Concerns about cost may limit the number of post-rehabilitation exercise interventions. These may be addressed by designing simple and accessible programmes using less expensive resources that can yield clinically meaningful effects. The labour-intensive exercise programmes used in most research settings (Beauchamp, et al., 2013; Moullec, et al., 2008; Desveaux, et al., 2014b) may be difficult to implement in the NHS due to limited financial resources. For the same reason, commissioning more programmes and sustaining existing ones will be problematic. Service providers are more likely to accept less labour-intensive programmes if they are effective. Studies of the cost effectiveness of post-PR programmes are warranted to support these assumptions.

Seventh, long-term adherence to programme is important to maintain or increase initial benefits of PR programmes. Drop-out is typical in most, if not all, studies of rehabilitation programmes (Bjoernshave, Korsagaard and Nielsen, 2010; Beauchamp, et al., 2013; Hellem, Bruusgaard and Bergland, 2012; Desveaux, et al., 2014b) and was observed in this present study. Several reasons have been cited for participants' drop-out. In a study by Bjoernshave, Korsagaard and Nielsen (2010), participants associated this problem with inadequate professional and inter-personal relationship skills of physiotherapists and what they described as 'the programme being too hard' reflecting physiotherapists' inability to adapt the intensity of exercise modalities to participants' fluctuating needs. The qualitative outcomes of this present study showed that the exercise instructor played a significant role. He understood participants' situations, capacities and limitations and adapted the programme to the changing course of their COPD, thus addressing the problems identified by Bjoernshave, Korsagaard and Nielsen (2010).

Finally, this research indicated some of the exercise modalities that rehabilitation professionals can incorporate into future CEPs. Spruit, et al. (2004) suggested making high-intensity endurance and muscle strengthening exercises compulsory components of rehabilitation programmes. This present study showed that it is important to have tolerable exercise modalities, different exercise equipment, not forcing participants to complete all exercises, promote choice and allow them to complete exercises at their own pace. These considerations facilitated long-term adherence, consistent with results from Lewis and Cramp (2010) and is believed to have physiological

importance, because Puhan, et al. (2008) found that participants who were unable to completely follow exercise protocols had limited benefits from a rehabilitation programme.

9.3 The strengths and limitations of the study

From a methodological perspective, this study has a number of strengths. First, it reported the relationship of daily PA with clinical outcomes using two approaches- quantitatively and from participants' perspectives. By comparing results from both approaches, a method referred to as across-methods triangulation (Foss and Ellefsen, 2002; Begley, 1996), a comprehensive understanding of how daily PA is associated with clinical outcomes was obtained along with issues around factors hindering or facilitating activity participation post-PR.

Second, it gathered relevant information through general observation of participants during the data collection process. This enabled the observations of participants' behaviours in their natural settings. It also obtained information from existing document related to the programme. This enabled an understanding of the context of the study and provides an indication of the context where study results can be generalised. Obtaining data from these sources improved the validity of our findings because the existing documents and participants' behaviours were free from researcher's influences. The participants behaved as they normally do and did not alter contents of their exercise recording sheets.

Third, the study is credited for using one-to-one semi-structured interviews of participants to explain some of the quantitative findings. This contributed to more robust findings, especially regarding more insight into the enablers and barriers daily PA and regular attendance. Fourth, the interviews were not retrospective. Participants were from an ongoing programme, hence, it was not difficult for them to recall their experiences. This provided good quality of information regarding the benefits, barriers and enablers of adherence. Fifth, there was minimal risk of respondent bias owing to the lack of close relationship between the researcher and participants. It can be inferred that participants' views were not influenced by the researcher (Lincoln and Guba, 1985; Creswell, 2013). Sixth, the qualitative findings are trustworthy. This was achieved by the application of four criteria; dependability, credibility, confirmability and transferability advanced by Lincoln and Guba (1985).

Seventh, participants' levels of daily PA were objectively assessed using accelerometer-based PAM (AM300). As assessment tools worn on participants' body, it is possible that the devices served as

reminders to be more active, thus causing a change in behaviour. Nelson and Hayes (1981) used the term reactivity to describe this phenomenon and defined it as a change in participants' behaviour resulting from data collecting procedures. Any chance of this happening was minimised because participants were not given information on how to read and interpret data from the devices. Besides, there is no evidence from the monitors that participants significantly increased their daily PA levels to support the phenomenon of reactivity. Finally, the study used a prospective observational study design which is the most appropriate design for observing behavioural patterns that change over time (Bhopal, 2007; Hulley, et al., 2013; Soicher, et al., 2012). Basically, the effects of the programme on outcomes of interest were measured at two time points. The assessment of outcomes during the CEP took place over a three-month period (November 2015 to February 2016). Results of measures of levels of daily PA, health status, exercise capacity, pulmonary function and number of hospital admission at T1 and T2 were compared to determine statistically significant changes. However, the short duration of the follow-up can also be considered as a limitation.

Other methodological limitations of this study deserve mention. One of the limitations is the study was the small sample size (n=26). Nevertheless, the typical improvement in clinical outcome measures demonstrated in studies evaluating the impact of PR and post-PR exercise programmes were evident. It can be said that this study presents the findings and views of a small number of participants with COPD in comparison to the entire number of people attending CEPs as part of their ongoing COPD management. Therefore, the findings cannot be generalised. Nevertheless, this study contributed new knowledge and provided valuable information on which to base future research. Limited sample size also restricted the number of variables entered into the final multiple regression model. The incorporation of qualitative data contributed more detail to the findings and overcome some limitations to small data sets as noted by Creswell (2013).

Second, as this was a small study, the influences of several possible confounding factors that may have influenced the results were not adjusted for in this study. This makes it difficult to believe that the programme caused the observed improvement in outcomes. Events may have occurred during this period that influenced the outcomes that were assessed. For example, the participants may have been exposed to other post-PR exercise programmes (e.g. exercising at home) which have been shown to be beneficial to people who have completed initial PR (Romagnoli, et al., 2006; Cooke, et al., 2009; Liu, et al., 2014). Because all participants attend monthly 'Breathe Easy' support group meetings, it cannot be ruled out that they participated in additional community-based PA organised by the support group. PA is a complex behaviour that can be influenced by a plethora of factors.

Factors such as unhealthy lifestyle (smoking and alcohol consumption), socio-demographic factors (education, marital status or cohabitation) and diet were not accounted for in this study. Hence, it was not possible to rule out the effects of these confounders that may have influenced the results of the current study.

Third, although applicability of findings to UK setting remains high, external validity (statistical generalisability) of findings is low due to the limited sample size (n=26). Findings from the study should be interpreted with caution. Because, participants were recruited from one CEP, the findings may not necessarily reflect population from other community and home-based exercise programmes. In addition, as all participants had previously completed an 8-week hospital-based PR, the findings cannot be extended to settings where people with COPD enter commercial fitness gyms without having previously completed PR. Nevertheless, theoretically, if people are running a CEP and the participants are similar to those in this study (see section 6.3.3) the findings from this study could apply or be transferred to their situation.

Fourth, it can be argued that the moderate and significant improvements in measured outcomes over the 3 months of the study were unexpected because participants had been attending the programme for years before the start of the study. Majority (65%) of the participants (n=17) had been attending the CEP for >1 year. Previous studies of the effectiveness of CEPs studied people beginning the programmes (Beauchamp, et al., 2013). It was not feasible to recruit enough participants who were just beginning the CEP as this was an ongoing programme. As it was observed (from participants' exercise recording sheets) that those who had been attending the class for >1 years had not been attending regularly, it was thought that the benefits derived from PR would have diminished, at least to some extent. Hence, participants levels of daily PA and other measured outcomes were expected to improve over the 3 months of the study. This informed the decision to recruit both existing and newly enrolled participants. A longitudinal study with newly referred participants alone will be required.

Fifth, the measure of number of hospital admission, using a non-validated questionnaire (SHAQ), is not a standardised measure of the outcome. Because participants self-reported data on number of hospital admission, the researcher relied on their honesty. Individuals are, to some extent, unable to introspectively assess themselves completely accurately. It is, therefore, possible that participants did not provide accurate responses to all questions due to lack of introspective ability. In this study, hospital admission was used to cover all forms of health service use such as of formal acceptance by a hospital of participants at least overnight, visits to doctors (GP surgeries) and unscheduled

visits to Accidents and Emergency (A&E) departments or primary care as a consequence of an exacerbation. It was not feasible to verify or reconcile self-reported data with hospital and primary health-care records and therefore cannot ascertain whether or not there is an overestimation or underestimation of the relationship between daily PA and number of hospital admission.

Sixth, the recall/responder bias associated with the 3 month recall period for SGRQ and SHAQ is thought to have also affected accurate estimation of the relationship of daily PA with health status and hospital admission. As suggested by Grimes and Schulz (2002), it can be assumed that the risk of a high recall bias in this study was minimal because the questionnaires did not contain socially unacceptable issues (e.g. IV drug use, prostitution or child abuse) or life-threatening disease (e.g. cancer or Parkinson) which participants may feel too embarrassed to admit the truth about. Nevertheless, Hassan (2005) and Pannucci and Wilkins (2010) contend that recall bias is a threat to the internal validity of a study (i.e the reliability or accuracy of the study results), especially when participants have pre-existing beliefs about the study which may or may not be true. This study is limited in this regard because it was not possible to determine whether or not the particiapnts came into the study with pre-existing beliefs about the benefits of PA, for example, regular exercise can improve health outcomes. Recall bias was not minimised as it was not feasible to reconcile self-reported data with medical records and blind participants to the study hypotheses as suggested by Hassan (2005).

Seventh, the timeframes of the quantitative and qualitative results were different. Whilst the quantitative results relate to the effect of the CEP over 12 weeks, the qualitative results relate to participants' experience of the programme overall. It was practically not feasible to separate participants' experiences within 12 weeks because most of the participants have been attending the CEP for a long time.

Finally, it is possible that the use of accelerometer-based PA monitors and the 6MWD testing induced reactivity in the participants (Rachele, et a., 2012; Nelson and Hayes, 1981). Participants may have modified their daily PA behaviours due to being aware that they are being observed or recorded by the activity monitors. Nevertheless, the chance of this happening was minimised by the physical design of the devices (light weight- 20mg) and blinding participants to the reading and interpretation of stored data. Another inherent limitation of the PAM AM300 device is that it does not accurately measure upper body activity (movement) because it is worn over the hip (Lee and Shiroma, 2014). In addition, it is also possible that the devices did not accurately record participants' levels of daily PA. For example, Lee and Shiroma (2014) reported that accelerometer-

based monitors are unable to distinguish between levels of PA when an individual is walking and carrying a weight (e.g. a heavy shopping bag) and when the individual walks with no load. Furthermore, Hardy et al. (2013) argued that some accelerometer-based activity monitors are unable to differentiate body position (i.e., sitting, lying and standing) or walking intensity. However, this was not a major limitation in this study because most of the participants were older adults for which walking is the most vital and frequently performed type of activity (Buman, et al., 2010; Westerterp, 2008).

9.4 Recommendations for future research

The results of this study and some of its inherent limitations suggest that further research would be needed to address the relationship of daily PA with relevant clinical outcomes in the post-PR phase of people with COPD. There is no doubt that during the course of this study, some issues were not fully attended to and these raised further questions that may suggest areas where future research should be directed. These are highlighted as follows.

Future studies should be directed at objectively measuring daily PA and its relationship with specific clinical outcomes in a larger sample. Researchers can use the results from this small PhD project to promote the physical, health, social and psychological benefits of participating in future studies to potential participants

Although data from the quantitative phase of this study provided valuable information, it is best to be described as a pilot study as the sample size (n=26) was not large enough to assertively generalise its findings. Findings from this study (e.g. mean difference between Time Points 1 and 2 SGRQ total scores and standard deviation) can be used to perform a post hoc power analysis to determine the appropriate sample size for future research as previously operationalised (Cooke, et al., 2009). This will provide stronger evidence on associations between daily PA and clinical outcomes and also enable findings to be generalised to a large population of people with COPD.

As noted earlier, this study did not account for the influence of several confounding factors. Wherever possible, it is important to anticipate and account for the influence of confounding factors and either incorporate them into the research design or control for them using multivariate models in future studies. This technique is useful for examining variables across multiple dimensions while considering or adjusting for the effects of all variables on the responses of interest (Garcia-Aymerich, et al., 2003; 2006; Pallant, 2010).

A non-healthcare professional (exercise instructor) was found to have a key role in coordinating, supervising and influencing uptake and long-term adherence to CEP. Using this and other findings of this study, it should be possible to determine the cost-effectiveness of using exercise instructors vs healthcare professionals (physiotherapists and respiratory nurse specialists). A strategic package aimed at helping exercise instructors to facilitate uptake and adherence to PR and post-PR exercise interventions can also be developed. Future studies can then be designed to test the effectiveness of such development against the standard programmes that are supervised by healthcare professionals.

When conducting longitudinal studies of the impact of rehabilitation programmes, researchers should expect some degree of unpredictability relating to participant attrition. When the duration of observation spans many months it can be difficult to track participants throughout the entire study. Participants may withdraw from studies for several reasons such as relocation, loss of interest and poor physical health due to the chronicity of COPD, its negative impact and the fact that deterioration cannot be fully prevented. Of the 30 participants in this study, 4 (13%) dropped out while 26 (87%) participants completed the study. Participants dropped out for two reason; experience of a heart attack and recovering at home (n=1) and relocation (n=3).

Steps were taken in the study design to minimise attrition. Following recruitment and first data collection (Time Point 1) 13 participants withdrew from the study because of the perceived burden associated with the study. Initially, the plan was to quantify participants' daily PA subjectively and objectively using PASE questionnaire and PAM AM300 accelerometer respectively. Initial plan was also to assess health status with a generic tool (SF-36) and a disease-specific questionnaire (SGRQ). Participants were also expected to complete 2 additional questions (The socio-demographic and Self-administered hospital admission questions) and 2 study procedures (6MWD and spirometry tests). In total, the study required participants to complete 5 questionnaires and 3 procedures. 13 participants considered this a burden and decided to withdraw. However, they expressed willingness to continue if the number of questionnaires is reduced. To solve this problem, it was decided that every outcome should be measured using one method (instrument). Participants' daily PA was measured objective with PAM AM300 accelerometer while health status was measured by the SGRQ. This limited the number of questionnaires to 3. The 13 participants were happy with this and decided to continue with the study. It is therefore recommended that, when assessing outcomes in future research, researchers should ideally focus on fewer measures that can be quickly and easily measured. Importantly, they should focus more on specific aspect of PA (e.g. time spent of PA, duration, frequency or intensity) and specific clinical outcomes e.g. health status,

pulmonary function, exercise capacity or hospital admission. This will minimise participants' attrition and also contribute to building a reliable evidence-base for the specific benefits of post-PR CEPs

9.6 Conclusion

With the current ageing population and increase in number of people with chronic conditions like COPD, the need for CEPs is obvious and the demand for them is expected to increase in similar fashion as that of PR. This study provides further evidence that participating in a CEP enabled participants to (a) moderately improve levels of daily PA (equivalent to 42 minutes/day of moderate-intensity PA) (b) significantly improve health status, 6MWD and FEV_1 and reduce number of hospital admission after 3 months (all $p< 0.05$). Daily PA correlated positively with 6MWD ($r = 0.40$, $p=0.046$) and negatively with health status ($r= -0.52$, $p=0.006$) and number of hospital admission ($r= -0.394$, $p<0.05$). Changes in levels of daily PA correlated positively with changes in 6MWD ($r= 0.31$, $p= 0.048$) and negatively with changes in health status ($r= -0.65$, $p= 0.0001$). Howver, only health status significantly predicted levels of daily PA (Beta= -0.47, t= -2.85, p=0.009, $R^2_{adjusted}= 0.38$). Regarding factors that influence these relationships, strengthening social support, reinforcing benefits of PA, ensuring affordable and easy access to PA intervention, convenient programme components, safe exercise modalities and PA and favourable season facilitated the relationships. The relationships were hindered by poor physical health, transport difficulties preventing access to PA intervention, family commitments and engaging in other commitments. The relationships reported in this study are largely based on objectively measured daily PA. However, generalizability is limited. Future studies should be directed at objectively measuring daily PA and its relationship with specific clinical outcomes in larger samples.

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APPENDICES

Appendix 1: Online Supplement Material

The relationship between physical activity and health status in patients with Chronic Obstructive Pulmonary Disease following pulmonary rehabilitation

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ONLINE SUPPLEMENT 1. PROTOCOL FOR SYSTEMATIC REVIEW

The next 9 pages contain the revised protocol for the systematic review about "Physical activity and health status following pulmonary rehabilitation" that was approved by the Faculty of Health Social Care and Education Research Degrees Sub Committee, on November 8th 2013, for the degree of MPhiI with possibility of transfer to PhD. This final protocol was approved by the supervisory team.

Protocol for "The relationship between physical activity and health status in patients with Chronic Obstructive Pulmonary Disease following pulmonary rehabilitation"

BACKGROUND

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition in which the airways are abnormally and characteristically narrowed so much so that airflow is limited and breathing becomes very difficult [1]. Currently, COPD ranks as the fourth leading cause of death worldwide [2] and it is predicted that COPD will rank as the third leading cause of death by 2020 [3]. The natural history of the disease is characterized by chronic cough, sputum production, reduced functional capacity and dyspnoea during physical activity (PA) leading to repeated symptom exacerbations and hospital admission [4]. PA is defined as "any bodily movement produced by skeletal muscles that requires energy expenditure" [5] and this includes free living physical activity undertaken in everyday functioning including occupational, sports and leisure activities [6].

Physical inactivity is considered a key clinical factor associated with high morbidity and mortality in COPD [7-9]. Physical inactivity remains the fourth leading risk factor for global mortality (6% of deaths globally) [10]. Specifically, a comparative study [11] of older adults with COPD and age-matched individuals found that people with COPD were less active in daily life by 37 minutes/day in walking time, 104 minutes/day in standing time, 0.6 meter/second^2 in movement intensity during walking and 36m in exercise capacity (6MWD). Their sitting and lying times were higher by 68 minutes/day and 58 minutes/day respectively in the same study. A reduction of activity levels (classified as very low) and by ≥30 meters (in 6MWD) has been correlated with an increased risk of hospital admission [12, 13]. Increasing activity levels is currently an important goal of COPD management[14] which could lead to improved long-term outcomes [9, 11-13].

Pulmonary rehabilitation (PR) remains an integral non-pharmacological intervention for people living with COPD [14]. Supervised exercise training is the principal component of all pulmonary rehabilitation programmes followed by self-management education, psychological and social support [15, 16]. Several studies have demonstrated that PR improves exercise capacity and activity participation as well as health status in people living with COPD [17-19]. In addition, PR also reduces mortality due to its modifying effects on prognostic indicators such as levels of daily activity, exercise tolerance, HRQoL and dyspnoea [8, 17, 19]. These improvements, which were

mostly observed after short-courses (4-12 weeks) of hospital or community-based PR, diminish significantly 6-24 months after programme completion [19-21]. Clinical guidelines [10, 14] now advocate exercise and activity in sustaining initial benefits from PR. In accordance with these guidelines, health professionals refer graduates of PR programmes to home and/or community-based exercise maintenance programmes to maximize their functional ability [15, 16].

A previous review, that investigated the medium and long-term benefits of the post-PR exercise maintenance programmes [22], found that, at 6 and 12 months follow-up, there was no difference between post-PR EMPs and usual care for COPD-specific HRQL (SMD, -0.07; 95% CI, -0.29-0.14; P=0.50) and (SMD, -0.15; 95% CI, -0.42-0.13; P=0.30) respectively. However, a significant difference in exercise capacity (SMD, -0.20; 95% CI, -0.39 to -0.01) was reported at 6 month, but this was not sustained at 12 months (SMD, -0.09; 95% CI, -0.29-0.11) [22]. In this review, the effectiveness of exercise maintenance programmes were reported, there were no reports of association between clinical outcomes in the post-PR life course of patients with the disease.

Objective of the review

The aim of this review is to conduct a mixed-methods systematic review to investigate the relationship between free living PA, measures of health status and hospital admissions in people with COPD following PR.

Research/Review questions:

This systematic review will be guided by the following research questions:

- What is the relationship between physical activity, health status and hospital admission in patients with COPD following pulmonary rehabilitation and what factors mediate this relationship?

Review Methods

The review will be conducted and reported in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [23]. Harden's review process for data synthesis in a mixed-methods systematic review [24, 25] will be applied. In accordance with the PRISMA guidelines, this review protocol is registered with the Prospective Register of Systematic Reviews (PROSPERO), an open access international database of prospectively registered systematic reviews protocols in health and social care [26]. The protocol's Registration no is CRD42014010201 and is available at <http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42014010201#.VIdWltdFDcs>

Searches

A systematic and comprehensive search of six electronic databases: CINAHL (1970-June 2015), Medline (1967-June 2015), PubMed (1982-June 2015), AMED (1986-June 2015), PsycINFO (1971-June 2015), and Cochrane Library (1999-June 2015) will be performed. Details of the search terms used in these databases are provided in online supplementary table S1. Hand searching of the reference lists of identified studies will also be performed.

Management of references

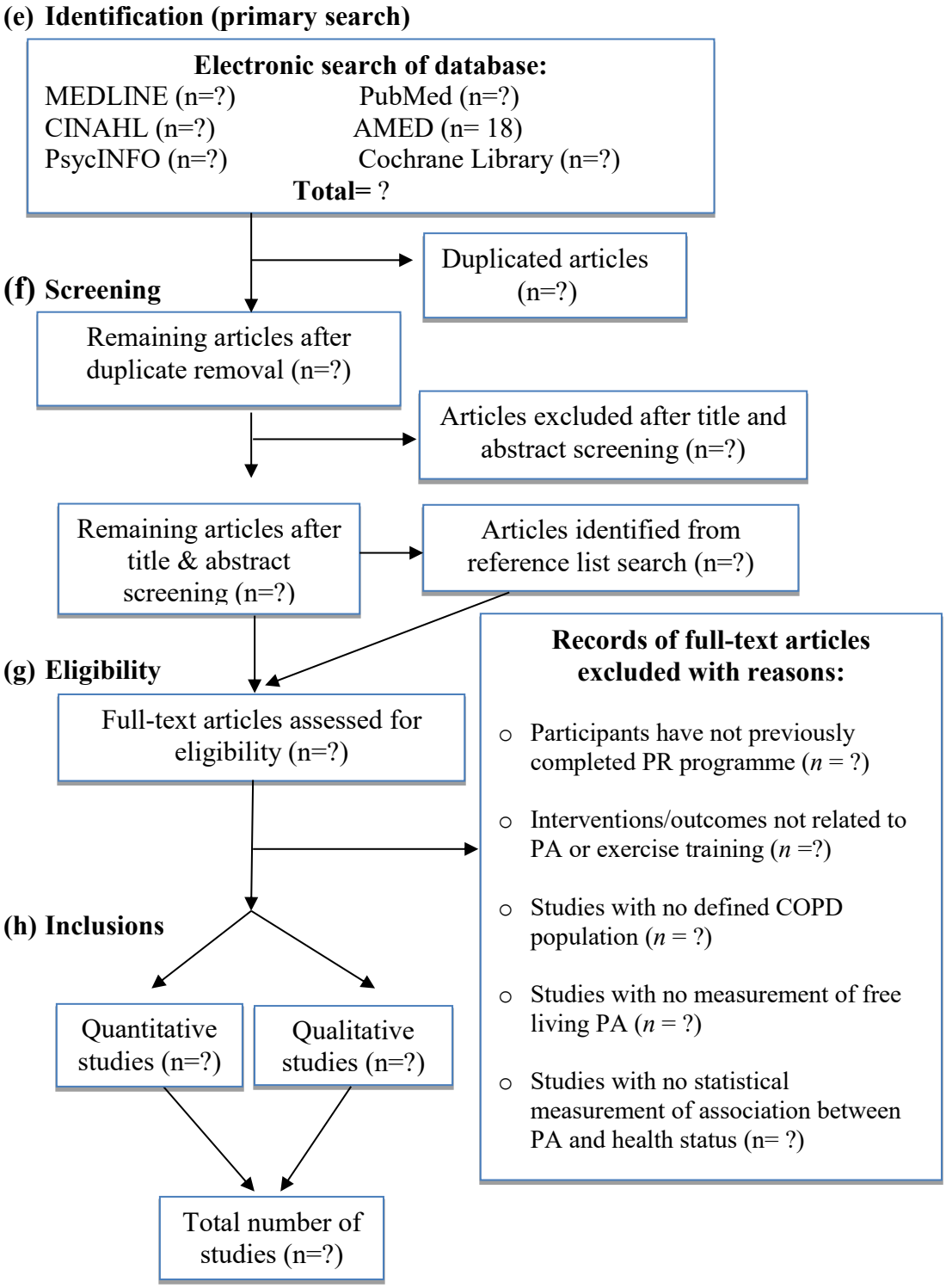
The bibliographic information of all returned articles will be managed in RefWorks (**http://www.refworks.com/**) [27], an online research management that is designed to help researchers easily gather, manage, store and share all types of information, as well as generate citations and bibliographies. Anglia Ruskin University has a licence agreement with ProQuest, the provider of RefWorks. The agreement allows students and academic staff to login from any place. As there is often a content overlap when similar searches are performed in different databases, the "Remove Duplicate" function on RefWorks will be used to remove duplicate records. Separate folders will be created manage included and excluded papers.

The Screening process/Study selection

The PRISMA and Harden study selection flow charts will be combined to describe and facilitate transparency of the study selection process [23, 24] (see Figure 1). All returned articles from the electronic database searches will be subjected to different levels of screening. The first level of screening will be title screening and this will be done by reading the titles of all returned articles. Titles clearly not fulfilling the inclusion criteria will be excluded. For the second level of screening full-text articles will be obtained for all remaining abstracts. Two reviewers will independently screened potential studies for final inclusion, and any discrepancies will be discussed and resolved by consensus within the team.

Figure 1: The PRISMA's flow diagram for study selection procedure

PR= pulmonary rehabilitation; PA= physical activity



Adapted from: [23, 24]

Eligibility criteria

The titles and abstracts of returned articles will be screened for eligibility according to the following inclusion and exclusion criteria.

Inclusion criteria

Study population:

Patients with COPD defined by spirometry (forced expiratory volume in one second, FEV_1 ≥80% and FEV1/FVC <0.7) [14]. Studies with mixed population will be included: (a) if they report results separately for each disease (b) they do not report results separately as long as they recruited ≥90% patients with COPD. Participants must have previously completed PR.

Content of study:

(a) Studies that consider subjective and/or objective measurement of physical activity and any other variable that is associated or correlated with physical activity as possible outcome (b) studies that evaluated patients' experiences of physical activity or exercise programmes or post-rehabilitation exercise maintenance classes.

Physical activity is *"any bodily movement produced by skeletal muscles that requires energy expenditure"* [5]. This include a measurement of free living physical activity, defined as activity undertaken in day-to-day life including occupational, sports and leisure activities [6]. For this review, the reviewers will consider as physical activity: (a) all objective measurements of activity (use of doubly labelled water, DLW; accelerometers, heart rate monitors, pedometers, global positioning system, GPS) and/or (b) all subjective measurements of activity (interviews, logs, surveys, questionnaires and activity diaries) [28-31]. All included studies have to include a description of type, intensity, frequency and duration of physical activity participation as well as how these were assessed, so that a better level of precision and confidence in the results could be achieved.

Other outcomes of interest: An outcome is defined as a possible result/effect that may stem from an exposure to a causal factor or from preventive or therapeutic interventions. This review will consider three secondary outcomes (a) health status/HRQoL (b) hospital admission (c) patients-reported outcomes (PROMs)

Health status is defined as "*the range of manifestation of disease in a given patient including symptoms, functional limitation, and quality of life, in which quality of life is the discrepancy between actual and desired function"* [32]. Patients' self-reported health status thus includes health-related quality of life and functional status such as FEV1, and dyspnoea scores.

Hospital admission is "defined as a stay in a hospital for nursing care for at least overnight or other forms of health-care use such as doctor visits or emergency visits as a consequence of COPD exacerbation [33, 12, 13].

Patient-reported outcomes are any reports coming directly from patients about how they function or feel in relation to a health condition and its therapy, without interpretation of the patient's responses by a clinician, or anyone else [34].

Study design:

(a) Longitudinal observational studies (RCTs, non-randomised, cross-sectional, cohort and case-control studies) that investigated the association between physical activity (including supervised and unsupervised exercise activities) and its outcomes in patients with COPD following PR will be included.

(b) Qualitative studies (focus groups and interviews) of patients' perceptions of physical activity and health status as well as barriers and facilitators of activity participation will also be considered for review.

Restriction and Languages:

Search will be performed from database inception to July 2014. The review will consider studies that have originally been written in English or translated from other languages to English language.

Publication type:

Original research manuscripts published in peer-reviewed journals

Time and place: None

Exclusion criteria

Study population:

Studies in which participants have not diagnosed with COPD based on spirometry and in which patients have not previously completed a PR programme

Study design:

Reports and series, systematic reviews and other studies that did not report methods.

Publication type:

(a) Narrative reviews, letters, editorials, commentaries, unpublished manuscripts, dissertations, government reports, organisations' annual reports, books and book chapters, conference proceedings, meeting abstracts, lectures and addresses, and consensus development statements (including guideline statements)

(b) General discussion papers not presenting data on impacts of physical activity in COPD.

(c) Studies without the out outcomes of interest as well as those without an abstract.

(d) Corresponding authors who do not respond to provide clarity regarding missing information.

Dealing with lack of information

If it is unclear whether an article satisfies the inclusion criteria after title, abstract and full text screening, a minimum of two attempts will be made to contact the authors by telephone or email giving one week to respond each time. If the relevant information cannot be retrieved following these attempts the article will be regarded as "potentially relevant study".

Data extraction and methodological quality appraisal

Sets of two independent reviewers (O.F.M., L.C., H.B. and S.A.) will appraise the quality of included studies and extract data into a standardized form. The quality of each quantitative study will be assessed using a modified Downs and Black checklist (MDB) [35]. The MDB tool consists of 27 items that relate to study description, reporting, external validity, internal validity (bias and confounding) and power to detect a clinically important effect. Each item will be scored one point, resulting in a maximum score of 27. The quality of qualitative studies will be assessed using the critical appraisal skill programme's (CASP) qualitative tool [36], which consists of 9 items that relate to key aspects of a qualitative study- aims appropriateness of study design, recruitment strategy, data collection, rigour, power relationship and ethical issues. Similarly, each item will be scored one point, resulting in a maximum score of 9. Any discrepancies between reviewers will be resolved by discussion within the team until consensus is reached. Reviewers have unanimously agreed to grade the quality of quantitative studies as poor, fair and good if they have MDB scores of <14, 15-19 and >20 respectively [35], while qualitative studies will be graded as low, medium and high if their CASP score is between 0-3, 4-6 and 7-9 respectively [36].

Quantitative and Qualitative Data Analyses

A mixed-synthesis method [24, 25], consisting of three stages, will be applied in this review. Following data extraction, a synthesis and summary of the relationships between PA and COPD outcomes from quantitative studies will be performed. Data will be meta-analysed if there is homogeneity in statistical analyses for associations reported between PA and other outcomes, otherwise evidence will be synthesized narratively. When there is heterogeneity of statistical techniques, Hendrick et al [37] suggested reporting only the univariate analyses unless the study only reported results of the multivariate analyses. The main consideration will be statistical measurements of association at $p<0.05$, or reports of 95% confidence interval (CI) and ≤1 odds ratio (OR), risk ratio (RR) or correlation coefficient. In studies where longitudinal relationships between variables were assessed, statistical relationships will be presented at reported time points.

Methods of qualitative data analysis in systematic reviews are still evolving and several techniques are available [38]. An approach similar to thematic synthesis [39] will be used in this review. Quotes from respondents and statements from author's interpretations will be repeatedly scrutinised in order to identify recurrent themes. Findings from each study will first be described separately before searching for common themes. Themes that emerged from the findings will be ordered and colour/symbol coded according to the number of studies in which they emerge. The themes will then be used to interrogate the quantitative findings to identify commonalities and differences. Themes will also be explored for contextual differences which will be discussed to include possible influences on the outcomes.

Organization of review

Protocol development: Oluwasomi Festus Meshe

Database search: Oluwasomi Festus Meshe and Leica Claydon

Reviewers: Hilary Bungay, Leica Claydon, Sharon Andrew and Oluwasomi Festus Meshe

Review co-ordination: Leica Claydon and Oluwasomi Meshe

Tentative timetable/milestones

Submission of draft protocol: 24th February 2014

Submission of revised draft protocol: 10th June 2014

Submission of final protocol: 30th June 2014

Database search: first week of July 2014:

Submission of search results: 27th July 2014

Title and Abstract Screening: second-third week of July 2014

Full Text Assessment: third-fourth week of July 2014

Data extraction: first-second week of August 2014

Quantitative data analysis: third week of August 2014

Qualitative data analysis: fourth week of August 2014

Quan + Qual (combined) data analysis: first week of September 2014

Report writing: second-third week of December 2014

Submission of draft of report: 9th January 2015

Submission of final draft of report: 23rd February 2015

Competing interests

There are no potential conflicts of interest between reviewers.

Online supplement 2. Search strategy and results in 6 electronic databases

We performed searches in the databases in six databases: CINAHL (1970-July 2014), Medline (1967-July 2014), PubMed (1982-July 2014), AMED (1986-July 2014), PsycINFO (1971-July 2014), and Cochrane Library (1999-July 2014) using the search terms in the online supplementary table 1. Additionally, we also performed hand searches of all references listed in 45 retrieved full-text articles. The bibliographic details of all retrieved papers were managed in a RefWorks. Duplicate records resulting from the various database searches were removed. Separate folders were created for included and excluded papers. Three reviewers independently screened potential studies for final inclusion, and any discrepancies were discussed and resolved by consensus within the team.

Online supplement table 1: Search terms applied to all databases

Search	Query
#6	#1 AND #2 AND #3 AND #4 (Filters activated: Full text, Humans, English, Adult: 19+ years)
#5	#1 AND #2 AND #3 AND #4
#4	"Observational stud*" OR "Longitudinal stud*" OR "Follow-up stud*" OR "Randomi?ed controlled trial" OR "RCT" OR "controlled clinical trial" OR "Randomi?ed clinical trial" OR "Experimental stud*" OR "Comparative study" OR "Validation study" OR "Cohort stud*" OR "Prospective cohort stud*" OR "Retrospective cohort stud*" OR "Case-Control stud*" OR "Cross-sectional stud*" OR "Prevalence stud*"OR "Qualitative stud*" OR "Phenomenology" OR "Ethnography" OR "Case study" OR "Focus group" OR "Grounded theory" OR "Action Research" OR "Discourse analysis" OR "Biography" OR "Interviews" OR "Mixed method*" OR Mixed-method OR "Mixed stud*" OR "multi-method stud*" OR "multi-method research".
#3	Outcom* OR "Outcome measur*" OR "Outcome assess*" OR "Clinical outcom*" OR "Health status" OR "Quality of life" OR QOL OR Well-being OR "Health Related Quality of life" OR HRQoL OR "Hospital admission" OR Readmission OR "health care utili?ation" OR Hospitali?ation OR "outpatient visits" OR "Doctor visits" OR "Emergency visits".
#2	"Lung diseas*" OR "Chronic lung diseas*" OR "pulmonary diseas*" OR "Chronic pulmonary disease" OR "Chronic Obstructive Pulmonary Disease" OR COPD OR "Chronic Obstructive Airway Disease" OR COAD OR "Chronic Obstructive Lung Disease" OR "Chronic Obstructive Lung Disorder" OR "Chronic Airflow Obstructions" OR "Chronic bronchitis" OR Emphysema OR "Pulmonary emphysema".
#1	"Physical Activit*" OR "Physical Exercis*" OR Exercis* OR "Exercise training" OR "Exercise movement techniq*" OR "Exercise physiology" OR "Motor activit*" OR "Activit* of daily living" OR "Daily living activit*" OR ADL OR Function* OR "function* activit*" OR Walking OR "functional performance" OR "physical therapy" OR "Physical and Rehabilitation Medicine" OR "Physical Medicine" OR "Physical Medicine Physiatry" OR Rehabilitation OR Physiatr* OR physiotherapy OR "physical endurance" OR "Aerobic Exercis*" OR "muscle training" OR kinesiotherapy
	COPD= chronic obstructive pulmonary disease; * ?= truncation, including related terms

Online supplement table 2. Search strategy and results in 6 electronic databases.

PubMed

Date of search: Friday, July 18, 2014

Search	Query	Items found	Date of search
#6	#1 AND #2 AND #3 AND #4 (Filters activated: Full text, Humans, English, Adult: 19+ years)	3,658	17 July 2014
#5	#1 AND #2 AND #3 AND #4	7,035	17 July 2014
#4	"Observational stud*" OR "Longitudinal stud*" OR "Follow-up stud*" OR "Randomi?ed controlled trial" OR "RCT" OR "controlled clinical trial" OR "Randomi?ed clinical trial" OR "Experimental stud*" OR "Comparative study" OR "Validation study" OR "Cohort stud*" OR "Prospective cohort stud*" OR "Retrospective cohort stud*" OR "Case-Control stud*" OR "Cross-sectional stud*" OR "Prevalence stud*"OR "Qualitative stud*" OR "Phenomenology" OR "Ethnography" OR "Case study" OR "Focus group" OR "Grounded theory" OR "Action Research" OR "Discourse analysis" OR "Biography" OR "Interviews" OR "Mixed method*" OR Mixed-method OR "Mixed stud*" OR "multi-method stud*" OR "multi-method research".	2,431,884	17 July 2014
#3	Outcom* OR "Outcome measur*" OR "Outcome assess*" OR "Clinical outcom*" OR "Health status" OR "Quality of life" OR QOL OR Well-being OR "Health Related Quality of life" OR HRQoL OR "Hospital admission" OR Readmission OR "health care utili?ation" OR Hospitali?ation OR "outpatient visits" OR "Doctor visits" OR "Emergency visits".	5,778,673	17 July 2014
#2	"Lung diseas*" OR "Chronic lung diseas*" OR "pulmonary diseas*" OR "Chronic pulmonary disease" OR "Chronic Obstructive Pulmonary Disease" OR COPD OR "Chronic Obstructive Airway Disease" OR COAD OR "Chronic Obstructive Lung Disease" OR "Chronic Obstructive Lung Disorder" OR "Chronic Airflow Obstructions" OR "Chronic bronchitis" OR Emphysema OR "Pulmonary emphysema".	413,588	17 July 2014
#1	"Physical Activit*" OR "Physical Exercis*" OR Exercis* OR "Exercise training" OR "Exercise movement techniq*" OR "Exercise physiology" OR "Motor activit*" OR "Activit* of daily living" OR "Daily living activit*" OR ADL OR Function* OR "function* activit*" OR Walking OR "functional performance" OR "physical therapy" OR "Physical and Rehabilitation Medicine" OR "Physical Medicine" OR "Physical Medicine Physiatry" OR Rehabilitation OR Physiatr* OR physiotherapy OR "physical endurance" OR "Aerobic Exercis*" OR "muscle training" OR kinesiotherapy	4,562,903	17 July 2014

Medline

Date of search: Friday, July 18, 2014

Search ID/#	Query/Search terms	Limiters/expanders	Items found	Last Run Via
S6	S1 AND S2 AND S3 AND S4	**Limiters** - Linked Full Text; English Language; Human; Age Related: All Adult: 19+ years; Language: English **Expanders** - Apply related words **Search modes** - Boolean/Phrase	146	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - MEDLINE
S5	S1 AND S2 AND S3 AND S4	**Search modes** - Boolean/Phrase	2,836	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - MEDLINE
S4	"Observational stud*" OR "Longitudinal stud*" OR "Follow-up stud*" OR "Randomi?ed controlled trial" OR "RCT" OR "controlled clinical trial" OR "Randomi?ed clinical trial" OR "Experimental stud*" OR "Comparative study" OR "Validation study" OR "Cohort stud*" OR "Prospective cohort stud*" OR "Retrospective cohort stud*" OR "Case-Control stud*" OR "Cross-sectional stud*" OR "Prevalence stud*"OR "Qualitative stud*" OR "Phenomenology" OR "Ethnography" OR "Case study" OR "Focus group" OR "Grounded theory" OR "Action Research" OR "Discourse analysis" OR "Biography" OR "Interviews" OR "Mixed method*" OR Mixed-method OR "Mixed stud*" OR "multi-method stud*" OR "multi-method research".	**Search modes** - Boolean/Phrase	1,511,663	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - MEDLINE
S3	Outcom* OR "Outcome measur*" OR "Outcome assess*" OR "Clinical outcom*" OR "Health status" OR "Quality of life" OR QOL OR Well-being OR "Health Related Quality of life" OR	**Search modes** - Boolean/Phrase	1,724,460	Interface - EBSCOhost Research Databases Search Screen - Advanced Search

	HRQoL OR "Hospital admission" OR Readmission OR “health care utili?ation” OR Hospitali?ation OR “outpatient visits” OR “Doctor visits” OR “Emergency visits”.			Database - MEDLINE
S2	“Lung diseas*” OR “Chronic lung diseas*” OR “pulmonary diseas*” OR “Chronic pulmonary disease” OR "Chronic Obstructive Pulmonary Disease" OR COPD OR "Chronic Obstructive Airway Disease" OR COAD OR “Chronic Obstructive Lung Disease” OR “Chronic Obstructive Lung Disorder” OR "Chronic Airflow Obstructions" OR “Chronic bronchitis” OR Emphysema OR “Pulmonary emphysema”.	**Search modes** - Boolean/Phrase	182,969	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - MEDLINE
S1	“Physical Activit*” OR “Physical Exercis*" OR Exercis* OR “Exercise training” OR “Exercise movement techniq*” OR “Exercise physiology” OR “Motor activit*” OR “Activit* of daily living” OR “Daily living activit*” OR ADL OR Function* OR “function* activit*” OR Walking OR “functional performance” OR “physical therapy” OR "Physical and Rehabilitation Medicine" OR "Physical Medicine" OR "Physical Medicine Physiatry" OR Rehabilitation OR Physiatr* OR physiotherapy OR "physical endurance" OR "Aerobic Exercis*" OR "muscle training" OR kinesiotherapy.	**Search modes** - Boolean/Phrase	3,246,026	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - MEDLINE

CINAHL

Date of search: Friday, July 20, 2014

Search ID/#	Query/Search terms	Limiters/expanders	Items found	Last Run Via
S6	S1 AND S2 AND S3 AND S4	**Limiters** - Full Text; English Language; Human **Expanders** - Apply related words **Search modes** - Find all my search terms	141	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text
S5	S1 AND S2 AND S3 AND S4	**Search modes** - Boolean/Phrase	718	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text
S4	"Observational stud*" OR "Longitudinal stud*" OR "Follow-up stud*" OR "Randomi?ed controlled trial" OR "RCT" OR "controlled clinical trial" OR "Randomi?ed clinical trial" OR "Experimental stud*" OR "Comparative study" OR "Validation study" OR "Cohort stud*" OR "Prospective cohort stud*" OR "Retrospective cohort stud*" OR "Case-Control stud*" OR "Cross-sectional stud*" OR "Prevalence stud*"OR "Qualitative stud*" OR "Phenomenology" OR "Ethnography" OR "Case study" OR "Focus group" OR "Grounded theory" OR "Action Research" OR "Discourse analysis" OR "Biography" OR "Interviews" OR "Mixed method*" OR Mixed-method OR "Mixed stud*" OR "multi-method stud*" OR "multi-method research".	**Search modes** - Boolean/Phrase	411,392	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text
S3	Outcom* OR "Outcome measur*" OR "Outcome assess*" OR "Clinical outcom*" OR "Health status" OR "Quality of life" OR QOL OR Well-being OR "Health	**Search modes** - Boolean/Phrase	534,636	Interface - EBSCOhost Research Databases

	Related Quality of life" OR HRQoL OR "Hospital admission" OR Readmission OR “health care utili?ation” OR Hospitali?ation OR “outpatient visits” OR “Doctor visits” OR “Emergency visits”.			Search Screen - Advanced Search Database - CINAHL Plus with Full Text
S2	“Lung diseas*” OR “Chronic lung diseas*” OR “pulmonary diseas*” OR “Chronic pulmonary disease” OR "Chronic Obstructive Pulmonary Disease" OR COPD OR "Chronic Obstructive Airway Disease" OR COAD OR “Chronic Obstructive Lung Disease” OR “Chronic Obstructive Lung Disorder” OR "Chronic Airflow Obstructions" OR “Chronic bronchitis” OR Emphysema OR “Pulmonary emphysema”.	**Search modes** - Boolean/Phrase	28,670	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text
S1	“Physical Activit*” OR “Physical Exercis*" OR Exercis* OR “Exercise training” OR “Exercise movement techniq*” OR “Exercise physiology” OR “Motor activit*” OR “Activit* of daily living” OR “Daily living activit*” OR ADL OR Function* OR “function* activit*” OR Walking OR “functional performance” OR “physical therapy” OR "Physical and Rehabilitation Medicine" OR "Physical Medicine" OR "Physical Medicine Physiatry" OR Rehabilitation OR Physiatr* OR physiotherapy OR "physical endurance" OR "Aerobic Exercis*" OR "muscle training" OR kinesiotherapy.	**Search modes** - Boolean/Phrase	433,481	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL Plus with Full Text

PsycINFO

Date of search: Friday, July 22, 2014

Search ID/#	Query/Search terms	Limiters/expanders	Items found	Last Run Via
S6	S1 AND S2 AND S3 AND S4	**Limiters** - English; Language: English; Population Group: Human **Expanders** - Apply related words; Also search within the full text of the articles **Search modes** - Find all my search terms	222	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - PsycINFO
S5	S1 AND S2 AND S3 AND S4	**Search modes** - Boolean/Phrase	143	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - PsycINFO
S4	"Observational stud*" OR "Longitudinal stud*" OR "Follow-up stud*" OR "Randomi?ed controlled trial" OR "RCT" OR "controlled clinical trial" OR "Randomi?ed clinical trial" OR "Experimental stud*" OR "Comparative study" OR "Validation study" OR "Cohort stud*" OR "Prospective cohort stud*" OR "Retrospective cohort stud*" OR "Case-Control stud*" OR "Cross-sectional stud*" OR "Prevalence stud*"OR "Qualitative stud*" OR "Phenomenology" OR "Ethnography" OR "Case study" OR "Focus group" OR "Grounded theory" OR "Action Research" OR "Discourse analysis" OR "Biography" OR "Interviews" OR "Mixed method*" OR Mixed-method OR "Mixed stud*" OR "multi-method stud*" OR "multi-method research".	**Search modes** - Boolean/Phrase	339,584	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - PsycINFO
S3	Outcom* OR "Outcome measur*" OR "Outcome assess*" OR "Clinical outcom*" OR "Health status" OR "Quality of life" OR QOL OR Well-being OR "Health Related Quality of life" OR	**Search modes** - Boolean/Phrase	368,962	Interface - EBSCOhost Research Databases

	HRQoL OR "Hospital admission" OR Readmission OR “health care utili?ation” OR Hospitali?ation OR “outpatient visits” OR “Doctor visits” OR “Emergency visits”.			Search Screen - Advanced Search Database - PsycINFO
S2	“Lung diseas*” OR “Chronic lung diseas*” OR “pulmonary diseas*” OR “Chronic pulmonary disease” OR "Chronic Obstructive Pulmonary Disease" OR COPD OR "Chronic Obstructive Airway Disease" OR COAD OR “Chronic Obstructive Lung Disease” OR “Chronic Obstructive Lung Disorder” OR "Chronic Airflow Obstructions" OR “Chronic bronchitis” OR Emphysema OR “Pulmonary emphysema”.	**Search modes** - Boolean/Phrase	2,653	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - PsycINFO
S1	“Physical Activit*” OR “Physical Exercis*" OR Exercis* OR “Exercise training” OR “Exercise movement techniq*” OR “Exercise physiology” OR “Motor activit*” OR “Activit* of daily living” OR “Daily living activit*” OR ADL OR Function* OR “function* activit*” OR Walking OR “functional performance” OR “physical therapy” OR "Physical and Rehabilitation Medicine" OR "Physical Medicine" OR "Physical Medicine Physiatry" OR Rehabilitation OR Physiatr* OR physiotherapy OR "physical endurance" OR "Aerobic Exercis*" OR "muscle training" OR kinesiotherapy.	**Search modes** - Boolean/Phrase	662,466	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - PsycINFO

AMED

Date of search: Sunday, July 22, 2014

Search ID/#	Query/Search terms	Limiters/expanders	Items found	Last Run Via
S6	S1 AND S2 AND S3 AND S4	**Limiters** - Linked Full Text; Language: English **Search modes** - Boolean/Phrase	18	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - AMED - The Allied and Complementary Medicine Database
S5	S1 AND S2 AND S3 AND S4	**Search modes** - Boolean/Phrase	107	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - AMED - The Allied and Complementary Medicine Database
S4	"Observational stud*" OR "Longitudinal stud*" OR "Follow-up stud*" OR "Randomi?ed controlled trial" OR "RCT" OR "controlled clinical trial" OR "Randomi?ed clinical trial" OR "Experimental stud*" OR "Comparative study" OR "Validation study" OR "Cohort stud*" OR "Prospective cohort stud*" OR "Retrospective cohort stud*" OR "Case-Control stud*" OR "Cross-sectional stud*" OR "Prevalence stud*"OR "Qualitative stud*" OR "Phenomenology" OR "Ethnography" OR "Case study" OR "Focus group" OR "Grounded theory" OR "Action Research" OR "Discourse analysis" OR "Biography" OR "Interviews" OR "Mixed method*" OR Mixed-method OR "Mixed stud*" OR "multi-method stud*" OR "multi-method research".	**Search modes** - Boolean/Phrase	23,759	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - AMED - The Allied and Complementary Medicine Database
S3	Outcom* OR "Outcome measur*" OR "Outcome assess*" OR "Clinical outcom*" OR "Health status" OR "Quality of life" OR QOL OR Well-being OR "Health Related Quality of life" OR HRQoL OR "Hospital admission" OR Readmission OR "health care utili?ation" OR	**Search modes** - Boolean/Phrase	44,520	Interface - EBSCOhost Research Databases Search Screen - Advanced

	Hospitali?ation OR “outpatient visits” OR “Doctor visits” OR “Emergency visits”.			Search Database - AMED - The Allied and Complementary Medicine Database
S2	“Lung diseas*” OR “Chronic lung diseas*” OR “pulmonary diseas*” OR “Chronic pulmonary disease” OR "Chronic Obstructive Pulmonary Disease" OR COPD OR "Chronic Obstructive Airway Disease" OR COAD OR “Chronic Obstructive Lung Disease” OR “Chronic Obstructive Lung Disorder” OR "Chronic Airflow Obstructions" OR “Chronic bronchitis” OR Emphysema OR “Pulmonary emphysema”.	**Search modes** - Boolean/Phrase	1,931	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - AMED - The Allied and Complementary Medicine Database
S1	“Physical Activit*” OR “Physical Exercis*" OR Exercis* OR “Exercise training” OR “Exercise movement techniq*” OR “Exercise physiology” OR “Motor activit*” OR “Activit* of daily living” OR “Daily living activit*” OR ADL OR Function* OR “function* activit*” OR Walking OR “functional performance” OR “physical therapy” OR "Physical and Rehabilitation Medicine" OR "Physical Medicine" OR "Physical Medicine Physiatry" OR Rehabilitation OR Physiatr* OR physiotherapy OR "physical endurance" OR "Aerobic Exercis*" OR "muscle training" OR kinesiotherapy.	**Search modes** - Boolean/Phrase	108,461	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - AMED - The Allied and Complementary Medicine Database

Cochrane Library

Date of search: Monday, July 28, 2014

Search ID/#	Query/Search terms	Search fields	Items found
#5	#1 AND #2 AND #3 AND #4	ti, ab, kw (Word variations have been searched)	912
#4	“Observational stud*” or “Longitudinal stud*” or “Follow-up stud*” or “Randomi?ed controlled trial” or “RCT” or “controlled clinical trial” or “Randomi?ed clinical trial” or “Experimental stud*” or “Comparative study” or “Validation study” or “Cohort stud*” or “Prospective cohort stud*” or “Retrospective cohort stud*” or “Case-Control stud*” or “Cross-sectional stud*” or “Prevalence stud*” or “Qualitative stud*” or “Phenomenology” or “Ethnography” or “Case study” or “Focus group” or “Grounded theory” or “Action Research” or “Discourse analysis” or “Biography” OR “Interviews” or “Mixed method*” or “Mixed-method” or “Mixed stud*” or “multi-method stud*” or “multi-method research”	ti, ab, kw (Word variations have been searched)	221, 857
#3	“Outcom*” or “Outcome measur*” or “Outcome assess*” or “Clinical outcom*” or "Health status" or "Quality of life" or “QOL” or “Well-being” or "Health Related Quality of life" or “HRQoL” or "Hospital admission" or “Readmission” or “health care utili?ation” or “Hospitali?ation” or “outpatient visits” or “Doctor visits” or “Emergency visits”	ti, ab, kw (Word variations have been searched)	208, 929
#2	“Lung diseas*” or “Chronic lung diseas*” or “pulmonary diseas*” or “Chronic pulmonary disease” or "Chronic Obstructive Pulmonary Disease" or “COPD” or "Chronic Obstructive Airway Disease" or “COAD” or “Chronic Obstructive Lung Disease” or “Chronic Obstructive Lung Disorder” or "Chronic Airflow Obstruction" or “Chronic bronchitis” or “Emphysema” or “Pulmonary emphysema”	ti, ab, kw (Word variations have been searched)	13, 259
#1	“Physical Activit*” or “Physical Exercis*" or “Exercis*” or “Exercise training” or “Exercise movement techniq*” or “Exercise physiology” or “Motor activit*” or “Activit* of daily living” or “Daily living activit*” or “ADL” or “Function*” or “function* activit*” or “Walking” or “functional performance” or “physical therapy” or "Physical and Rehabilitation Medicine" or "Physical Medicine" or "Physical Medicine Physiatry" or “Rehabilitation” or “Physiatr*” or “physiotherapy” or "physical endurance" or "Aerobic Exercis*" or "muscle training" or “kinesiotherapy”	ti, ab, kw (Word variations have been searched)	139, 444

Online supplement 3: Form for guidance of title, abstract and full text assessment process

Decide on including or excluding study based on title, abstract and/or full text and the following inclusion criteria

Reviewer:	**First author:**	**Year:**	**Language**

S/no	**Inclusion criteria**	**Decision**	
1	**Study population:** Patients with COPD defined by spirometry (FEV1/FVC <0.7 and FEV1 in % predicted <80%)	**Yes** ☐	**No** ☐
2	**Study with mixed population:** other populations including patients with COPD: the authors report results separately for each disease.	**Yes** ☐	**No** ☐
3	**Study with mixed population:** other populations including patients with COPD: the authors did not report the results separately but COPD population is ≥90%	**Yes** ☐	**No** ☐
4	**Primary outcome:** study considers measurement of the primary outcome- Physical Activity (objective and/or subjective measurement)	**Yes** ☐	**No** ☐
5	**Secondary outcomes:** study considers any measurements of other outcomes such as HRQoL, 6MWD, hospital admission, FEV1, dyspnoea and PROMs	**Yes** ☐	**No** ☐
6	Study design is: - longitudinal observational studies (RCT, cohort, case-control, cross-sectional) - Qualitative studies.	**Yes** ☐	**No** ☐
7	Participants have previously completed a PR programme	**Yes** ☐	**No** ☐
8	**Measure of association:** study considers any statistical measurements of association at p<0.05, or reports of 95% confidence interval (CI) and ≤1 odds ratio (OR), risk ratio (RR) or correlation coefficient.	**Yes** ☐	**No** ☐

If not included, specify reasons below:

☐ Not relevant patient group
☐ Study does not consider Physical Activity
☐ Article presents data from review and no primary data
☐ Physical Activity is measured as exercise/fitness capacity
☐ Others

Final decision: **Include** ☐ **Exclude** ☐

Online supplement table 3: Data extraction form for quantitative and qualitative studies

Quantitative studies							
Author, publication year, country	**MDB Quality score**	**Study design**	**Sample size and gender (M/F)**	**Age (years)**	**Loss to Follow-up**	**BMI (Kg/m^2)**	**COPD diagnosis (FEV_1 % predicted)**

Qualitative studies							
Author, publication year, country	**CASP Quality Score**	**Main aim/objective of study**	**Main outcomes assessed**	**Study design & data analysis**	**Sample size (n) and Gender (M/F)**	**Age (years)**	**COPD diagnosis**

Adapted from: Higgins and Deeks [40]

Online supplement 4. Details on methods of data extraction and methodological quality appraisal

Data extracted from each included study include: name of first author, journal, year of publication, objective(s) of the study, study description (design, setting, recruitment method, sample size, number of participants), participants' characteristics (age, sex, exercise habit, BMI, COPD diagnosis, FEV_1, and dyspnoea), methods of outcome measurement and estimate of the association, statistical test or model, and covariates. These data were extract into a standardized form (Online supplement Table 3)**.**

Four reviewers (O.F.M., L.C., H.B. and S.A.) independently appraised the quality of included studies and reached a consensus on the final rating. The quality of each quantitative study was assessed using a modified Downs and Black checklist (MDB). The MDB tool consists of 27 items that relate to study description, reporting, external validity, internal validity (bias and confounding) and power to detect a clinically important effect. Each item was score one point, resulting in a maximum score of 27 (Online supplement table 4). Reviewers unanimously agreed to grade the quality of quantitative studies as poor, fair and good if they have MDB scores of <14, 15-19 and >20 respectively. The quality of included qualitative studies were assessed using the critical appraisal skill programme's (CASP) qualitative tool which consists of 9 items that relate to: aims of the study, appropriateness of study design, recruitment strategy, data collection, rigour, power relationship and ethical issues. Similarly, each item was score one point, resulting in a maximum score of 9 (see Online Supplement table 5). The qualitative studies were rated as low, medium and high their CASP score is between 0-3, 4-6 and 7-9 respectively.

Online supplement table 4: Modified Downs and Black quality checklist to assess measurement of PA people with COPD

Reporting	Score
1. Is the hypothesis/aim/objective of the study clearly described?	1
2. Are the main physical activity outcomes to be measured clearly described in the Introduction or Methods?	1
3. Are the characteristics of the patients include in the study clearly described?	1
4. Are the physical activity measurement of interest clearly described?	1
5. Are the distributions of principal confounders in each group of subjects to be compared clearly described?	1
6. Are the main findings of the study clearly described?	1
7. Does the study provide estimates of the random variability in the physical activity data for the COPD-related outcomes?	1
8. Have all important adverse events that may be a consequence of the intervention been reported?	1
9. Have the characteristics of patients lost to follow-up been described?	1
10. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?	1
External Validity	
11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	1
12. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	1
13. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?	1
Internal validity – bias	
14. Was an attempt made to blind study subjects to the intervention they have received?	1
15. Was an attempt made to blind those measuring the main outcomes of the intervention?	1
16. If any of the results of the study were based on "data dredging", was this made clear?	1
17. In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?	1
18. Were the statistical tests used to assess the main outcomes appropriate?	1
19. Was compliance with the physical activity measurements reliable?	1
20. Were the main physical activity measures used accurate (valid and reliable)?	1
Internal validity - confounding (selection bias)	
21. Were the patients in different physical activity groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?	1
22. Were study subjects in different physical activity (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?	1
23. Were study subjects randomised to physical activity groups?	1
24. Was the randomised intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?	1
25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	1
26. Were losses of patients to follow-up taken into account?	1
Power	
27. Did the study mention having conducted a power analysis to determine the sample size needed to detect a significant difference in effect size for one or more outcome measures?	1
Total Score =	**27**

Online Supplement Table 5: Critical Appraisal Skills Programme (CASP) for qualitative studies

Consideration	Score
1. Was there a clear statement of the aims of the research?	1
2. Is a qualitative methodology appropriate?	1
3. Was the research design appropriate to address the aims of the research?	1
4. Was the recruitment strategy appropriate to the aims of the research?	1
5. Was the data collected in a way that addressed the research issue?	1
6. Has the relationship between researcher and participants been adequately considered?	1
7. Have ethical issues been taken into consideration?	1
8. Was the data analysis sufficiently rigorous?	1
9. Is there a clear statement of findings?	1
Total Score =	**9**

[1] When doing critical reviews, there are strategic points in the process at which you may decide the research is not applicable to your practice and question. You may decide then that it is not worthwhile to continue with the review.

[2] Throughout the form, "no" means the authors explicitly state reasons for not doing it; "not addressed" should be ticked if there is no mention of the issue.

Online supplement table 6: Number of studies in which the perceived barriers and facilitators have been identified

		Facilitators												Barriers						
Authors (Years)	**MAIN THEMES**	Influence of the referring doctor	Social supporters : health professionals & friends)	Group support or companions	Goal setting	Personal attributes	Availability of exercise options	Motivation and encouragement	Perceived benefits (positive exercise outcomes)	Self-confidence	Enjoyment of the programme	Will power	Fitting exercise into one's personal schedule	Lack of social support at home	Overcoming the effort of living with COPD	Changing physical health status (co-morbidities and exacerbations)	Fear and anxiety	Environment: fumes, weather and competition in gyms	Safety issues	Lack of motivation and encouragement
Arnold [41]		√√√	√√√	√√√				√√√	√√√	√√√	√√√			####	####					
Halding [42								√√√			√√√									
Halding [43]																	####			
Hogg [44]			√√√	√√√				√√√						####		####	####	####		####
Lewis [45]		√√√	√√√	√√√	√√√	√√√	√√√	√√√	√√√			√√√	√√√	####		####	####	####		
Milne [46]			√√√	√√√				√√√							####	####				
Norweg [47]			√√√	√√√				√√√		√√√							####			
O'Shea [48]			√√√	√√√						√√√						####		####	####	####
Rogers [49]			√√√	√√√																
Wang [50]		√√√	√√√	√√√					√√√		√√√					###	####	####	####	####
Williams [51]			√√√													####	####			
Stewart [58]			√√√	√√√				√√√	√√√	√√√	√√√					####				####
Zakrisson [59]																				

√√√ **Facilitators** #### **Barriers**

Online supplement table 7: Number of studies in which the perceived effects/benefits of PR exercise maintenance have been identified.

		Improved health status								Physical benefits						Psychological benefits:					Other outcomes					
First authors [Ref.]	Effects of PR, EMP or exercise	Loosening secretion	Improve breathing	Reduced breathlessness during activities	Increased control (management) of breathlessness during activities	Reducing arthritis	Helping recovery after an exacerbation	Change in perception of breathlessness	Increase education/knowledge of disease, self-care & coping skills	**L**ooking attractive	Increase stamina (Being invigorated) and balance	Less fatigue in performing daily activities	Increase exercise capacity, PA and regular exercise	Acknowledgement of post-PR activity limitations	Social benefits	Increase self-confidence in performing daily PA	improve self-esteem & the feel-good factor	Overcome fear of physical and social activities	Strengthened hope for the future and mutual trust	Desire and motivation for self-management	No change in levels/experience of breathlessness	No relationship with regular exercise	Negative effects	Tiredness/Fatigue and discomfort	Frustrations	Post-PR support needs
Arnold [41]																										
Halding [42															√√	√√			√√	√√						
Halding [43]														√√	√√	√√		√√	√√	√√						##
Hogg [44]									√√						√√	√√	√√	√√								##
Lewis [45]		√√	√√	√√	√√	√√	√√				√√				√√		√√	√√						##		
Milne [46]			√√	√√	√√		√√		√√				√√	√√	√√	√√			√√	√√						
Norweg [47]			√√	√√	√√		√√	√√	√√		√√	√√	√√		√√	√√	√√	√√		√√						
O'Shea [48]		√√	√√	√√	√√	√√	√√			√√	√√	√√	√√		√√	√√	√√	√√			**X**				##	
Rogers [49]									√√				√√		√√				√√		**X**				##	##
Wang [50]			√√	√√	√√						√√	√√	√√	√√	√√					√√		**X**		##	##	
Williams [51]			√√	√√	√√		√√	√√	√√		√√	√√			√√	√√	√√	√√			**X**					
Stewart [58]																										
Zakrisson [59]					√√		√√		√√					√√				√√		√√	**X**	**X**		##		##

√√ **Perceived benefits** **X** **No perceived benefits** ## **No perceived benefits**

Online supplement table 8: Longitudinal improvement in PA

First author [Ref.]	Outcome	Baseline value (mean)	Follow-up value	Difference	Length of follow-up
Pitta [52]	PFSDQ-M activity score	44±12	35±12	9 (p<0.05)	3 mo
Pitta [52]	PFSDQ-M activity score	44±12	31±13	13 (p<0.05)	6 mo
Skumlien [53]	HPAQ score	10,649 (2,842)- RTG 11,025 (2,170)- ETG	NR NR	-60 (95% CI=-614-495) 241 (95% CI=-498-982)	3 mo 3 mo
Pitta [52]	Mean WTIDL	55±26 mins/d	59±27 mins/d	4 mins/day (p=0.21) (7% improvement)	3 mo
Pitta [52]	Mean WTIDL	55±26 mins/d	65±29	10 mins/d (p=0.008) (20% improvement)	6 mo
Jones [54]	Median time for 5STS-time	14.1s (11.5, 21.3)	12.4 (10.2, 16.3)	-1.4s (-3.9, 0.0), effect size 0.32, p<0.01	2 mo
Soicher [55]	WTEA	80 mins (at 4 mo)	50 mins	30 mins decrease	12 mo
Skumlien [53]	ADL-time	4.0min (3)- RTG 4.0min (3.1)-ETG	NR NR	-0.1 (95% CI=-0.6-0.5) -0.3 (95% CI=-0.6-0)	3 mo 3 mo
Bendstrup [56]	ADL score	127±9.5	NR	6.2±2.8 (p=0.086)	6 weeks
Bendstrup [56]	ADL score	127±9.5	NR	17.7±5.6 (p=0.004)	3 mo
Bendstrup [56]	ADL score	127±9.5	NR	14.4±4.7 (p=0.007)	6 mo
Soicher [55]	Mean 6MWD	369±86m	399±71m	30m	12 mo
Skumlien [53]	MEAN 6MWD	466m (99)- RTG 468 (137)- ETG	NR NR	32 (95% CI=-3-66) 46 (95% ci=20-72, p<0.05)	3 mo 3 mo
Pitta [52]	Mean 6MWD	436±121m	484±120m	48m (p<0.05)	3 mo
Pitta [52]	Mean 6MWD	436±121m	483±125m	47m (p<0.05)	6 mo
Bendstrup [56]	Mean 6MWD	316±33.7m	NR	79.8±15.5m (p=0.004)	6 weeks
Bendstrup [56]	Mean 6MWD	316±33.7m	NR	113.1±17.8m (p=0.001)	3 mo
Bendstrup [56]	Mean 6MWD	316±33.7m	NR	96.2±16.1m (p=0.001)	6 mo
Jones [54]	Median ISWD	200m (80, 340)	NR	50m (10, 100); effect size=0.46; p<0.01	2 mo
Cooke [57]	6MWD (vs Bl)	NR	NR	Increase reported	6 & 12 mo

At 3-6 months, there appear to be a positive trend of improvements in levels of free living activity and time spent in daily/week activities from six studies (n=588) but average value was not determined due to heterogeneity of measuring tools.

Average 6MWD from four studies (n=344) increased by 62 meters. Mean 6MWD from Soicher et al [55] was exclude because they were only reported at 12 months; data from Cooke et al [33] was also not included in the average estimation because no follow-up results were reported.

Online supplement table 9: Longitudinal improvement in HRQoL

First author [ref.]	Outcome	Baseline value (mean)	Follow-up value	Difference	Length of follow-up
Soicher [55]	SGRQ t. score	46±15	44±14	-2	12 mo
Jones [54]	Median SGRQ t. score (25^{th}, 75^{th} centiles)	52.2 (16.4)	NR	-4.7 (12.0), effect size=0.22; p<0.01	2 mo
Cooke [57]	SGRQ t. score	NR	NR	-1.093	6 & 12 mo
Skumlien [53]	SGRQ t. score	55 (12)- RTG 47 (18)- ETG	NR NR	-3.2 (95% CI=-7.4-1.2) -0.56 (95% CI=-5.8-4.7, p<0.05)	3 mo 3 mo
Pitta [52]	CRDQ t. score	74±20	97±16	23 (p<0.05)	3 mo
Pitta [52]	CRDQ t. score	74±20	103±17	29 (p<0.05)	6 mo
Bendstrup [56]	CRDQ t. score	86±4.9	NR	6.6±3.1 (p=0.174)	6 weeks
Bendstrup [56]	CRDQ t. score	86±4.9	NR	8.6±3.5 (p=0.133)	3 mo
Bendstrup [56]	CRDQ t. score	86±4.9	NR	11.1±4.5 (p=0.018)	6 mo
At 3-6 months, Average SGRQ total score from four studies (n=523) improved by 2.31 points while CRDQ total score from two studies (n=65) improved by 15.66 points.					

Online supplement table 10: Longitudinal improvement in FEV1

First author [Ref.]	Outcome	Baseline value (mean)	Follow-up value	Difference	Length of follow-up
Soicher [55]	FEV1 %	44.4±13.0	ND	ND	12 mo
Cooke [57]	FEV1 %	41 (30-56%)	ND	ND	ND
Pitta [52]	FEV1 %	46±16	50±21	4 ($p<0.05$)	3 mo
Pitta [52]	FEV1 %	46±16	48±19	2 ($p<0.05$)	6 mo
Jones [54]	FEV1 %	48.1 (19.8)	ND	ND	2 mo
Bendstrup [56]	FEV1 ($Lmin^{-1}$)	1.02±0.06	ND	Report: No signif. changes	3 & 6 mo
Skumlien [53]	FEV1 %	48 (17)- RTG 50 (13)- ETG	ND ND	-1.7 (95% CI=-6.4-3.0) 1.2 (95% ci=-2.4-4.8)	3 mo 3 mo
At 3-6 months, FEV_1 from three our studies (n=105) improved minimally by 1.3%. FEV_1 data from three studies (n=483) were not included because no follow-up results were reported.					

Online supplement table 11: Longitudinal improvement in dyspnoea

First author [Ref.]	Outcome	Baseline value (mean)	Follow-up value	Difference	Length of follow-up
Cooke [57]	Dyspnoea			0.9 impr. from Bl	12 mo
Pitta [52]	PFSDQ-M Dyspnoea score	44±13	36±12	8 ($p<0.05$)	3 mo
Pitta [52]	PFSDQ-M Dyspnoea score	44±13	33±14	11 ($p<0.05$)	6 months
Pitta [52]	CRDQ dyspnoea score	14±3	22±7	8 ($p<0.05$)	3 mo
Pitta [52]	CRDQ dyspnoea score	14±3	23±7	9 ($p<0.05$)	6 mo
Jones [54]	MRC-dyspnoea	3.3 (1.1)			
Skumlien [53]	Dyspnoea (Borg CR10) score	6 (2.5)- RTG 6 (2.3)-ETG	ND ND	0 (95% CI=-1-1) -0.3 (95% CI=-1-0.5)	3 mo 3 mo
At 3-6 months, there appear to be a positive trend of improvements in dyspnoea. Heterogeneity of measuring tools precluded averaging.					

Abbreviations: ND= no data; RTG= resistant training group; ETG= endurance training group; WTEA= weekly time spent in endurance activity; WTIDL= walking time in daily life; higher values of CRDQ mean better HRQoL; higher values of SGRQ mean worse HRQoL; PFSDQ-M= pulmonary function status and dyspnoea questionnaire modified version; the PFSDQ-M range from 0-100, lower values mean better functional status; FEV1= forced expiratory volume in 1 second; ADL-time= time to complete activity of daily living test; 5STS-time= time to complete 5 sit-to-stand test; 6MWD= six-minute walking distance, ISWD= incremental shuttle walking distance; Bl= baseline; CRDQ= chronic respiratory disease questionnaire; SGRQ= St. Georges' respiratory disease questionnaire;

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Appendix 2: Recruitment flyer

RESEARCH STUDY:

Physical activity and health status in people with COPD following pulmonary rehabilitation

Faculty of Medical Science
2nd Floor, Postgraduate
Medical Institute Building,
Bishop Hall Lane, Chelmsford
Essex, CM1 1SQ.

Anglia Ruskin University
Cambridge Chelmsford Peterborough

Research Ethical Approval No: 15/IEC08/0034

1 Invitation

You are invited to participate in a study evaluating how levels of daily physical activities are related to health and number of hospital admission in people living with COPD after they complete pulmonary rehabilitation. The study is conducted by Olu Festus Meshe, a PhD student at the Faculty of Medical Science, Anglia Ruskin University.

2 Eligibility

You are eligible to participate in this study if you are:

- ❑ An adult living with COPD and
- ❑ Have completed any pulmonary rehabilitation and
- ❑ Have been referred to any exercise maintenance class in the community

3 What you will be asked to do?

You will be asked to:

- ❑ Spend one (1) hour at your usual exercise class on 7 occasions over 6 months.
- ❑ Complete 5 short questionnaires that will help us determine your health and well-being, amount of daily physical activity and number of visits to hospital or GP as a result of your chest/breathing problem.
- ❑ Wear an accelerometer, a simple device that will monitor your daily activity for 7 days
- ❑ We will also measure your ability to exercise and how well you breathe as well as hear your views about the effect of the exercise class on your daily life.
- ❑ No medications will be given.

4 Compensation

Participation is voluntary. However, you will be given £20 at the end of the study as a token for the time given to the project and to cover travel expenses.

If you are interested in participating or would like more information about participating, please contact:

Olu Festus Meshe at:
oluwasomi.meshe@student.anglia.ac.uk
or call **07587897975**

Appendix 3: Participants' Information Sheet (PIS)

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Appendix 4: Consent Form

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Appendix 5: Socio-Demographic Questionnaire

Anglia Ruskin University
Cambridge Chelmsford Peterborough

SOCIO-DEMOGRAPHIC QUESTIONNAIRE

The researcher would like to know some basic information about you. Can you please print clearly and complete all sections in this form.

Name:	
Contact address:	
Phone no:	

Q1	**What is your age?** Please write in the *boxes* Please, write in the boxes ☐☐ Years
Q2	**What is your gender?** Please tick (**v**) *one box* ☐ Male ☐ Female ☐ Other ☐ Prefer not to say
Q3	**What is your legal marital or same-sex civil partnership status?** Please tick (**v**) *one box* ☐ Never married and never registered a same-sex civil partnership ☐ Married ☐ Separated, but still legally married ☐ Divorced ☐ Widowed ☐ In a registered same-sex civil partnership ☐ Separated, but still legally in a same-sex civil partnership ☐ Formerly in a same-sex civil partnership which is now legally dissolved ☐ Surviving partner from a same-sex civil partnership
Q4	**What is ethnic group?** Please tick (**v**) *one box* ☐ White ☐ Mixed/multiple ethnic group ☐ Asia/Asian British ☐ Black / African / Caribbean / Black British ☐ Other ethnic group

Q5	**What is the highest level of education you have completed?** Please tick (**√**) *one box* ☐ Degree level qualification or higher ☐ Professional qualification below degree level ☐ A levels ☐ GCSEs/O levels ☐ Other qualifications ☐ No qualifications
Q6	**What is your current employment status?** Please tick (**√**) *one box* ☐ Working as an employee ☐ On a government sponsored training scheme? ☐ Self-employed or freelance ☐ Working paid or unpaid for your own or your family's business ☐ Away from work ill, on maternity leave, on holiday or temporarily laid off ☐ doing any other kind of paid work ☐ Unable to work ☐ Retired ☐ None of the above
Q7	**(For researcher only)** Participant's weight = ☐☐ Participant's height = ☐☐ Participant's BMI (Kg/m^2) = ☐☐ (Kg/m^2)
Q8	**Do you currently use tobacco?** Please tick (**√**) *one box* ☐ Yes, on a regular basis ☐ Yes, but only once in a while ☐ Not anymore, I quit ☐ No, I have never used tobacco
Q9	**Do you use:** **Oxygen therapy?** **Nebulizer?** Please tick (**√**) *one box* Please tick (**√**) *one box* ☐ Yes ☐ Yes ☐ No ☐ No
Q10	**How long have you been attending the exercise classes?** Please, write in the boxes ☐☐ Months ☐☐ Years

Thank you for filling in this questionnaire. Before you finish would you please check to see that you have answered all the questions

Appendix 6: Self-Reported Hospital Admission Questionnaire (SHAQ)

Anglia Ruskin University
Cambridge Chelmsford Peterborough

SELF-REPORTED HOSPITAL ADMISSION QUESTIONNAIRE

This questionnaire is designed to help us learn much more about your hospital admission because of your breathing or chest trouble in the last 12 months.

Name of Participant:	
Date:	

In answering the following questions:

Hospital admission is when you were provided with a room to stay in a hospital for at least overnight for the purpose of receiving nursing care for your chest/breathing trouble. It also includes visits to Accident and Emergency Department because of your chest or breathing trouble

Q1	Have you been admitted to a hospital because of your chest or breathing trouble in the last 12 months? Please tick (**V**) *one box* ☐ No----------→ Go to Q4 ☐ Yes
Q2	How many times were you admitted to a hospital because of your chest or breathing trouble in the last 12 months? ☐ Times
Q3	How long did you stay in a hospital when you were admitted because of your chest or breathing trouble in the last 12 months? ☐ days
Q4	Have you visited your doctor (GP) or a respiratory nurse specialist because of your chest or breathing trouble in the last 12 months? Please tick (**V**) *one box* ☐ No----------→ Go to Q6 ☐ Yes
Q5	How many times did you visit your doctor (GP) or a respiratory nurse specialist because of your chest or breathing trouble in the last 12 months? ☐ Times
Q6	Have you visited an Accident and Emergency Department because of your chest or breathing trouble in the last 12 months? Please tick (**V**) *one box* ☐ No ☐ Yes
Q7	How many times did you visit an Accident and Emergency Department because of your chest or breathing trouble in the last 12 months? ☐ Times

Thank you for filling in this questionnaire. Before you finish would you please check to see that you have answered all the questions

Appendix 7: Saint George's Respiratory Questionnaire (SGRQ)

ST. GEORGE'S RESPIRATORY QUESTIONNAIRE (SGRQ)

This questionnaire is designed to help us learn much more about how your breathing is troubling you and how it affects your life. We are using it to find out which aspects of your illness cause you most problems, rather than what the doctors and nurses think your problems are.

Please read the instructions carefully and ask if you do not understand anything. Do not spend too long deciding about your answers.

Name of Participant:	**Date:**

Before completing the rest of the questionnaire: Please tick in one box to show how you describe your current health:

Very good ☐ Good ☐ Fair ☐ Poor ☐ Very poor ☐

PART 1						
Questions about how much chest trouble you have had over the past 3 months. Please tick (**√**) *one box for each question*:						
		most days a week	several days a week	a few days a month	only with chest infections	Not at all
Q1	Over the past 3 months, I have coughed:					
Q2	Over the past 3 months, I have brought up phlegm (sputum):					
Q3	Over the past 3 months, I have had shortness of breath:					
Q4	Over the past 3 months, I have had attacks of wheezing:					

Q5 During the past 3 months how many severe or very unpleasant attacks of chest trouble have you had?

Please tick (**√**) *one box*

More than 3 attacks ☐ 3 attacks ☐ 2 attacks ☐ 1 attack ☐ No attacks ☐

Q6 How long did the worst attack of chest trouble last? *(Go to question 7 if you had no severe attacks)*

Please tick (**√**) *one box*

A week or more ☐ 3 or more days ☐ 1 or 2 days ☐ Less than 1 day ☐

Q7 Over the past 3 months, in an average week, how many good days (with little chest trouble) have you had?

Please tick (**√**) *one box:*

- ☐ No good days
- ☐ 1 or 2 good days
- ☐ 3 or 4 good days
- ☐ Nearly every day is good
- ☐ Every day is good

Q8 If you have a wheeze, is it worse in the morning?

Please tick (**√**) *one box:*

- ☐ Yes
- ☐ No

PART 2
SECTION 1

How would you describe your chest condition?
Please tick (**√**) *one box:*

- ☐ The most important problem I have
- ☐ Causes me quite a lot of problems
- ☐ Causes me a few problems
- ☐ Causes no problem

If you have ever had paid employment.
Please tick (**√**) *one box:*

- ☐ My chest trouble made me stop work altogether
- ☐ My chest trouble interferes with my work or made me change my work
- ☐ My chest trouble does not affect my work

SECTION 2

Questions about what activities usually make you feel breathless these days.

Please tick (**√**) in ***each box*** that applies to you ***these days***:

	True	False
Sitting or lying still	☐	☐
Getting washed or dressed	☐	☐
Walking around the home	☐	☐
Walking outside on the level	☐	☐
Walking up a flight of stairs	☐	☐
Walking up hills	☐	☐
Playing sports or games	☐	☐

SECTION 3

Some more questions about your cough and breathlessness these days.

Please tick (**√**) in ***each box*** that applies to you ***these days***:

	True	False
My cough hurts	☐	☐
My cough makes me tired	☐	☐
I am breathless when I talk	☐	☐
I am breathless when I bend over	☐	☐
My cough or breathing disturbs my sleep	☐	☐
I get exhausted easily	☐	☐

SECTION 4

Questions about other effects that your chest trouble may have on you these days.

Please tick (√) in ***each box*** that applies to you ***these days***:

	True	False
My cough or breathing is embarrassing in public	☐	☐
My chest trouble is a nuisance to my family, friends or neighbours	☐	☐
I get afraid or panic when I cannot get my breath	☐	☐
I feel that I am not in control of my chest problem	☐	☐
I do not expect my chest to get any better	☐	☐
I have become frail or an invalid because of my chest	☐	☐
Exercise is not safe for me	☐	☐
Everything seems too much of an effort	☐	☐

SECTION 5

Questions about your medication, if you are receiving no medication go straight to section 6.

Please tick (√) in ***each box*** that applies to you ***these days***:

	True	False
My medication does not help me very much	☐	☐
I get embarrassed using my medication in public	☐	☐
I have unpleasant side effects from my medication	☐	☐
My medication interferes with my life a lot	☐	☐

SECTION 6

These are questions about how your activities might be affected by your breathing.

Please tick (√) in ***each box*** that applies to you ***because of your breathing***:

	True	False
I take a long time to get washed or dressed	☐	☐
I cannot take a bath or shower, or I take a long time	☐	☐
I walk slower than other people, or I stop for rests	☐	☐
Jobs such as housework take a long time, or I have to stop for rests	☐	☐
If I walk up one flight of stairs, I have to go slowly or stop	☐	☐
If I hurry or walk fast, I have to stop or slow down	☐	☐
My breathing makes it difficult to do things such as walk up hills, carrying things up stairs, light gardening such as weeding, dance, play bowls or play golf	☐	☐
My breathing makes it difficult to do things such as carry heavy loads, dig the garden or shovel snow, jog or walk at 5 miles per hour, play tennis or swim	☐	☐
My breathing makes it difficult to do things such as very heavy manual work, run, cycle, swim fast or play competitive sports	☐	☐

SECTION 7

We would like to know how your chest usually affects your daily life.

Please tick (√) in ***each box*** that applies to you ***because of your chest trouble***

	True	False
I cannot play sports or games	☐	☐
I cannot go out for entertainment or recreation	☐	☐
I walk slower than other people, or I stop for rests	☐	☐
I cannot go out of the house to do the shopping	☐	☐
I cannot do housework	☐	☐
I cannot move far from my bed or chair	☐	☐

Here is a list of other activities that your chest trouble may prevent you doing. (You do not have to tick these, they are just to remind you of ways in which your breathlessness may affect you):

Going for walks or walking the dog	☐
Doing things at home or in the garden	☐
Sexual intercourse	☐
Going out to church, pub, club or place of entertainment	☐
Going out in bad weather or into smoky rooms	☐
Visiting family or friends or playing with children	☐

Please write in any other important activities that your chest trouble may stop you doing:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Now would you tick in the box (one only) which you think best describes how your chest affects you:

Please tick (√) in ***each box***

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

Thank you for filling in this questionnaire. Before you finish would you please check to see that you have answered all the questions.

Appendix 8: Spirometry Test Protocol

Vitalograph®

Respiratory Monitor copd-6 BT

Model 4000

User Training Manual

CE
0086

Medical Devices Directive 93/42/EEC L169, Vol. 36,

EN ISO 13485, FDA QSR 21 CFR 820/803

Manufacturer: Vitalograph (Ireland) Ltd, Ennis, Ireland

1. The subject should sit down when blowing into the device (unless advised otherwise). Insert a new disposable SafeTway mouthpiece into the device.
2. Turn the device on, ⏻ (if not already ON). When the device is ready for a test the blow icon shows ( ).
3. Instruct the subject and demonstrate (using a mouthpiece) as follows:
    a. "Hold your head up, breathe in as deeply as possible, hold the device in front of your mouth".
    b. "Hold your breath, place the mouthpiece into your mouth, like this, bite the mouthpiece lightly, and seal your lips firmly around it, like this". I will demonstrate.
    c. "Blow out as HARD, and FAST as you can, like this, until I tell you to stop" (the unit will beep at end of test - after 6 seconds).
    d. "Be careful not to block the mouthpiece with your tongue or teeth. A 'spitting' action will give false readings".
    e. "Now you do it – deep breath in – bite and seal – blast the air out…keep going – keep blowing"
    f. "Well done!" "Now, we need to do that three times. Rest for a while until you are ready to blow again".
4. To view the result (the best values in the session), press the ↵ button.
    a. The COPD Classification will show on the right hand arrow.
        i. Green is NORMAL, negative for COPD. No need to refer this subject for spirometry.
        ii. Any one of the blue zones, I, II, II or IV are not normal. This subject should be referred for spirometry.
    b. The Obstructive Index (OI) shows on the left hand arrow.
        i. 0 - Green is normal.
        ii. 1, 2 or 3 – Yellow, amber or red are not normal. Refer for spirometry, but this is unlikely to be COPD.
        iii. ***Note:*** *If the right hand (COPD) arrow is not green, nor will the left hand (OI) arrow be green.*
5. This is the end of the test, but if desired some test parameters may be viewed.
6. Following each blow and at the end of the test session, the FEV1 value will be displayed and below that, FEV1 % Predicted results for that blow, or for the best in session if the ↵ button has been pressed. Pressing ↵ again will toggle between best and last blow.
7. Pressing the ▲ button will show the FEV6 and FEV6 % Predicted results.
8. Pressing the ▲ button again will show the FEV1/FEV6 and FEV1/FEV6 % Predicted results
9. Press the ▲ button for a final time will show the estimated Lung Age ( )

Setting the Obstructive Index and COPD Classification Zones

The Vitalograph copd-6 BT Obstructive Index and COPD Classification zones are set by the manufacturer to the GOLD (**G**lobal Initiative for Chronic **O**bstructive **L**ung **D**isease) standard and it is unlikely that a user will wish to change this – however if this is required please follow the following instructions:

The colour systems for each zone type are pre-set as follows:

FEV1% Pred.	Obstructive Index		COPD Classification	FEV1/FEV6 Ratio and FEV% Pred.
≥ 80%	0		Not COPD	FEV1/FEV6 > 0.7
		Top Boundary	Stage I	FEV1/FEV6 < 0.70 and FEV1 ≥ 80% Pred.
< 80%	1	Middle Boundary	Stage II	FEV1/FEV6 < 0.70 and FEV1 < 80% Pred.
< 50%	2	Bottom Boundary	Stage III	FEV1/FEV6 < 0.70 and FEV1 < 50% Pred.
< 30%	3		Stage IV	FEV1/FEV6 < 0.70 and FEV1 < 30% Pred.

To set the boundary percentage values for both the Obstructive Index and COPD Classification zones together, follow these steps;

1. Turn the device on, ⏻.
2. When the  icon appears, press and hold the ↵ and ▲ buttons for approximately 3 seconds.
3. The top boundary can now be set. This is done by pressing the ▲ or ▼ button and releasing when the value is reached. The values will increase/decrease in values of 1%. If the button is kept depressed, the values will scroll faster.
4. Press ↵ to set the top boundary value.
5. The middle boundary can now be set. This is done by pressing the ▲ or ▼ button and releasing when the value is reached. The values will increase/decrease in values of 1%. If the button is kept depressed, the values will scroll faster.
6. Press ↵ to set the middle boundary value.
7. The bottom boundary can now be set. This is done by pressing the ▲ or ▼ button and releasing when the value is reached. The values will increase/decrease in values of 1%. If the button is kept depressed, the values will scroll faster.
8. Press ↵ to set the bottom boundary value.
9. Press ↵. The device will return to the age entry screen.

Reviewing the Last Session Test Results

The Vitalograph copd-6 BT will always store the last test session, even after the device has powered itself down or has been switched OFF. In order to view the last test session, follow these steps:

1. Turn the device on, ⏻.
2. When the device is ready for age entry (), press the ↵ button for approximately 3 seconds. The last test session (best results) data will now show again.
3. When you have finished reviewing the data, press the OFF button for 3s. OR
4. Press ↵. The device will return to the age entry screen ready for entering the next test subject's data.

Appendix 9: Thematic Analysis of Qualitative Data

The qualitative data were thematically analysed and guided by the six phases of thematic analysis approach advanced by Braun and Clark (2006). To ensure clarity, rigour and increase the strength of the results, the application of the steps or a stage of thematic analysis in this study is presented. Brief extracts from each interview question analysis are provided along with thematic maps to illustrate the thematic analysis process. The six stages applied included:

1. Familiarising yourself with your data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report

1. Familiarising yourself with your data

In this step, the researcher immersed and familiarised himself with the data. This was achieved through repeated listening to the audio-recorded interviews, transcription of interviews into texts, intensive reading and re-reading of all transcripts. Initial ideas about coding were noted. The main idea at this stage was the separation of texts based on interview questions and assembly of texts relating to each question.

2. Generating initial codes

At this stage, the texts were examined more closely and line by line. This facilitated microanalysis of the entire data and production of initial codes. The coding was performed manually. Coloured pens and Microsoft Word features such as Text Highlight colour were used to colour map, make notes on texts and code the entire transcripts systematically (see Table 1). Several codes for potential subthemes and themes were used in this step. After coding the entire data, manual searches were conducted to identify items relating to the same or similar codes and these were organised into categories. This is illustrated in Table 2. These were the initial procedures that led to the research findings and as these were outlined transparently, reliability was enhanced (Lewis and Ritchie 2003). A paper and electronic-based audit trail of the initial coding were sent to the supervisor for review. This contributed to dependability and confirmability of the findings (Koch, 2006).

3. Searching for themes

At the end of step 2, a long list of initial codes was developed (Table 2). At step 3, potential themes were identified. To achieve this, the researcher collated all codes, sorted them and grouped them into potential themes. The recurring themes were identified based on how frequent they occurred within the texts. Thematic maps were used to sort the initial codes as recommended by Braun and Clark (2006). Some of the codes were retained as sub-themes or main themes, while others were discarded. At the end of this step, themes and sub-themes were developed (see Figures 1a-6a).

4. Reviewing themes

This is the stage where the themes were refined. Some of the themes were collapsed into other themes (e.g. barriers and enablers). All data extracts fitting or relating to each team were re-read to ensure there is a coherent pattern. The themes were considered in relation to the entire data and the relationships between them were visualised from the thematic map. Effort was made to ensure that the relationships between the themes reflected the meaning of the entire data. The thematic maps developed in step 3 were revised and new maps were produced (see Figures 1b-6b).

5. Defining and naming themes

At this stage, the themes and sub-themes were clearly identified. The researcher trawled back through the entire data to re-contextualise the identified themes and sub-themes i.e. the entire data was cconsidered in terms of the categories or themes and sub-themes developed through the analysis. Following this, a final thematic map of all themes and sub-themes was produced (see Figure 7).

6. Producing the report

At this final stage, the themes and their narratives were used to create an overall narrative of the analysis. The descriptions of themes and sub-themes were written up and a few quotes from the original transcripts were used to illustrate them in order to help communicate their meanings. This also enhanced the reliability of findings because researcher's interpretations were supported with evidence (quotes from participants) (Lewis and Ritchie 2003). The results of the analysis were reported and discussed in chapters 7 and 8 respectively.

Comments

Both deductive and inductive coding approaches were employed both of which align with thematic analysis of qualitative data (Braun and Clark, 2006). Deductive coding was performed with relative

ease because most of the initial codes such as perceived benefits, barriers and enablers of participation and recommendations for improvements were deduced or derived from the research questions that guided the study. As bracketing was not achieved totally, generating some of the initial codes was influenced and facilitated by some theoretical concepts from previous literature. For example, the published mixed methods systematic review (see Chapter 3) and other studies (Desveaux, et al., 2014b) reported on some social, physical and psychological health benefits of rehabilitation programmes as well as barriers, facilitators and recommendations on how to improve programme delivery.

Some initial codes were also generated inductively to allow some codes to emerge from the data. It was more difficult to do this because they appeared linked with other deductive codes, especially perceived benefits, barriers and enablers. Following inductive coding, one unanticipated theme (perception of safety) and four sub-themes (consistency, self-protective safety measures, exercise options and social support and supervision) were identified.

Most of the deductive codes were easier to group or fit into identified themes. For example, data relating to social, physical and psychological health benefits fitted easily into the theme perceived benefits. However, other codes were more difficult to fit into themes and this presented a dilemma. For example, texts relating to seasons (winter and summer) could not easily fit into themes like barriers and enablers because at one time participants mentioned it as an enabler and at other times, other considered it a barrier. In addition, codes such as social support and supervision and exercise options fitted into more than one theme. Social support and supervision were mentioned as social benefits, enablers and as one of the factors that contributed to perception of safety. Initially, the researcher reported all themes and sub-themes using separate thematic maps. The supervisor suggested using one thematic map to illustrate all themes and sub-themes. It also agreed that dilemmas of fitting codes into themes be resolved by linking the codes in the thematic map as well as in the overall narrative of the analysis. Figure 7 represents the revised thematic map following supervisor's suggestion.

Table 1: Brief extracts from each interview question analysis

Interview topic and question	Generating Initial Coding (By OFM & HB)
Referral **(a) Who suggested that you might attend this exercise maintenance follow up class?**	
P22: It's the nurse at —— the hospital. He gave me (the exercise instructor)'s telephone number and to —— and to [sic] phone him, if you —— oh no, no, that's wrong. The nurse told me, said to do it and we filled in a form, giving our telephone number. And then (the exercise instructor) phoned me and then —— I was here.	Nurse Exercise instructor
P7: I went to (the local hospital), first of all do take that into account. I will have to say Aaron, I only heard of —— any of these via a friend of a friend of a friend. It did not come from any medical person, if this helps your research. And —— I have —— I have an annual MOT with my doctor anyway and on one of the occasions when I saw the nurse, I mentioned this (local hospital) —— the (local hospital) class to her. And at that stage I had to undergo some tests and she knows the name for it. I can't remember what it's called —— and then she diagnosed that I had COPD, and she then referred me to (the local hospital). But if I hadn't just been talking to a friend about my —— I would never had known. So I keep telling people this, because I think the medical people ought to be aware that these classes are available. So that's how I came to (the local hospital).	Friends Doctor COPD diagnosis Nurse Friend Health care professionals Pulmonary rehabilitation
Referral **(b) Why do you think you were referred to this exercise maintenance follow up class?**	
P22: Oh, it's —— breathing problems. To follow up from the exercise, to keep —— to keep doing it on a regular basis. You know it's quite —— I mean for my group that was down the hospital [sic] only two people turned up here?	Breathing problems Regular exercise
P7: Well, yes, because it's just helpful for me, isn't it, for my chest. And —— the nurse said, "There was this class going and if I was interested I could go along". And I said, "I'm interested". And here I am, yeah.	Beneficial Chest/breathing problems
P10: Well because I was finding it hard to walk and was getting breathless. You know, —— it was my legs really. I mean this one especially [pointing to her right leg], I had terrible pains down this leg. And it was getting that way that —— it was becoming really hard work just to walk, yeah. And I thought I've got to do something about this. So first of all, they went to put me on for physio. —— but all down this leg [pointing to her right leg]. And then I heard about the	Functioning problem Breathing problems

other and so I went down to (the local hospital), on the six-week course. And they also —— from there, they also referred me to a physio for my leg as well, which was very good, yeah. Then I requested to come here to continue. They give you —— it's up to you. They say, when you finish that course, they say this is then available. And —— I wanted to continue because obviously I felt it was doing me so much good. So I —— I put in then to be transferred to here, and then (the exercise instructor) contacted me and said, "There was a place" because you have to wait till there was a place to get in, you know.	Continuity Regular exercise Maintain benefit
Benefits **Do you think this programme is beneficial? Why or why not?**	
P22: Well, my muscles are better, and my breathing has improved but I still can't get up the hill. [Pause]. Well, I think [pause] I don't know what I will do if I didn't come (Aaron). I think it's —— it's not too long. The only thing I —— it take up three days —— 2 days in a week. But days that are free for me I can't do anything. If I try and do something in the morning I can't because I've got to get ready to go —— because I don't drive. Well, I —— I can't understand. It makes me breath, I meet people, as I probably wouldn't go out. And —— I've met some friends here and —— they are all nice, they are —— I don't know how they are compare to me.	Strengthened muscles Improved breathing Physical fitness Improved breathing Meeting people
P7: Yes I do benefit from this. For instance, I've just said one of the exercises, which is this —— this business [demonstrating one of the seated warm-up exercises]. When I started at (the local hospital) I couldn't do it. Now, I can get my feet up. So yes it is beneficial to me. I can do more than I used to be able to do, yeah. —— I think it must do, but to be honest with you I don't do much walking Aaron. Because with hips and backs and breathing, I don't find it easy. —— But yes, I think it has helped my breathing. I think I can walk a little farther than I used to. I still can't walk long ways, but I think it has helped.	Physical fitness Increase physical activity Improved breathing Physical fitness Increase physical activity
Enablers **What helps you to be able to attend this program?**	
P7: Well I'm retired. So I have the time, —— that's basically it. I have the time and I can come. What makes me attend, —— because I think it's good for me and I've got the opportunity to do so. We shouldn't —— in my view, particularly with health, if we have opportunities offered to us we should use them. I have the time to come. That's because I'm retired. And I have to add —— it might help your research I don't know. I no longer drive, because I've got dead feet and I can't always feel the pedals. So my husband brings me —— he brings me and collects me. So I've got a very good husband. Yes, because if someone —— you know if you depend —— if I was dependent on public transport or anything to get here, I couldn't come. I could come by taxi, but that's more money and we are all on pension basically, yes.	Being retired Having the time Perceived benefit Being retired Having the time No longer drive Support by husband

Barriers

What makes it more difficult for you to attend?

P23: **What sort of thing would prevent me coming? If the family would be going out for a meal mid-day.** So many of us are retired. It maybe special occasion and I won't come. **Well, I think I can miss one and go out and have lunch or whatever. My son might need to see me or talk,** I might have something important to do. I might have to see the bank manager. It's varying things. **I —— I —— this is a priority most of the time.** But I'm retired too —— too long ago. [redacted] There was a time at Christmas, **I had a —— a viral thing. One before and one after Christmas and there was no way I could get here, so I didn't attend that. —— I think I —— yeah, that was the only time that I've not attended through physically being shattered. I just haven't —— I didn't have the strength, yeah, so I didn't come.**

Family commitment
Being retired
Having the time
Other commitment (see bank manager)
Prioritising it
Making the effort
Poor physical health

Safety

What makes you feel safe while exercising in the community centre?

P7: (The exercise instructor) makes me feel safe. The trainer makes me feel safe. And —— of course I only use certain equipment. I only use —— I use the weights and I use the bicycle. Well, basically because that was the programme I started on and I haven't sort of changed anything. —— I could be more adventurous I suppose, but I'm not. That's probably up to me. I could be more adventurous. They are all helpful if you need help. They are all ready to have a talk or you know. They've all been very helpful to me. Because, the gym equipment —— until you know what you are doing, it's a bit hard, but they are there to help you. So it's been good, very good. Once I'm here, I'm fine. I have to be honest to say when I'm at home I think, "Do I really want to go?" But I'm saying, "Yes". Once I'm here I'm fine and I enjoy it.

Instructor's presence
Exercise option

Social support (peers)

P10: Well, I just feel —— like I came last week and I didn't stay. And I came —— you know he [the exercise instructor] hasn't been here for a couple of weeks. Before that, I've been away myself. I didn't stay and some of them said, "But we stayed why didn't you stay?" And I just feel —— not as confidence [sic] when (the exercise instructor) is not here. I feel —— when he's here —— I feel part of the group, I feel like, we go down we do them. When he's not here we don't do any of that, we just go straight into the gym. He [the exercise instructor] —— he gives me confidence. Yeah, he gives me confidence.

Social support (instructor)

Self-confidence

Self-confidence (instructor)

Recommendations for improvement

What would you recommend to improve this programme (what to change)?	
P7: The studio exercises. I would recommend we keep those. Because we can all do those and haven't learned them, we can do those at home, ok, which I've been doing in the past four —— we can sit in our arm chairs at home and do these exercises. —— I quite like the equipment I use, which is basically just the weights drawing them up to my chest. —— So but I would definitely keep the studio good. If I had a choice, I would keep the studio good.	Studio exercises Keep it the same Exercise equipment Studio exercises
P10: Well, I can't see —— I mean, I mean at the end of the day, the programme is all about exercise, isn't it? You can't really change the exercise, that's the whole thing of the —— of the programme. So I —— I won't change anything. You know, I mean I —— I want mainly my —— my leg muscles, strengthening, you know. Because that's the thing that I found was getting so bad and that's the thing I found the improvement in. So, yes, oh gosh yes, without a doubt keep the exercises	Exercises Keep it the same Exercises
P5: Well I think I like the —— sort of warm up exercises and —— well not having experienced it before I like it as it is. Warm up exercises, and then your preference, you know you can prefer to go on to the various things in the gym and do what you want that fills in for an hour or so. Yes, you know you are not forced to go on any of them [laughing] if you don't like them.	Studio exercises Exercise equipment Exercise options Choice or preference

Table 2: Brief extracts of Initial codes & manual searching to identify the same or similar codes

Initial codes generated	Common or similar codes (By OFM & HB)
Referral	
Nurse at hospital; Application; Contacted by exercise instructor; Friends; Doctor; COPD diagnosis; Nurse at GP surgery; Friend; Health care professionals; Pulmonary rehabilitation; Nurse; exercise instructor; Friend; Seeing benefits; Self-belief; Doctor; Physical health problems; Contemplation to act; GP referral; Interview; Pulmonary rehabilitation; Duration, type of activities; Completed PR; Nurse & physiotherapist; Fitness gym; Physical health problems; COPD diagnosis; Pulmonary rehabilitation; Nurse & physiotherapist.	Nurses and physiotherapist Doctors GP Friends Pulmonary rehabilitation
Reasons for Referral	
Breathing problems; Regular exercise; Beneficial; Chest/breathing problems; Functioning problem; Breathing problems; Continuity; Regular exercise; Maintain benefit; Breathing problems; Perceived benefit; Breathing problems; Breathing problems; **Functioning problem;** Stop it getting worse; Motivation for exercise; Social dynamics; Social dynamics;	Breathing problems Regular exercise Maintain benefits
Benefits	
Strengthened muscles; Improved breathing; Physical fitness; Improved breathing; Meeting people ; Physical fitness; Increase physical activity; Improved breathing; Physical fitness; Increase physical activity; Improved breathing; Meeting people; Talking to people; Peer/social support; Motivation; Strengthened muscles; Physical fitness; Walking; Season and wellbeing; Improved wellbeing; Reduced anxiety; Meeting people; Socialising; Increased morale; Social isolation; Motivation; Meeting people; Physical fitness; Physical health; Strengthened muscles; Improved breathing; Getting off antibiotics; Improved wellbeing; Improve well-being; Physical fitness; Maintaining levels of physical activity; Physical fitness; Restored previous hobby; More physically active; Season and activities; Playing golf; Improved breathing; Getting off oxygen therapy; Cope with breathlessness; Restored hope; Physical fitness; Restored previous hobby; More physically	Strengthened muscles Improved breathing Physical fitness Meeting people Motivation Reduced anxiety

active e.g. bowling, decorating, walking; Reduced fear ; Cope with breathlessness; Peer influence; Physical fitness;

Enablers and Barriers

Other activities; No longer drive; Support by peers; Other activities; Being retired; Having the time; Perceived benefit; Being retired; Having the time; No longer drive ; Support by husband; Perceived benefit; Motivation; Perceived benefit; Socialising; Physical health; Chest infection; Proximity; Own a car; **Convenient**; Proximity; Perceived benefit; Meeting people; Peer support; Information from peers; Perceived benefit; Physical fitness; Maintaining hobbies; Proximity; **Convenient**; Perceived benefit; Risk of deterioration; Consistency; Perceived benefit; Peer support; Own a car; **Convenient; Family commitment; Programme characteristics;** Perceived benefit; Support from instructor; Peer support; Social network; Being retired; Having the time; Own a car; Proximity; Easy access; **Planning/organising; Programme characteristics; Convenient; Convenient; Programme characteristics; Planning/organising;**

Peer support
Being retired
Perceived benefits
Proximity
Own a car
Convenience
Physical health

Safety

Feels safe; Adverse event; Instructor's presence; Feels safe; Feels safe; Feels safe; Feels safe; Feels safe; Independence; Self-confidence; Not overdoing it; Instructor's presence; Supervision & support; Instructor's presence; Exercise option;s Social support (peers); Social support (instructor); Self-confidence; Self-confidence (instructor); Environment; Social support (instructor); Social support (peers); Self-confidence (instructor); Social support (instructor); Social support instructor); Social support (others); Social support (peers); Exercise options; Social support (instructor); Supervision; Self-confidence; Self-confidence; Social support (instructor); Safety checks.

Feels safe
Instructor's presence
Social support
Supervision
Exercise options
Self-convidence

Recommendations for improvement

Keep it the same; Studio exercises; Exercise equipment; Studio exercises ; Keep it the same; Keep it the same; Studio exercises; Exercise equipment; Exercise options; Choice or preference ; Keep it the same; **Purpose-built unit;** Keep it the same; Exercise equipment; Exercise options; Choice or preference; Studio exercises; Keep it the same; Exercise instructor; Studio exercises; Keep it the same; Keep it the same; Keep it the same; Keep it the same; **Purpose-built unit;** Keep it the same; Keep it the same; Keep it the same; Keep it the same; Keep it the same; Ambivalent; Keep it the same; Keep it the same; Keep it the same; Keep it the same; Keep it the same; Keep it the same; Continuity; Continuity; Continuity; Lucky to have this; Lucky to have this; Continuity; It is important; Continuity; It is important.

Keep it the same
Studio exercise
Continuity
Purpose-built unit

Figure 1(a): Thematic map showing one main theme and other subthemes

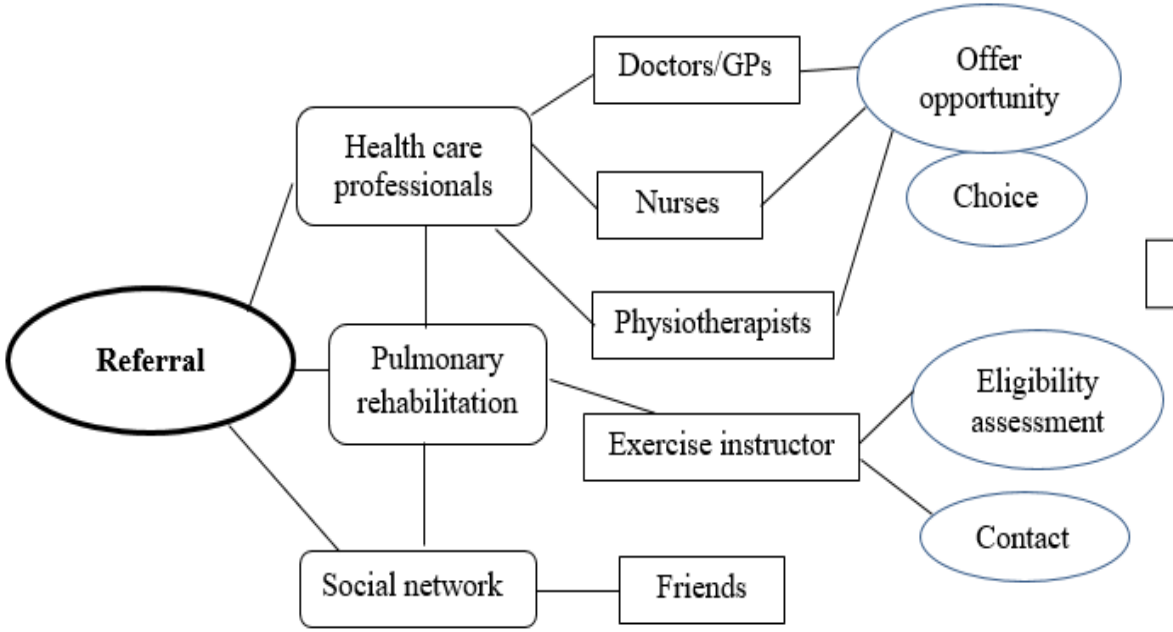


Figure 1(b): Revised thematic map

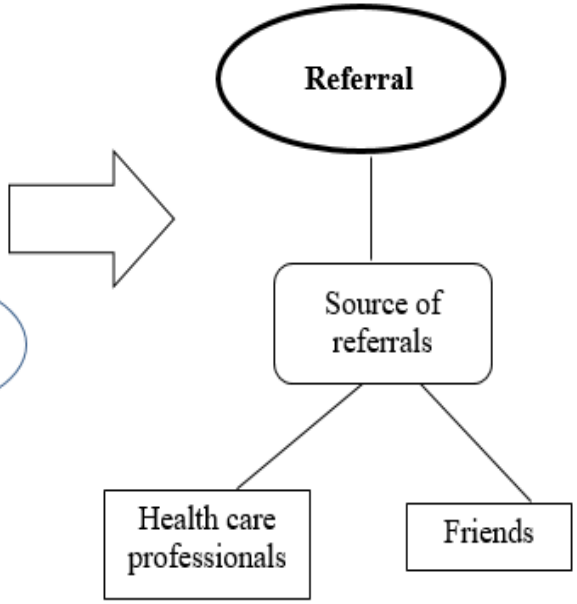


Figure 2(a): Thematic map showing one main theme and other subthemes

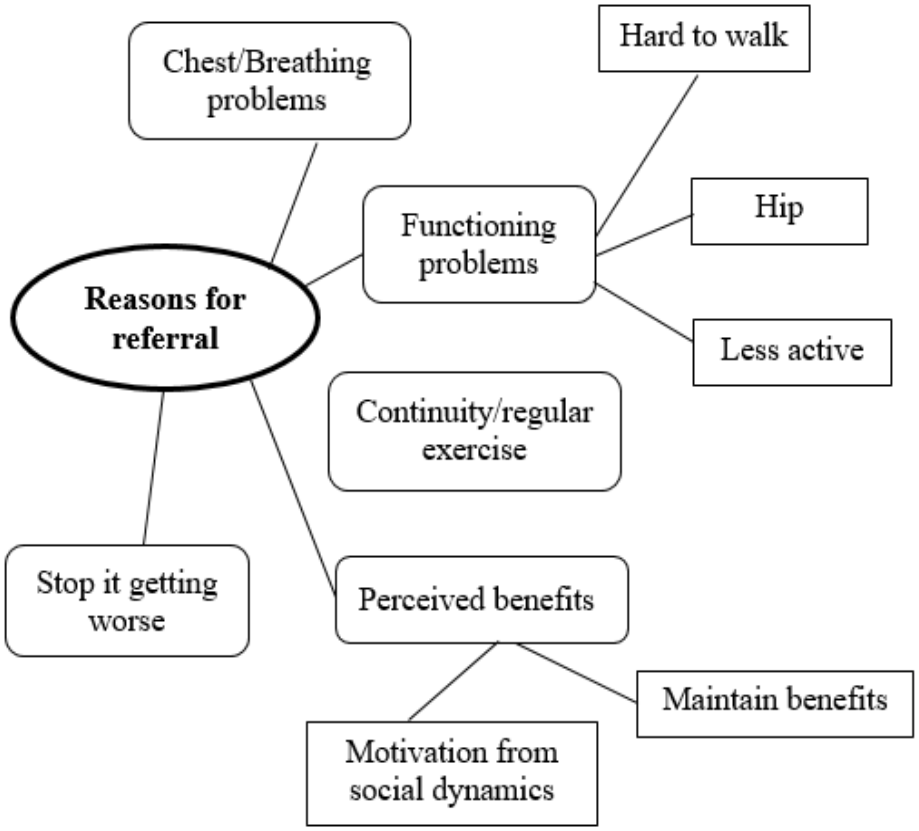


Figure 2(b): Revised thematic map

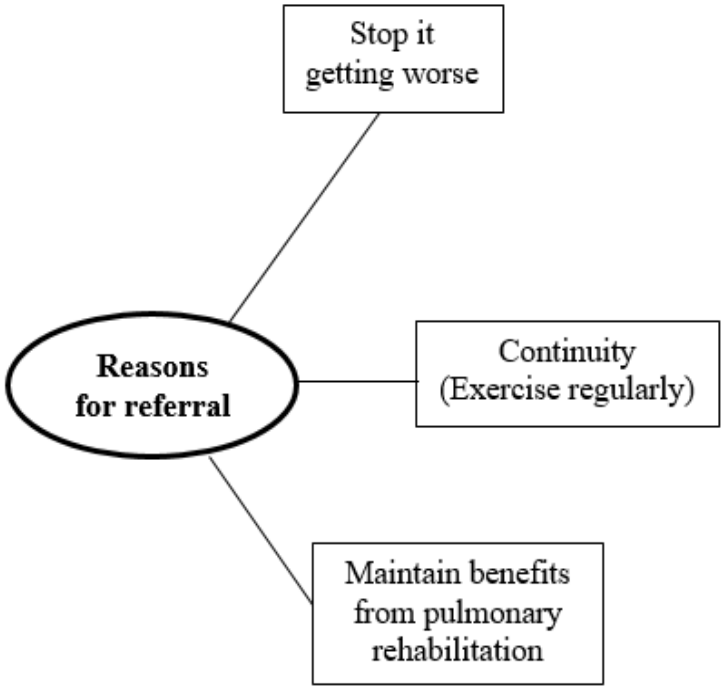


Figure 3(a): Thematic map showing one main theme and other subthemes

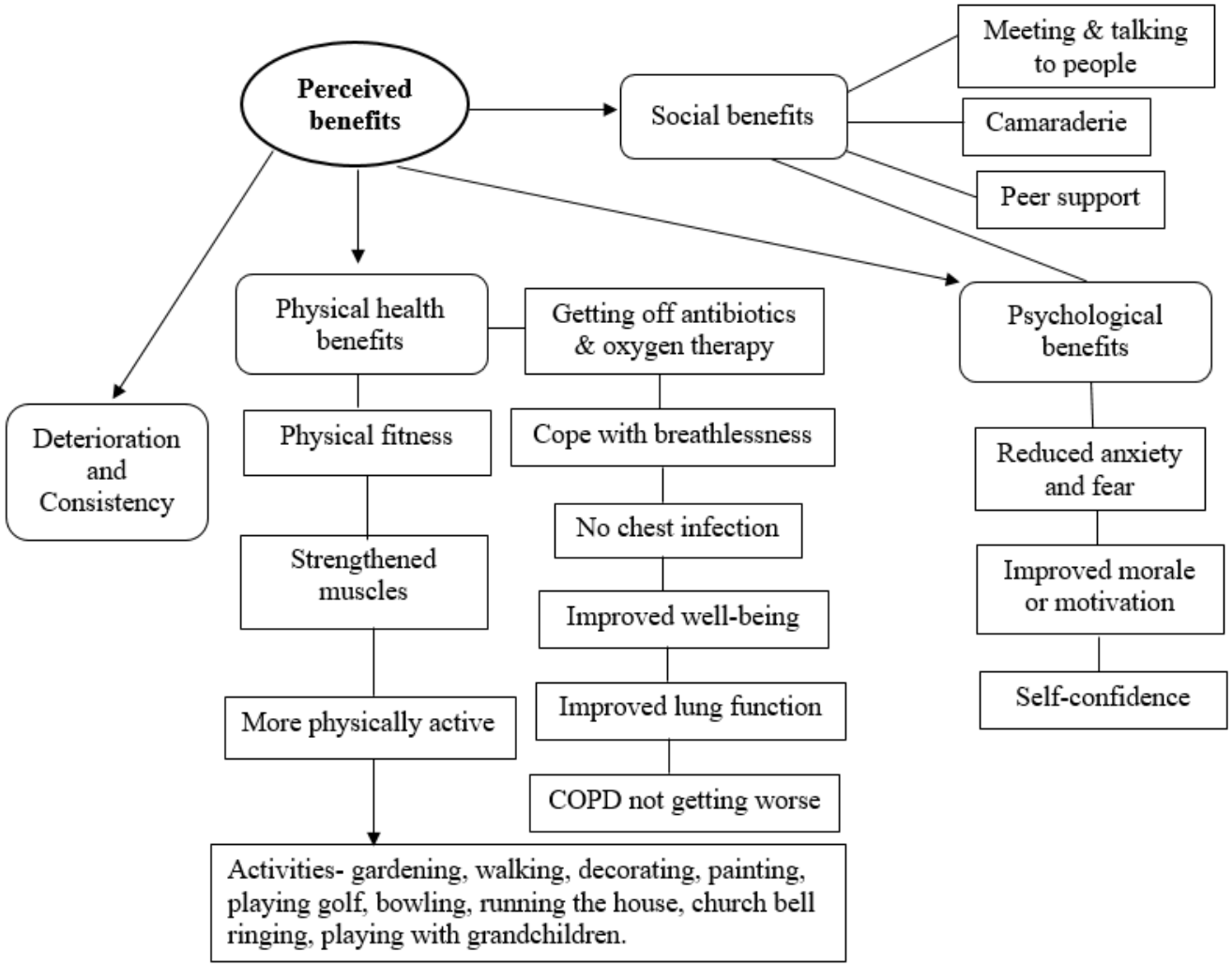


Figure 3(b): revised thematic map

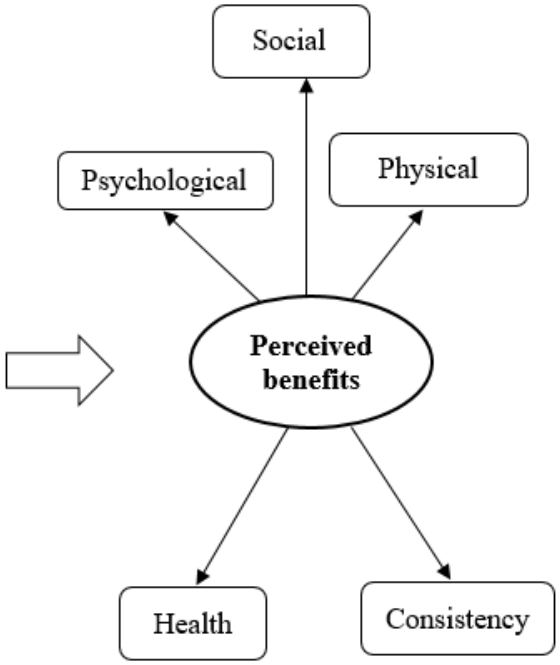


Figure 4(a): Thematic map showing one main theme and other subthemes

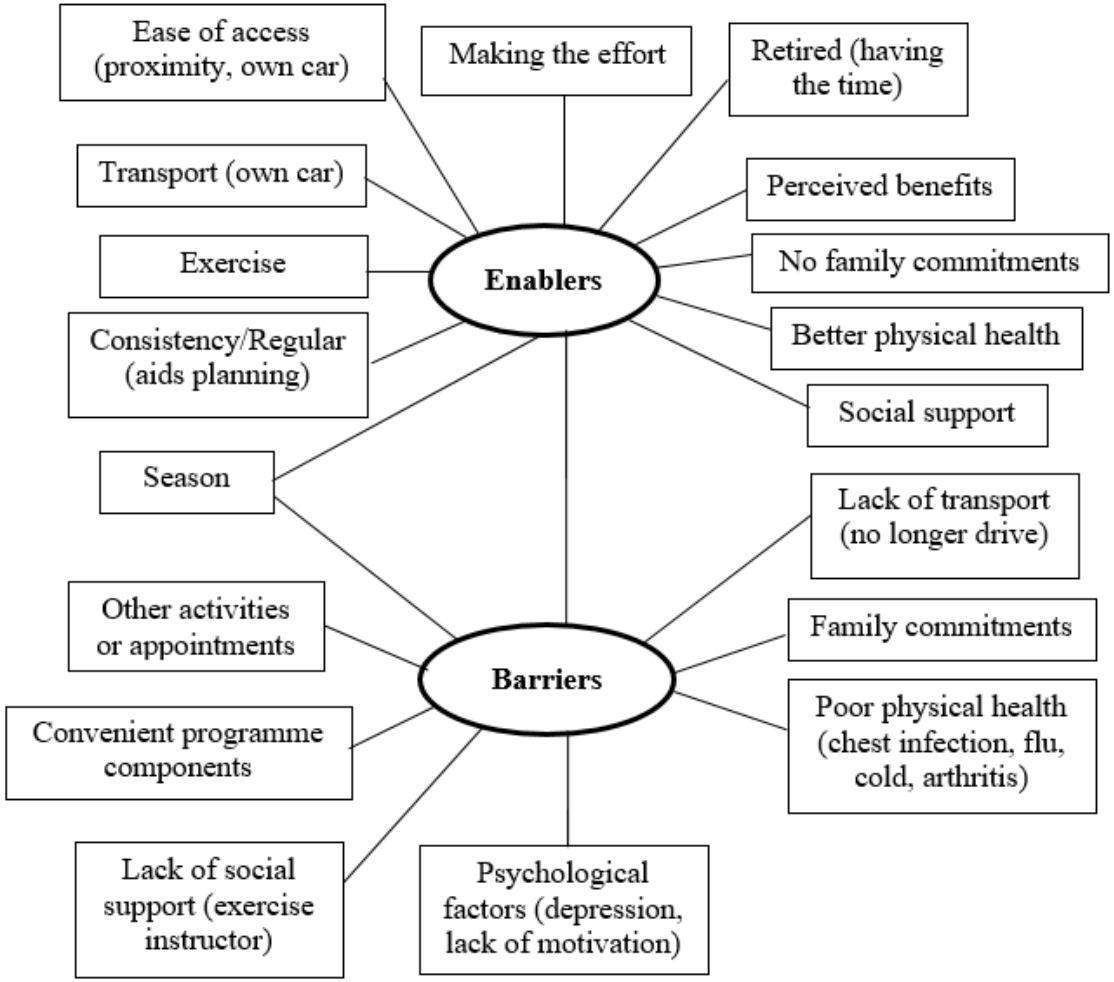


Figure 4(b): Revised thematic map

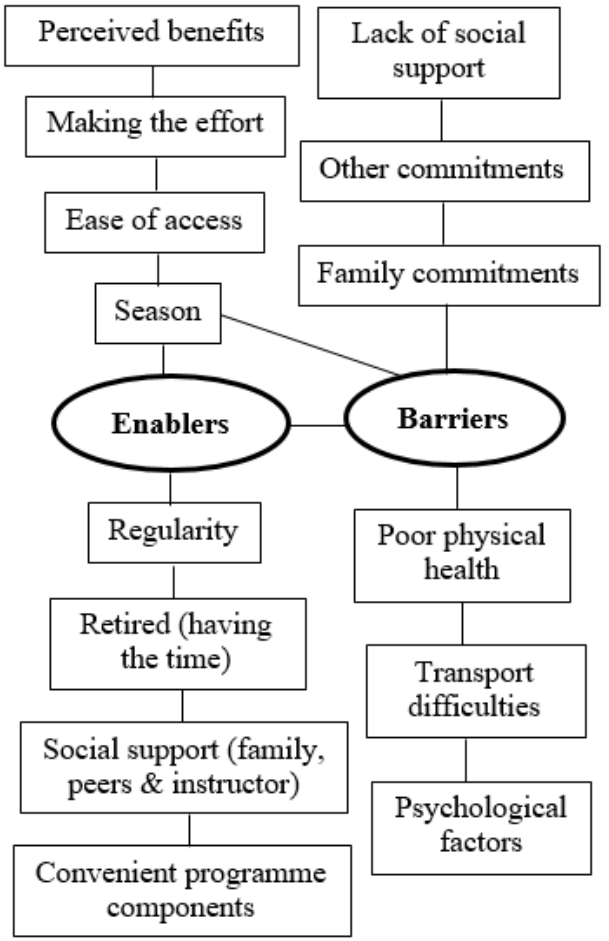


Figure 5(a): Thematic map showing one main theme and other subthemes

Figure 5(b): Revised thematic map

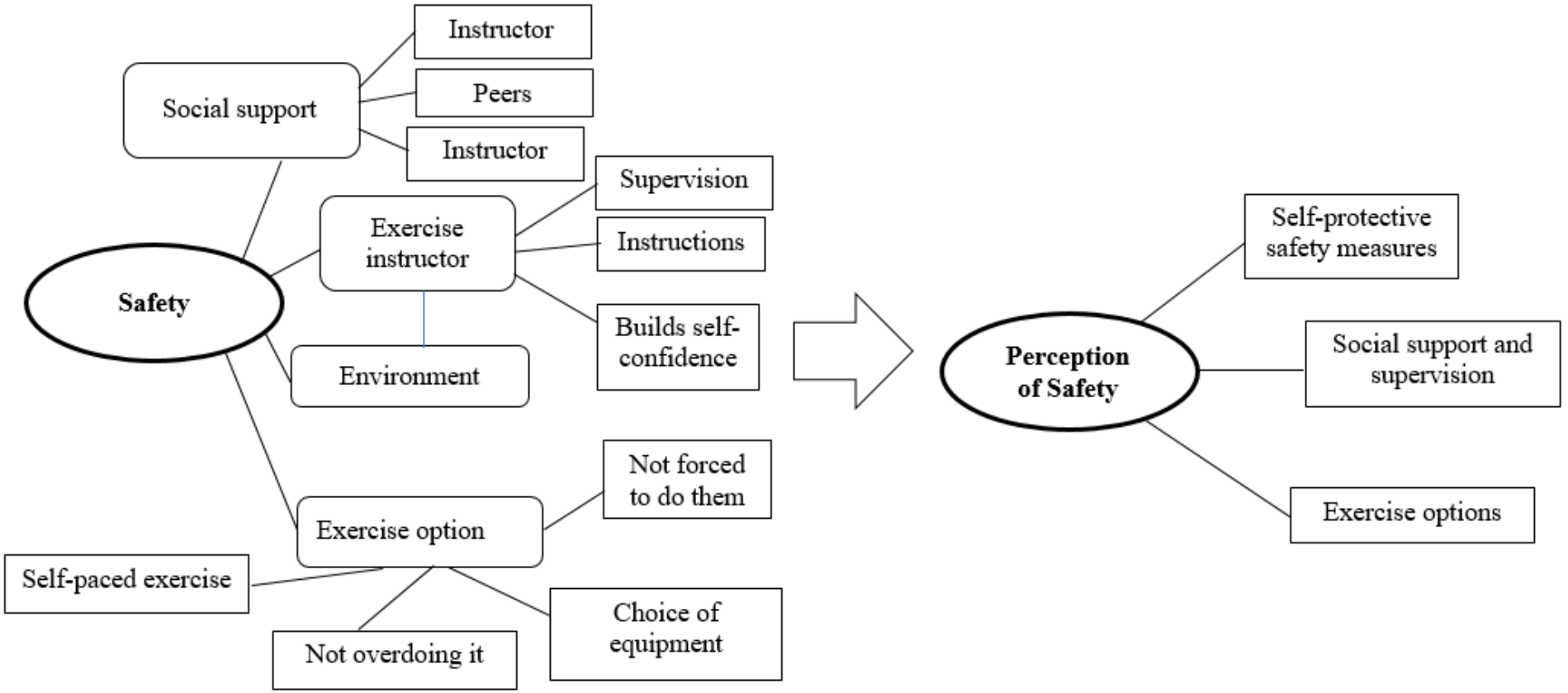


Figure 6(a): Thematic map showing one main theme and other subthemes

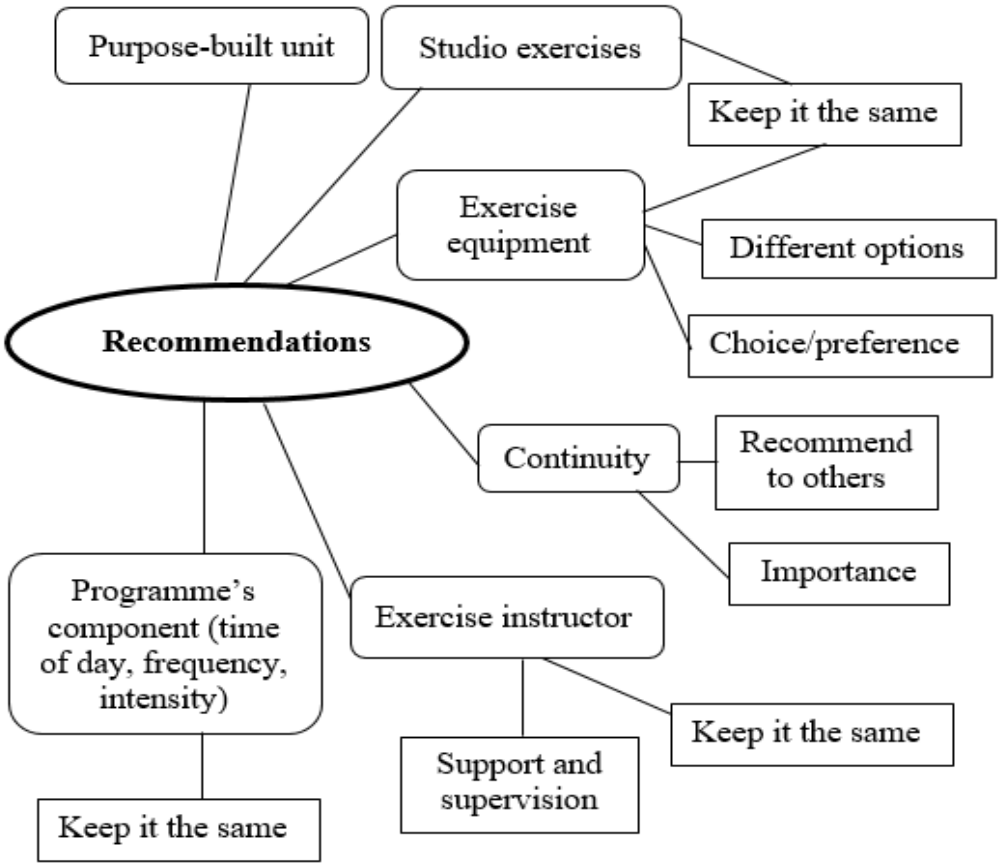


Figure 6(b): Revised thematic map

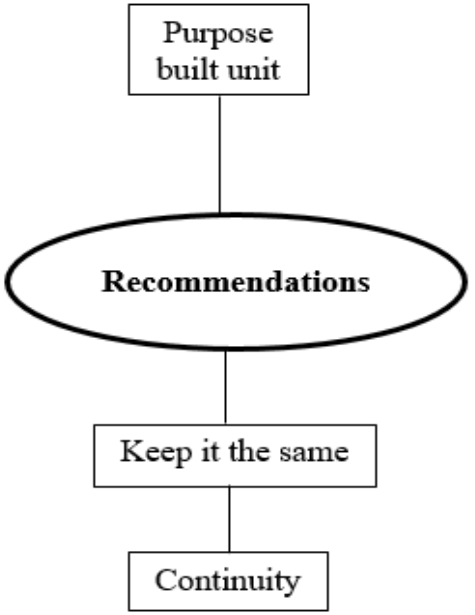
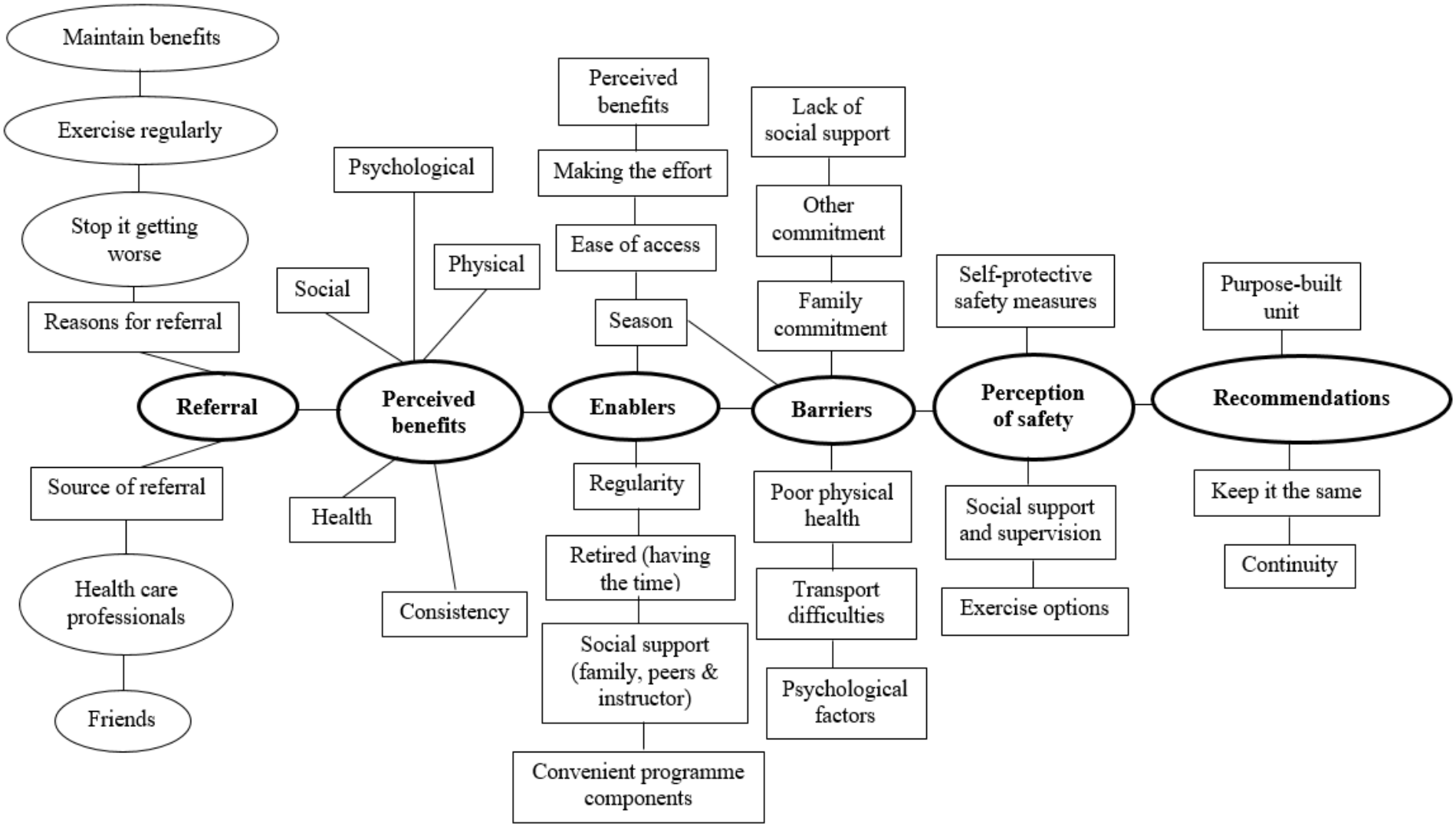


Figure 7: The final thematic map showing all themes and subthemes from interview data



Appendix 10: Institutional Ethical approval letter

[Redacted from this version]

Appendix 11: SCREC ethical approval letter

[Redacted from this version]

[Redacted from this version]

[Redacted from this version]

Appendix 12: Application to Uttlesford District Council

[Redacted from this version]

Appendix 13: Approval letter from Uttlesford District Council

[Redacted from this version]

[Redacted from this version]

Appendix 14: Research methods, ethical principles, potential risks and minimisation plan

Method/procedure	Purpose	Potential risk(s)	Right that could be potentially violated	Ethical principle	Risk elimination or minimisation measures
Spirometry	Objectively assess pulmonary function/confirm COPD diagnosis	Psychological distress such as increased anxiety in patients with COPD Health and safety: risk of infection through spirometer's mouth piece. Poor reading and misinterpretation of spirometric results	Right to safety Right to be informed Right to choose Right to respect	Justice Veracity Beneficence Fidelity Non-maleficence Confidentiality Autonomy	This is a reliable tool that is currently used in clinical practice and research. Standard infection control guideline were followed. The COPD-6 device was cleaned and disinfected after each use. Participants did not use the same mouth piece. Several clean disposable mouth pieces were available for use. COPD-6 device was set up correctly and all safety instructions were observed as per manufacturer's instructions (Vitalograph 2013). Researcher completed BTS's Spirometry in practice training course (BTS, 2005) and performed test as per manufacturer's instructions (Vitalograph 2013) and recommended guidelines (Miller et al., 2005) Participants were informed about the voluntariness, aims and objectives of the study. Informed consents of participants were obtained and they were not coerced or induced to participate in the study

Method/procedure	Purpose	Potential risk(s)	Right that could be potentially violated	Ethical principle	Risk elimination or minimisation measures
Self-Reported Hospital Admission Questionnaire (SHAQ)	To determine the frequency of hospital admissions and visits to emergency department due to COPD-related problems	Psychological harm Waste of participants' time Unrealistic positive expectations which may lead to subsequent disappointment if not met.	Right to be informed Right to choose Right to respect	Justice Veracity Beneficence Fidelity Non-maleficence Confidentiality Autonomy	SHAQ is a short and simple non-validated tool that was purposely designed for this study. The questions were clearly worded and were not capable of evoking painful memories/feelings The questionnaire is understandable, accessible to people with low levels of literacy. There is no need for translation into other languages as potential participants are proficient in English language. Can be completed on time (within 5 minutes) All questionnaires were completed in a safe, conducive and private room at the leisure centres to protect both the interviewees and the interviewer. Participants were allowed to ask questions for clarity. The primary researcher (OFM) was there to answer questions. Completed questionnaires were kept in a locked cabinet and computers used were password protected.

The Saint George's Respiratory Questionnaire (SGRQ)	A COPD-specific heath status questionnaire	Same as with SHAQ Poor recording and scoring.	Same as with SHAQ	Same as with SHAQ	Same as with SHAQ SGRQ is a reliable and validated questionnaire that has been used in previous studies Scoring was based on the recommended Excel-based scoring calculator (Jones et al (1991)
Method/procedure	**Purpose**	**Potential risk(s)**	**Right that could be potentially violated**	**Ethical principle**	**Risk elimination or minimisation measures**
PAM AM300	Objectively measured participants' levels of daily PA	There is no serious personal safety issues involved with the use of accelerometers. However, there is a minimal probability that participants may feel uncomfortable with wearing th device. Nevertheless, this is unlikely to amount to any significant distress. Low compliance	Right to privacy Right to choose Right to safety	Justice Veracity Beneficence Non-maleficence Autonomy	PAM AM300 is a reliable and validated activity monitor that have been used in previous researches. Participants were debriefed about aims and objectives of the device. Participants were instructed/trained on how to use the device
Exercise Recording Sheets and other documents relating to the CEP	To describe context of the study and characterise exercise modalities.	There is no obvious risk to the physical or psychological well-being of the participants	Right to be informed Right to choose Right to privacy	Veracity/Honesty Autonomy Confidentiality	Participants were informed and they consented for the researcher to have access to their exercise diaries All relevant data extractions from these documents were carried out on site to prevent or minimise risk of damaging or misplacing the documents and breaching confidentiality.

Method/procedure	Purpose	Potential risk(s)	Right that could be potentially violated	Ethical principle	Risk elimination or minimisation measures
The Six-Minute Walk Distance test (6MWD)	Assess functional status/exercise capacity	There is no serious personal safety issues involved with the 6MWT. The risk of harm, discomfort and fatigue during the walking distance testing are no greater than what participants experienced in their routine exercise classes and in everyday life. This is unlikely to amount to any significant physical harm or distress.	Right to safety Right to be informed Right to choose	Veracity/Honesty Autonomy Beneficence Non-maleficence	The exercise sessions were supervised by a Registered Exercise Profession, REP (exercise instructor). All participants practiced the 6MWD test on two occasions for familiarity and to minimize learning effects. Participants were given the option of refusing to participate in the research. Researcher and exercise instructor ensured that participants were appropriately dressed and wore appropriate footwear.
Self-administered Socio-demographic questionnaire	Obtain data such as current smoking, alcohol consumption, socioeconomic factors (sex, age, education, marital status and cohabitation) and anthropometry (weight, height and Body Mass Index)	No serious risk that is likely to amount to significant psychological distress.	Right to be informed Right to choose	Confidentiality Autonomy	Same as with SHAQ above The questionnaire were designed to gather information directly relevant to the research questions. No private or personal questions were asked.

Method/procedure	Purpose	Potential risk(s)	Right that could be potentially violated	Ethical principle	Risk elimination or minimisation measures
Semi-structured interviews	Obtain qualitative data	Coming too close to the participants' life Psychological distress, fatigue, feelings of fear. The potential for harm or distress is no greater than what might be experienced in everyday life. The questions relate to everyday life of physical activity and maintenance classes. Sensitive issues will not be discussed. Misinterpretation of participants' perceptions of phenomena Refusal to answer a question or discuss a topic during interviews Loss of data or data theft Disclosure risk. Preserving participants' Anonymity	Right to privacy Right to choose Right to safety	Confidentiality Non-maleficence Autonomy Veracity	The questions did not contain any degrading, discriminating or other unacceptable language that could be offensive to participants. Private data were not collected and participants' names were not reported All data were kept confidentially and were anonymised Interview transcripts or notes of participant's interviews were sent to them for checking? Interviewees were given the opportunity to comment on or change their interview transcripts if they felt that the transcripts or interpretattions misrepresented their ideas or words Collected data and transcripts were stored in password protected the researcher's personal computer to maintain confidentiality. Arbitrary numbers were used to represent personal data. All interviewees were given fictitious names. Any information which may reveal the identity of the participants (for example, the mentioning of addresses or places of work by the interviewees), were also represented using fictitious names.

					Participants were informed, in the Participant Information Sheet, of their right to opt out of the study at any time during data collection process. The data was only used as part of the researcher's thesis, in partial fulfilment of the requirements for the award of a PhD degree. The data will be deleted as soon as the degree is awarded. All interviews took place in a safe, conducive and private room at the leisure centre to protect both the interviewees and the interviewer.

Method/procedure	Purpose	Potential risk(s)	Right that could be potentially violated	Ethical principle	Risk elimination or minimisation measures
Audio recording	Ensure that no verbal information is missed during interviews. Enable verbatim transcript for analysis.	Loss of data or data theft Disclosure risk. Preserving participants' Anonymity Poor audio quality Faulty recorder	Right to privacy Right to choose	Confidentiality Non-maleficence Autonomy Veracity	It was clearly stated in the information sheet and consent form that interviews will be audio-recorded. Participants were allowed to partly edit the tape. Participants were allowed to withdraw, even during the recording process. The voice recorded data were used in any presentation of some sort that may reveal participants' identity. Audio files were kept in a locked cabinet by the primary researcher. Recorded data were deleted after transcription The data have been used to produce this PhD thesis and will be deleted as soon as the degree is awarded or retained for academic purposes e.g. academic publications. Each participant signed a consent form
Setting/location for data collection	This is where data will be collected		Right to privacy Right to safety Right to respect Right to dignity	Non-maleficence Beneficence	Written permission were obtained from the Uttlesford District Council and 1Life Manage Solutions Ltd for the use of the leisure centre for data collection. No video recordings were made during interviews

Method/procedure	Purpose	Potential risk(s)	Right that could be potentially violated	Ethical principle	Risk elimination or minimisation measures
Publishing findings of the study	Report findings to academic audience and lay people	Falsification, fabrication and misinterpretation of data Academic fraud and plagiarism	Intellectual property rights (IPR) Right to privacy Right to safety Right to be informed Right to respect	Honesty Confidentiality Fidelity Veracity Justice Non-maleficence Autonomy	Private data including names would not be reported All participants will be informed and reassured that their identities will not be disclosed in the thesis and other academic publications. In this PhD thesis and other publications based on data obtained from participants, results were not and will not be reported on individual basis but as descriptive summaries of the sample. This will make it impossible to infer the identity of any participant. The work of other authors that were used in any part of this study were acknowledged and appropriately referenced with the Harvard Referencing style.

Appendix 15: Chair-based warm up and cool down exercise modalities

1. Seated breathing exercises: Patients sat in default stable posture, inhaled through the nose for 5 seconds and exhaled through the mouth for 9 seconds. They were encouraged to try to get all the breath out of their lungs on the exhalation. They completed 5 rounds of this breathing exercise, having a little bit of a pause for recovery breath at the end of each round.

2. Seated leg marches: From default stable position. They do a gentle march out- moved their bent legs from the floor up and then back to the floor. The gentle march out were repeated 10-15 times. Patients were encouraged to get their feet off the floor.

3. Seated arm marches: From default stable position, patients bent their arms at the elbow and marched them backward and forward for about 5-10 times. Patients were encouraged all the way.

4. Simultaneous seated leg and arm marches (combination of exercises 2 and 3).

5. Seated heel dip forward: From the default stable position, patients extended their legs in front of them, feet flexed and heels just a few inches off the floor and then back to default position. Heel dip forwards were repeated 5-10 times.

6. Seated heel dip sideways: From default stable position, patients extended their legs sideways, feet flexed and heels just a few inches off the floor and then back to default position. Heel dip sideways were repeated 5-10 times.

7. Seated upper arm stretches (forwards, sideways and above the shoulder): From the default stable position, patients moved their arms out with fingers pointing forward towards toes (sometimes pointing sideways away from the body) and then return to starting position. (15-20 times).

8. Simultaneous seated heel dip sideways and upper arm stretches (combination 6 and 7).

9. Seated bicep curls: From default stable position, patients clenched their fists and bent at their elbows to curl the clenched fists to shoulder level and slowly lower the fists back to the starting position.

10. Seated heel dip forward plus bicep curls (simultaneously) for up to 15-20 times.

11. Seated shoulder lifts: From default stable position, patients dropped their hands down by the sides of their chairs, gently lifted their shoulders up to the ears and down to the starting position. This was repeated 3-5 times.

12. Seated shoulder shrugs (Backward and forward): From default stable position, patients dropped their hands down by the sides of their chairs, gently lifted their shoulders up to the ears, rolled them back and returned to the starting position. This was repeated 3-5 times. The exercise is repeated but with shoulders rolled forward.

13. Seated heel raises: From default position, patients lifted their heels up as high as they can, keeping their toes on the floor, held for a count of 5 and then lowered heels slowly to the start position. They repeated this for at least 5 times. Both legs were done at the same time.

14. Seated toe/foot raises: From default position, patients lifted their toes up as high as they can, keeping their heels on the floor, held for a count of 5 and then lowered heels slowly to the start position. They repeated this for at least 5 times. Both legs were done at the same time.

15. Seated trunk stretch 1: From default posture, patients put their both hands to the back of their chairs, pushed their chests forward and held the stretch until the stretch is felt in their upper back (this took about 8-10 seconds). They are encouraged to keep breathing during this stretch.

16. Seated trunk stretch 2: From default posture, patients put their left hands by the sides of their chairs, lifted their right hands up and over their heads. They then learnt their bodies towards the right until the stretch is felt in their left side. They slowly came out of the stretch and repeated the stretch on the other side.

17. Seated chin drop: From default posture, patients put their hands together, stretched them forward, made a little bend in the elbow, dropped their chins as far as possible toward the sternum (breastbone) and held the stretch until it was felt in the back of their necks (8-10

18. Seated calf stretch: From default stable posture, patients extended their right legs in front of them, with heels on the floor and hands by the sides of the chair. They flexed their feet with toes up towards their bodies, looked over the top of their shoes and held the pose for 15-20 seconds.

19. Seated back (piriformis) stretch: From default stable posture, patients extended their right legs in front of them, with heels on the floor (toes pointing away). They placed hands unto their bent right legs, leaned forward from the hips letting their right elbows come down to their

20. Seated triceps stretch: From default stable posture, patients placed their right palms on their backs between their shoulder blades with their elbows pointing upwards. Then, they gently pulled their elbows towards their heads with the left hands. The instructor encouraged them apply

seconds).	They switched sides and repeated the stretch on the other side.	right knees. They were encouraged to look ahead, keep breathing and hold the stretch for 10 seconds. They slowly returned to their original default position, relaxed, switched sides and repeated the exercise.	a bit of pressure just so they feel a tightening in their right shoulders and to hold this position for 15-20 seconds. Thereafter, they slowly returned to their original default position, relaxed, switched sides and repeated the exercise.
21. Seated biceps Stretch: From default stable posture, patients held their palms together behind their backs, straightened their arms and rotated their wrists slightly such that their fingertips pointed downwards. Then, they slowly lifted their arms up as high as their muscles permitted. They were encouraged to hold this position for 10-15 seconds until they felt the stretch simultaneously in their biceps, shoulders and chests.	**22. Seated cross-crawl exercise:** From default stable posture, patients bent both of their lower arms towards their biceps; brought their left elbows down to touch their raised right knees and returned to the starting position. Then they brought their right elbows down to touch their raised left knees and returned to the starting position. They got their knees up as opposed to their elbows down. They repeated this exercise for 10-15 times.	**23. Seated slide-and-breath exercise:** From default stable posture, patients breathe out as they moved forward with the hands sliding down towards their ankles and breathe in as they slowly returned to their original default position. They repeated this for 5-10 times.	**24. Seated upward stretch:** From default stable posture, patients placed their palms together above their heads and extended their arms upwards keeping their palms in contact. With their backs kept straight, they moved their arms slowly backwards. They held this position for 15-20 seconds or until they felt a mild tension in their muscles. Then they slowly returned to their default position and relaxed.

Appendix 16: The intensities and duration of cardiovascular and resistance exercises

Cardiovascular training equipment (exercises)					
Mode	**No of Users**	**Speed/Distance (min-max)**	**Gradient or level (min-max)**	**Borg score (1-10) (min-max)**	**Time (mins.) (min-max)**
Treadmill	21	0.6-9.0 km/h	1-8%	2-9	3-15
Cross trainer	7	0.6-6.0 km/h	1-1.5%	3-8	3-15
Rower	13	250-1000m	Level 3-8	Missing	2.5-10
Hand Bike	2	RPM 40-60+	Level 5	Missing	5
Bike	12	RPM 30-85	Level 1-6	3-8	3-15

Resistance training equipment (exercises)			
Mode	**No of Users**	**Weight (Kg) (min-max)**	**Sets (min-max)**
Adductor	21	10-85	3 x 10
Abductor	20	15-85	3 x 10
Seated leg press	18	5-50	3 x 10
Leg curl	15	5-45	3 x 10
Leg extension	18	5-45	3 x 10
Seated row	11	5-35	3 x 10
Pec fly	16	5-45	3 x 10
Rear Deltoid	10	5-45	3 x 10
Pull down	19	5-45	3 x 10
Shoulder press	12	5-25	3 x 10
Abdominal crunch	13	10-45	3 x 10
Chest press	11	5-30	3 x 10

Appendix 17: Simple and Multiple Regressions of data

1. Dependent variable: log (PAMscoreT1)
The simple linear regressions (n=26)

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Gender	.3835219	.1304368	2.94	0.007	.1143134	.6527303
_cons	2.040867	.2155474	9.47	0.000	1.595999	2.485735

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Age	-.0047827	.0108595	-0.44	0.664	-.0271956	.0176303
_cons	2.99405	.7946092	3.77	0.001	1.354057	4.634043

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
YearCEP						
2	.0841641	.1769034	0.48	0.639	-.2817886	.4501167
3	-.0821081	.1940307	-0.42	0.676	-.4834912	.319275
_cons	2.635386	.1283392	20.53	0.000	2.369896	2.900876

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BMIT1	-.0224748	.0123499	-1.82	0.081	-.0479638	.0030141
_cons	3.326224	.3805528	8.74	0.000	2.540802	4.111646

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
PulmfunT1	-.0172677	.159796	-0.11	0.915	-.3470704	.312535
_cons	2.672104	.2560676	10.44	0.000	2.143606	3.200601

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ExcapT1	.0009408	.0006763	1.39	0.177	-.0004551	.0023367
_cons	2.291118	.264929	8.65	0.000	1.744332	2.837905

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
SGRQTotalT1	-.0096675	.0043078	-2.24	0.034	-.0185582	-.0007767
_cons	3.097319	.2125429	14.57	0.000	2.658652	3.535986

log_PAMsco~1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
HadminT1	-.0294276	.0412262	-0.71	0.482	-.1145143	.0556592

```
       _cons |   2.711297   .1182753    22.92   0.000     2.467189    2.955405
------------------------------------------------------------------------------
```

The multiple regression

```
------------------------------------------------------------------------------
log_PAMsco~1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      Gender |   .3359894   .1258201     2.67   0.014     .0757107    .5962681
 SGRQTotalT1 |  -.0076394   .0039189    -1.95   0.064    -.0157462    .0004674
       _cons |   2.472738   .3011435     8.21   0.000     1.849775    3.095701
------------------------------------------------------------------------------
Adjusted R-squared= 0.3142
------------------------------------------------------------------------------
log_PAMsco~1 |      Coef.   Std. Err.      t    P>|t|                    Beta
-------------+----------------------------------------------------------------
      Gender |   .3359894   .1258201     2.67   0.014                .4508323
 SGRQTotalT1 |  -.0076394   .0039189    -1.95   0.064               -.3291072
       _cons |   2.472738   .3011435     8.21   0.000                       .
------------------------------------------------------------------------------
```

2. Dependent variable: log (PAMscoreT2)
The simple linear regressions (n=26)

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      Gender |   .4074752   .1547654     2.63   0.015     .0880551    .7268954
       _cons |   2.051258   .2557505     8.02   0.000     1.523415    2.579101
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         Age |      .0034   .0125738     0.27   0.789     -.022551    .0293509
       _cons |   2.446141   .9200424     2.66   0.014     .5472668    4.345015
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     YearCEP |  -.0523845   .1106745    -0.47   0.640    -.2808054    .1760365
       _cons |   2.794554   .2297048    12.17   0.000     2.320467    3.268642
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       BMIT2 |  -.0235567   .0140475    -1.68   0.107    -.0525493    .0054359
       _cons |    3.40415   .4314789     7.89   0.000     2.513621    4.294678
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   PulmfunT2 |   .0445711   .1912618     0.23   0.818    -.3501738    .4393159
       _cons |   2.622467   .3182067     8.24   0.000      1.96572    3.279213
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     ExcapT2 |   .0018684   .0009418     1.98   0.059    -.0000755    .0038123
       _cons |   1.904913   .4057339     4.69   0.000     1.067519    2.742306
------------------------------------------------------------------------------
```

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 SGRQTotalT2 |  -.0134589   .0040086    -3.36   0.003    -.0217322   -.0051856
       _cons |   3.268147   .1854389    17.62   0.000      2.88542    3.650874
------------------------------------------------------------------------------

------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    HadminT2 |  -.1126576   .0482157    -2.34   0.028    -.2121699   -.0131452
       _cons |   2.793474   .0892066    31.31   0.000      2.60936    2.977587
------------------------------------------------------------------------------
```

The multiple regression

```
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      Gender |   .2929588   .1417984     2.07   0.061    -.0003736    .5862912
 SGRQTotalT2 |  -.0111589    .003922    -2.85   0.009    -.0192722   -.0030457
     HadminT2 |   .0164312    .0569976     0.29   0.776    -.1017746    .1346369
       _cons |   2.708028   .3221279     8.41   0.000     2.041656     3.3744
------------------------------------------------------------------------------
Adj R-squared= 0.3762.
------------------------------------------------------------------------------
log_PAMsco~2 |      Coef.   Std. Err.      t    P>|t|                     Beta
-------------+----------------------------------------------------------------
      Gender |   .2929588   .1417984     2.07   0.061                 .3403526
 SGRQTotalT2 |  -.0111589    .003922    -2.85   0.009                -.4687193
     HadminT2 |   .0164312    .0569976     0.29   0.776                 .0183821
       _cons |   2.708028   .3221279     8.41   0.000                        .
------------------------------------------------------------------------------
```

Appendix 18: Integration of Quantative and Qualitative Findings

(A Joint Display showing Experiences of Participants with Low and High Changes in Outcome scores)

Average daily PAM score- Levels of daily activity measured by PAM AM300		
Category	**Change in score**	**Participant's experiences**
Low PAM score	< Mean score= 1, n= 26 (Z= -1.33, p= 0.18)	▪ Engaged more in low-intensity PA e.g. painting, decorating, gardening, etc *"Well as I said, I like decorating and for a long time I come here twice a week. I've been decorating for the last month"* ▪ Less frequent activity *"I still get out, I get in the car, I go down, I walk around, but not all the time, I go in the pub, see my mates, have a beer. Not as much as I used to.* ▪ Reported more barriers to PA and attending exercise classes *"Sometimes my wife's health prevents me from coming because I'm supporting her. But not always. If she has a migraine or sickness she is in bed, so I tell her I want to go training"* *"I had a viral and urinary upset and it took a month and that prevented me from coming to exercise"* ▪ Enjoyed the seated warm-up and cool-down exercise stretches more than using exercise equipment ▪ Concerned about safety and used self-protective measures
High PAM score	≥ Mean score= 1, n= 26 (Z= -1.33, p= 0.18)	▪ Engaged more in moderate-intensity PA e.g. walking *"I mean a couple of weeks ago after I've been here and we went out for a walk. It was a beautiful day and I walked for an hour and half. I can't remember, but I know I've been to the gym and I went home and took the dogs out and we walked for an hour and a half"* ▪ Restoration (return to hobbies and activities previously enjoyed before being restricted by COPD) *"I had given up bowling and I'm back on it now. I bowled for the whole of the winter season. And I'm just waiting for the summer season to start. ── so that's a plus"* ▪ Enjoyed both seated warm-up and cool-down exercise stretches and using exercise equipment ▪ Not exercising at home due to lack of motivation ▪ Concerned about safety and used self-protective measures ▪ Benefitted from social support

Exercise Capacity- Measured by the 6MWD test		
Category	**Change in score**	**Participant's experiences**
Low 6MWD test score	< Mean score= 45m, n= 26 (95% CI:-68 to -23, p<0.0001)	▪ Engaged more in low-intensity PA ▪ Uncertain about increase in physical fitness *"I suppose there must be, there must be really. I don't notice it but there must be. There got to be, yes"* ▪ Concerned about safety and used self-protective measures
High 6MWD test score	≥ Mean score= 45m, n= 26 (95% CI:-68 to -23, p<0.0001)	▪ Reported more facilitating/enabling factors ▪ <u>Engaged more in moderate-intensity PA</u> *"I enjoy bowling, I mean if you go and play a full game of that, that's four and a half hour walking up and down and bowling at the same time. In my opinion, the programme is very beneficial, oh yes".* ▪ <u>Certain about increase in physical fitness and functioning</u> *"I think─ according to what I do in the gym, my level of fitness has gone up compared to what it used to be before I started coming here, definitely, yeah, yeah, yes it has gone up"* *"I mean I never did [exercises] ── you know, just the fact of coming to an exercise class ── to the gym twice a week is better than it was. I didn't use to do that. And ── and yeah, yes I feel physically stronger and better"* ▪ Enjoyed both seated warm-up and cool-down exercise stretches and using exercise equipment ▪ Not exercising at home due to lack of motivation ▪ Concerned about safety and used self-protective measures ▪ Benefitted from social support
Health status- Measured by the SGRQ total score		
Category	**Change in score**	**Participant's experiences**
Low SGRQ total score	< Mean score= 4.05units, n= 26 (95% CI:-0.50 to 8.6, p=0.04)	▪ Engaged more in low-intensity PA ▪ Uncertain about increase in physical fitness ▪ Reported more facilitating/enabling factors ▪ Concerned about safety and used self-protective measures
High SGRQ total score	≥ Mean score= 4.05units, n= 26 (95% CI:-0.50 to 8.6, p=0.04)	▪ <u>Improved physical health</u> *"Well, touch wood, em em, I haven't had a chest infection for well over a year now. Yeah, and usually at this time of the year I usually go down with one and I didn't. I haven't so far, so em it's been well over a year and I absolutely think it's because I've been exercising"* *"I've just found that my wellbeing has been better since I've been coming to the gym than it would normally be"* ▪ Engaged more in moderate-intensity PA ▪ Certain about increase in physical fitness

		▪ Reported poor physical health as barrier to PA and attending exercise classes ▪ Not exercising at home due to lack of motivation ▪ Concerned about safety and used self-protective measures ▪ Benefitted from social support
Pulmonary function, FEV_1 (L)- measured by COPD-6 spirometer		
Category	**Change in score**	**Participant's experiences**
Low FEV1 score	< Mean score= 0.04L, n= 26 (Z=-2.68, p=0.007)	▪ Reported poor physical health (e.g. breathing problems) as barrier to PA and attending exercise classes *"I mean ── I've been off ── like I said I've been off for a month I haven't been in, and my breathing is terrible at the moment. Like you see I'm stiff all in the muscles"*
High FEV1 score	≥ Mean score= 0.04L, n= 26 (Z=-2.68, p=0.007)	▪ Got off oxygen therapy *"I wouldn't have got off oxygen without it [the CEP]. I still feel breathless, well, it's part of the course really isn't it? You learn to cope with it. And to cope with it without oxygen is eh a big plus as well. Because I thought at one point that that was it"* ▪ COPD symptoms did not get worse *"I think I was diagnosed with COPD in about 2013 or something. And certainly, I have had ── I just don't feel that it's gone worse ── I mean I feel it hasn't progressed or get any worse at all. ── and if anything, I feel more comfortable now"*
Number of hospital admission		
Category	**Change in score**	**Participant's experiences**
Low number of hospital admission	< Mean score= 2.0, n= 26 (Z= -3.04, p=0.02)	▪ Engaged more in moderate-intensity PA ▪ Certain about increase in physical fitness ▪ Concerned about safety and used self-protective measures ▪ Benefitted from social support
High number of hospital admission	≥ Mean score= 2.0, n= 26 (Z= -3.04, p=0.02)	▪ Reported poor physical health as barrier to PA and attending exercise classes ▪ Deterioration in physical ability and COPD symptoms *"One thing I do notice with this ── I was recently [sic] had two weeks, no three to four weeks not coming and for whatever reason I wasn't here for a month. I noticed it when I came back that I can't do what I was doing before. So it's very important that you have a consistency. As soon as you don't go in once ── or if you leave it for a week or two, the body falls back. I still haven't got back to what I was doing a month ago"* ▪ Not exercising at home due to lack of motivation ▪ Concerned about safety and used self-protective measures ▪ Benefitted from social support

Abbreviations: PA= physical activity; PAM= physical activity monitor; 6MWD= six minutes walking distance; SGRQ= Saint George's Respiratory Questionnaire; FEV_1= forced expiratory volume in 1 second measured in L (litre); CEP= community-based exercise programme; n= sample size in the quantitative study.