A home based self-management rehabilitation programme for chronic obstructive pulmonary disease: is it a feasible alternative to conventional rehabilitation?

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A thesis submitted in partial fulfilment of the University's requirements

for the Degree of Doctor of Philosophy (PhD)

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Declaration

The work submitted within this thesis has been undertaken during the period of my registration. I declare that this work is my own, conducted by myself with assistance where acknowledged. I contributed to the project design, protocol and ethics application in collaboration with Prof Sally Singh. The Pulmonary Rehabilitation team took responsibility of assessing patients for eligibility to the trial and invited patients to participate, all baseline measure were taken during the normal pulmonary rehabilitation referral appointment. I subsequently consented participated to the trial and acted as the blinded researcher and completed outcome measures. Vicki Johnson-Warrington randomly assigned patients to an intervention group and Lindsay Apps and Katie Mitchell completed the introduction to the SPACE for COPD programme the 2 telephone calls. I completed all the data inputting and statistical analysis.

No part of this thesis has been submitted in a previous application for a higher degree.

Signature:

Date: February 2015

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Abstract

Introduction: Patients with COPD are characterised by symptoms of dyspnoea, limited exercise tolerance and low levels of physical activity which can lead to reduced quality of life. Pulmonary rehabilitation (PR) is recommended, however, not all are able to participate and there is a large dropout rate from this service. Home-based programmes aiming to enhance self-management skills can potentially provide an alternative model of delivery, allowing increased options for treatment. As one of the key components of PR is to enhance exercise endurance and physical activity, valid and reliable measures are needed to determine programme effectiveness. Therefore, the first aim of this thesis is to determine the validity, reproducibility and sensitivity of the SenseWear Pro 2 Armband, activity monitor (SWM) to be used in the main trial. The primary aim of this thesis is to describe the noninferiority randomised control trial of the effectiveness of the home based **S**elf-management **P**rogramme of **A**ctivity **C**oping and **E**ducation (SPACE for COPD) in comparison to PR in patients with COPD.

Methods: **Validation of methods**; One subject (EH) completed a battery of repeated walking tests using the speeds from the endurance shuttle walk test. Minute by minute energy expenditure (EE) and step counts were recorded from 9 SWM and indirect calorimetry was used as the criterion measure to determine the validity of EE output from the monitor.

Noninferiority randomised controlled trial; 287 (187 male: mean (SD) age 67 (9) yrs; FEV_1 1.25 (0.55); BMI 27.63 (6.22) kg/m^2) patients with COPD were recruited from referral to PR and randomised to either the SPACE for COPD programme or conventional PR. The primary outcome was the self-reported measure of dyspnoea from the chronic respiratory questionnaire. Secondary measures included exercise performance (incremental and endurance shuttle walk tests (ISWT and ESWT), anxiety, depression and self-efficacy. Daily physical activity was measured over five days using the SWM in a subgroup of 154 patients. Outcome measures were taken at baseline, post intervention (seven weeks) and six months.

Results: The SWM was shown to be acceptable at measuring slow standardised walking speeds. However, reproducibility and sensitivity was more acceptable when using step count rather than EE.

There was a significant improvement in dyspnoea (mean (95% CI) 0.58 (0.28 to 0.88) units; $p<0.001$) and endurance capacity (ISWT 18 (3 to 32) m, $p=0.015$; ESWT 212 (139 to 284) sec, $p<0.001$), at seven weeks in the SPACE for COPD group that was to a similar level in the PR group (dyspnoea between group difference (95% CI) -0.032 (-0.71 to 0.08), p0.113), although it remains unclear as to the level of noninferiority. At six months some of the initial benefits in the ESWT were maintained in the SPACE for COPD group. However the other outcome measures (dyspnoea and ISWT) declined to baseline levels which were also evident in the PR group.

Daily PA was low at baseline in those recruited to the trial and reduced as dyspnoea symptoms increased (mean (SD) steps; MRC 2 5824 (3027); MRC 3 3908 (2162); MRC 4 3278 (2351); MRC 5 2382 (2046)). 51 patients had complete data sets at each measurement time point from the main trial. Those in the SPACE group significantly increased their PA above the PR group at seven weeks (mean (SD) between group difference for step count 1463 (280 to 2645) p0.020). By six months PA had decreased towards baseline levels in both groups.

Conclusion: SPACE for COPD does provide a number of health benefits so has the potential to be offered as an alternative to those who decline PR. As these benefits were not sustained at six months future work needs to be focussed on strategies to provide continued support for these patients.

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Publications

Papers

Harrison S.L., **Horton E.J**., Smith R.S., Sandland C.J., Steiner M. C., Morgan M. D. L., Singh S. J. (2013). Physical activity monitoring: Addressing the difficulties of accurately detecting slow walking speeds. Heart and Lung. 42(5):361-364 (Appendix K)

Conference presentations

Horton E, Mitchell K, Johnson-Warrington V, Apps L, Young H, Singh S. (2014) Results of the SPACE FOR COPD programme in comparison to Pulmonary Rehabilitation at 6 months. European Respiratory Journal; 44: Suppl. 58, 4833. Oral presentation at the European Respiratory Society Congress.

Horton E, Mitchell K, Johnson-Warrington V, Apps L, Young H, Singh S. (2014) Physical activity in patients with chronic obstructive pulmonary disease (COPD). Journal of Sport Sciences 201432 (suppl 2);s30. Poster presented at BASES annual conference.

Horton E, Mitchell K, Johnson-Warrington V, Apps L, Young H, Singh S. (2013). A Self-Management Programme of Activity, Coping and Education (SPACE) for COPD: A randomised non-inferiority trial in a Pulmonary

Rehabilitation population. Thorax 2009; 68 (suppl 3): A15. Oral presentation at the British Thoracic Society winter conference 2013.

Wilcock E.J., Apps L., Wagg K, Singh S. (2009). The effect of a novel independent self-management manual on exercise performance and daily physical activity in patients with COPD: a pilot study. Poster presented at the European Respiratory Society Congress 2009.

Wagg K., **Wilcock E.**, Williams J., Sewell L., Steiner M., Morgan M., Singh S. (2009) 'Pulmonary Rehabilitation using the SPACE (A Self-management Programme of Activity, Coping and Education) manual at home': A randomised controlled trial. Current Strategies in Pulmonary Rehabilitation Thorax 2009 64: P53 A97. Presented at the British Thoracic Society Conference 2009.

Wilcock E.J., Cox V., Singh S. (2008). Validity and reproducibility of a multisensor accelerometer at slow walking speeds in COPD. Poster presented at the European Respiratory Society Congress 2008.

Wilcock E.J., Singh S. (2008). Exercise capacity and physical activity in patients with chronic obstructive pulmonary disease. Poster presented at the British Association of Sport and Exercise Sciences conference 2008

Abbreviations

<	less than
≤	less than or equal to
>	more than
≥	more than or equal to
x	multiplied by
%	percent or percentage
6MWT	six minute walk test
6MWD	six minute walk distance
am	ante meridian “before midday”
ANCOVA	analysis of covariance
ANOVA	analysis of variance
ATS	American Thoracic Society
BMI	body mass index
BMR	basal metabolic rate
BTS	British Thoracic Society
C	control group
CAT	COPD Assessment Tool
CI	confidence interval

cm	centimetres
CONSORT	Consolidated Standards of Reporting Trials
COPD	Chronic Obstructive Pulmonary Disease
CPET	cardiopulmonary exercise test
CRQ	Chronic Respiratory disease Questionnaire
CRQ-SR	Chronic Respiratory disease Questionnaire – Self Report
CWR	constant work rate
EE	energy expenditure
e.g.	for example
ESWT	Endurance Shuttle Walk Test
et al.	et alii “and others”
FEV_1	forced expiratory volume in one second
FVC	forced vital capacity
GOLD	Global initiative for chronic Obstructive Lung Disease
HADS	Hospital Anxiety and Depression Scale
HRQoL	health related quality of life
I	intervention group
IBM	International Business Machines
ICS	inhaled corticosteroids
i.e.	id est “that is”

ISWT	Incremental Shuttle Walk Test
ITT	intension to treat
kcal	kilocalories
kg	kilograms
km	kilometres
l	Litres
l/min	litres per minute
LTOT	long-term oxygen therapy
m	metres
MCID	minimal clinical important difference
METs	metabolic equivalents
mins	minutes
Mo	Months
MRC	Medical Research Council
n=	number is
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NS	not significant
p=	probability is
p<	probability less than

p≤	probability less than or equal to
PA	physical activity
PAL	physical activity level
PaO_2	partial pressure of oxygen in arterial blood
PhD	Doctor of Philosophy
PICO	Population, Intervention, Comparison, Outcome
pm	post meridian “after midday”
PR	pulmonary rehabilitation
PRAISE	Pulmonary Rehabilitation Adapted Index of Self-Efficacy
QoL	Quality of life
r=	correlation coefficient
RCT	randomised controlled trial
RER	respiratory exchange ratio
SABA	short-acting beta2 agonist
SD	standard deviation
SE	standard error
sec	seconds
SGRQ	St George’s Respiratory Questionnaire
SM	self-management
SPACE	Self-management Programme of Activity Coping and Education
SpO_2	saturation of peripheral oxygen
SPSS	Statistical Product and Service Solutions

SWM	SenseWear Armband
TEE	total energy expenditure
UK	United Kingdom
VO_2	oxygen consumption
VO_2max	maximal oxygen consumption
VO_2peak	peak oxygen consumption
W	watts(s)

Chapter 1 - Introduction

This chapter briefly introduces the issues examined in this thesis and provides a context and rationale for the research. This chapter is divided into three sections. The first (1.1) focuses on Pulmonary Rehabilitation (PR) in the UK and the need to investigate alternative models of care for those with Chronic Obstructive Pulmonary Disease (COPD). Home-base and programmes supported by self-management (SM) training may provide this opportunity. This discussion sets out a justification for the study and supports the origin of the aims and objectives outlined in the second section (1.2). The third section (1.3) describes the structure of the thesis and briefly explains the purpose and content of chapter's two to nine.

1.1 Study context and rationale

COPD is a growing cause of morbidity, mortality and healthcare utilisation in the UK (National Clinical Guideline Centre; NICE 2010) and is predicted to be the 3rd leading cause of death by 2020 (World Health Organisation 2006).

The management of COPD (NICE 2010) involves providing a treatment strategy which often includes smoking cessation, optimising medication and PR. Those with limited functional capacity and muscle weakness can benefit from PR, with findings also suggesting PR is effective at reducing hospital admissions and mortality (Lacasse et al. 2007).

PR provides a framework to deliver exercise training, education and support and develop self-management skills. It is normally offered as a 6-7 week outpatient programme with supervised exercise and education sessions. A recent audit of PR provision in the UK demonstrated that only 58% of Acute Trusts provided PR to all eligible patients and a further 32% had limited provision. Furthermore many PR programmes failed to meet the full guidelines recommended by the National Institute of Clinical Excellence (Yohannes et al. 2011).

A potential opportunity to improve the scope of PR for patients with stable COPD and to increase patient choice of treatment options is a home based programme. Home based PR programmes have been shown to have similar improvements in exercise performance (Maltais et al. 2008) and self-reported dyspnoea (Güell et al. 2008, Puente-Maestu et al. 2000) in comparison to outpatient PR. However, these studies had initial hospital based education sessions before the commencement of exercise training and the former study provided exercise equipment in the patients home (Maltais et al. 2008).

The healthcare system in the UK is moving towards patients having a more active role in their own healthcare provision. Engaging patients in this process can be encouraged by improving SM skills. SM support aims to improve knowledge of the disease, self-efficacy and the development of skills and behaviours to enhance health (Bourbeau 2004). Supported SM programmes are established in other long term conditions in the UK (Lewin et al. 1992, Skinner et al. 2006). However, its effect in patients with COPD is unclear

(Barlow et al. 2002). There is potential for SM to enhance the delivery of home based programmes to elicit behaviour modification for long term maintenance.

The key challenge in interpreting the literature surrounding SM programmes for patients with COPD is in the various definitions and interpretations of its implementation. Whereby some SM programmes are brief action plans or brief advice (Watson et al. 1997), others are comprehensive supervised education and exercise programmes lasting two years (Monninkhof et al. 2003a). In addition to the inconsistency in SM programmes in the literature there is also variation in what outcome measures are reported. Health related quality of life (HRQoL), exercise capacity and walking capacity have been described, however, the impact on changing physical activity behaviour is lacking in the COPD population. To enable the assessment of PA, activity monitors need to be valid measures and sensitive enough to detect small changes in walking speeds given that walking pace is slower in patients with COPD in comparison to healthy controls (Troosters 2009). At present there has been no study investigating a home based supported SM programme in comparison to convention PR in the UK.

1.2 Aims and Objectives

The aim of this thesis is to contribute to the literature on the effectiveness of a home based supported SM programme in comparison to conventional PR in patients with stable COPD.

A **S**elf-Management **P**rogramme of **A**ctivity **C**oping and **E**ducation, or SPACE for COPD, manual has been developed by the University Hospitals, Leicester NHS Trust. This thesis evaluates the effectiveness of this home based SPACE for COPD programme in a randomised noninferiority controlled trial in comparison to conventional PR.

The primary outcome measure was self-reported dyspnoea with secondary measures of HRQoL, self-efficacy, exercise performance and daily physical activity patterns.

The specific aims of this thesis were to:

- Determine the reproducibility, sensitivity and validity of the SenseWear Pro2 Armband (SWM) in detecting and distinguishing between slow speeds of walking.
- Explore the impact of the SPACE for COPD programme on HRQoL, exercise performance and self-efficacy after a seven week intervention and then a six months follow up in comparison to conventional PR.

- Explore the PA patterns of patients with COPD in relation to disease impact and to determine if they meet the national and international guidelines for PA participation.
- Explore the effect of the SPACE for COPD programme on PA levels at seven weeks and six months.

It was hypothesised that the SPACE for COPD would be noninferior to PR in regards to HRQoL.

1.3 Structure of the thesis

Chapter 2 focusses on a review of the current pertinent literature on the delivery of PR and provides a rationale for the thesis. The methods used in this experimental work are described in chapter 3. Chapter 4 provides data on the validity, sensitivity and reproducibility of the Seanswear Pro 2 Armband used to monitor PA in the main trial. The effectiveness of the SPACE for COPD programme at seven weeks in comparison to PR will be presented in chapter 5 and the six months findings in chapter 6. Both chapters 5 and 6 examine data on HRQoL, exercise performance, psychological functioning and self-efficacy. Chapter 7 describes the PA levels of the participants across the various impact categories of the disease and contrasts these PA levels with national and international guidelines. Chapter 8 explores the impact of the SPACE for COPD programme on PA levels at seven weeks and six months. This thesis ends with chapter 9 which evaluates the key findings of this noninferiory RCT, its limitations and areas of future work.

Chapter 2 - Literature Review

This chapter introduces the issues examined in the thesis and provides a context and rationale for the research. A more detailed exploration of the points outlines here are presented throughout the thesis. This chapter is divided into 3 sections. The first section (2.1) describes chronic obstructive pulmonary disease (COPD), in terms of what it is and what issues it raises for both the individual and healthcare system. The second section (2.2) explores a key theme for this thesis, physical activity (PA). Here the national and international PA guidelines will be outlined, levels of PA in patients with COPD, and how to measure PA in patients with low levels of daily PA will be analysed. The final section (2.3) describes the treatment for COPD and provides evidence for usual care Pulmonary Rehabilitation (PR). The location of rehabilitation will be addressed and the use of supporting programmes with self-management (SM) will be introduced. The chapter will conclude with a summary of the salient issues relevant to this thesis.

2.1 Chronic Obstructive Pulmonary Disease

2.1.1 Definition of Chronic obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) encompasses a group of lung conditions that cause a narrowing of the airways, leading to shortness of breath. Chronic bronchitis and emphysema are the most common forms of COPD. It is usually progressive, not fully reversible and is associated with

abnormal inflammatory responses of the lungs (Rabe et al. 2007). One of the main symptoms of COPD is breathlessness and the predominant risk factor for the condition is long-term cigarette smoking. Individual with COPD frequently become trapped in a vicious cycle of inactivity, social isolation and depression. Disabling breathlessness most frequently instigates his decline.

2.1.2 Aetiology

The primary risk factor for COPD is cigarette smoking and develops from exposure of the lungs to noxious particles found in cigarettes (Vestbo et al. 2013). Smoking accounts for 80-90% of all cases of COPD and smokers are ten times more likely to die from the disease than non-smokers (Doll et al. 1994). The risk for COPD in smokers is dose related (Burrows et al. 1977) with age at starting to smoke, pack years and current smoking status also being predictive of COPD mortality. However, if a patient with COPD stops smoking, the rate of decline in lung function returns to that of a non-smoker (Fletcher and Peto 1977). Passive smoking may also contribute to the development of COPD (Eisner et al. 2005).

Other risk factors associated with COPD are; Age, prevalence of the condition increase in the older age groups, but it is not clear if age itself is a risk factor or whether it reflects the accumulative exposure throughout life (Vestbo et al. 2013). The deficiency of the antiprotease enzyme, α_1-antitrypsin may lead to lung tissue disruption and eventually COPD. Occupational exposure to airborne pollutants, including organic and inorganic dust particles, and chemical agents and fumes are associated with the development of COPD

(Matheson et al. 2005). There is also considerable evidence that those with lower socioeconomic status have a higher risk of developing COPD (Prescott, Lange and Vestbo 1999). It is not clear, however, to its true relationship or whether it really reflects exposure to pollutants, crowding, poor nutrition or infection (Vestbo et al. 2013). Those that have a history of childhood respiratory infection, and asthma also have an increased risk of developing COPD (Vestbo et al. 2013).

2.1.3 Pathophysiology

COPD is caused by two key mechanisms: chronic inflammation of the small airways and gradual destruction of the alveoli (Rabe et al. 2007). Pathological changes within the lung tissue are largely attributed to cigarette smoke. The pathological damage to the lung tissue is initiated long before signs and symptoms are present (Sutherland and Martin 2003) , and even after smoking cessation the inflammatory process continues (Willemse et al. 2005).

Inhaled cigarette smoke and other noxious particles cause lung inflammation, a normal response which appears to be amplified in patients with COPD. Lung inflammation can also lead to damage of the elasticity and support of the alveoli, which result in loss of elastic recoil (Sutherland and Martin 2003). COPD is also characterised by mucus hypersecreation which block bronchioles, causing alveoli to become dysfunctional.

2.1.4 Prevalence

COPD is a leading cause of mortality, morbidity and healthcare usage worldwide and in the UK (Britton 2003). This, therefore, results in a huge burden both economically and individually. COPD is currently the fourth most common cause of death worldwide and the World Health Organisation anticipates that by 2020 it will have become the third, primarily related to the changes in smoking behaviour in the developing world (World Health Organisation 2006). A systematic review estimated the prevalence of physiologically defined COPD in the over 40's is 9-10% worldwide (Halbert et al. 2006). In 2004 over 27,000 people in the UK died from COPD (British Thoracic Society 2006), however, mortality data may underestimate the impact of COPD as it is often listed as a contributing factor towards death or not listed at all (Pauwels et al. 2001).

The precise number of individuals with a current diagnosis of COPD in the UK is difficult to ascertain but it is reported to be around 900,000 (NICE 2010). This number is considerably lower than the prevalence rate of 3 million as estimated by (Stang et al. 2000) based on smoking rates. The discrepancy in these figures has become known as the 'missing millions' and refers to the millions of people that have undiagnosed COPD (Department of Health 2010).

2.1.5 Diagnosis of COPD

There is no single diagnostic test for COPD, therefore, diagnosis is based on clinical symptoms, heath status, exercise capacity, and presence of airflow obstruction using spirometry. The NICE guidelines for COPD (2010) state that

COPD should be considered in patients over 35 who have a risk factor (generally smoking) and who present with one or more of the following symptoms:

Exertional breathlessness

Chronic cough

Regular sputum production

Frequent winter bronchitis

Wheeze

Spirometry results indicating COPD would be:

- A reduced Forced Vital Expiratory volume in one second (FEV_1) of less than 80% of predicted values and
- A reduced FEV_1/Forced Vital Capacity (FVC) ratio less than 70%

2.1.6 Signs and symptoms of COPD

The most commonly reported symptom of CODP are dyspnoea (breathlessness), a productive cough, reduced exercise tolerance and fatigue (Department of Health, 2010). Symptoms may be mild or even absent in the early stages of disease and therefore patients often don't present to their GP's until the condition has progressed further and symptoms become more severe. Symptoms can change from day to day and the severity of symptoms does not always correlate to the severity of disease (Vestbo et al. 2013). Dyspnoea has been shown to be a key determinant of quality of life (Bentsen, Rokne and Wahl 2012), and can lead to anxiety and depression (Bailey

2004). Dyspnoea commonly leads to avoidance of physical activity and exercise which result in reduced exercise tolerance and muscle weakness

2.1.7 Classification of COPD

The severity of dyspnoea can be classified by the Medical Research Council's (MRC) Dyspnoea scale (Fletcher et al. 1959). The scale is used to grade breathlessness according to the level of exertion required to elicit it (table 2.1).

Table 2.1 Medical Research Council Dyspnoea scale (Fletcher et al. 1959)

Grade	*Level of breathlessness*
1	Not troubled by breathlessness except on strenuous exercise
2	Short of breath when hurrying or walking up a slight hill
3	Walk slower than contemporaries on level ground because of breathlessness, or has to stop for breath when walking at own pace
4	Stop for breath after walking about 100 yards or after a few minutes on level ground
5	Too breathless to leave the house, or breathless when dressing or undressing

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) have classified the severity of airflow limitation using spirometry (Vestbo et al. 2013; Table 2.2). Together with exacerbation frequency, MRC dyspnoea score or score from the COPD Assessment Tool (CAT), which indicated health status,

a model has been develop to assist in stratifying patients by severity and symptoms in order to aid treatment plans (Vestbo et al. 2013 table 2.3)

Table 2.2 Vestbo et al. (2013) classification of disease severity

GOLD stage	
Stage 1: Mild	FEV_1/FVC <0.70 FEV_1 ≥ 80% predicted
Stage 2: Moderate	FEV_1/FVC <0.70 50% ≤ FEV_1 < 80% predicted
Stage 3: Severe	FEV_1/FVC <0.70 30% ≤ FEV_1 <50% predicted
Stage 4: Very severe	FEV_1/FVC <0.70 FEV_1 < 30% or FEV_1 <50% predicted plus chronic respiratory failure.

	MRC 1-2 OR CAT <10	MRC 3-5 OR CAT ≥10
GOLD 3-4 OR ≥2 exacerbation in past 12 months	C High risk Less symptoms	D High risk More symptoms
GOLD 1-2 OR 0-1 exacerbation in past 12 months	A Low risk Less symptoms	B Low risk More symptoms

Figure 2.1 GOLD assessment of COPD disease stratification (Vestbo et al. 2013)

2.1.8 Burden of COPD

Burden to the Healthcare System

The Chief Medical Officer has estimated that COPD accounts for more than £800 million in direct health care costs, 1.4 million primary care consultations and one million in-patient bed days per year. With more severe cases resulting in greater cost. COPD is one of the most expensive conditions to be managed by the NHS (National Institute for Health and Clinical Excellence

2010). A significant proportion of this cost of managing COPD is due to the high rates of hospitalisation, with the second largest cause of emergency admissions in the UK being due to COPD (British Lung Foundation 2007). It also has a high readmission rate of 33% and a median length of stay of 5 days as recorded in 2008 by the Royal College of Physicians of London (2008). Patients with COPD also have significantly higher numbers of visits to see their GP, with 74% of patients contacting their GP once and 31% contacting their GP 3 or more times before a hospitalisation (National Institute for Health and Clinical Excellence 2010).

In addition, the indirect cost of this chronic condition are substantial impacting on annual productivity with an estimated 24 million workdays lost to COPD at a loss of £2.7 billion to industry (Department of Health and Chief Medical Officer 2005).

Burden to the individual

The burden to the individual is significant and can greatly impact on everyday life (Braido et al. 2011) and health related quality of life (Ferrer et al. 1997). The symptoms of COPD as described in section 2.1.6 result in reduced exercise capacity (Killian et al. 1992) and daily physical activity in comparison to healthy older adults (Pitta et al. 2005a) which can lead to disability in many patients with COPD (Braido et al. 2011). Physical activity levels will be discussed in detail in section 2.1.10. Health related quality of life is also lower in this group in comparison to the general population (Schlenk et al. 1998) and the prevalence of anxiety and depression significantly increased (Hill et

al. 2008). The risk of depression in patients with COPD has been shown to be associated with disease severity with an overall incidence rate of 6.1% (van et al. 2009), and the prevalence of anxiety in these patient is generally considered to be high with rates ranging from 10-33% (Dowson, Kuijer and Mulder 2004, Hynninen et al. 2005). Causes of anxiety are often attributed to dyspnoea (Hill et al. 2008), limited functional performance, poor coping strategies and reduced self-efficacy (McCathie, Spence and Tate 2002). There is also a significantly higher risk of hospital readmissions in those with anxiety and depression (Dahlén and Janson 2002).

Physical Activity

2.1.9 Exercise recommendation

The Department of Health, The British Association of Sport and Exercise Sciences and the American College of Sport and Exercise Sciences recommend that all adults (19-64 years and 65+ years) should take part in a minimum of 150 minutes of moderate intensity (3-6 METs: Metabolic Equivalent) aerobic activity per week to develop and maintain health related fitness. A MET is the ratio of work metabolic rate to a standard resting metabolic rate. Metabolic rate is the rate at which a person uses energy, 1 MET is considered to be resting metabolic rate. Moderate to vigorous activity is considered to be between 3 to 6 METs. Aerobic activity should be completed in bouts of at least 10 minutes and should be performed 5 or more days per week (Department of Health 2011, Nelson et al. 2007, O'Donovan et al. 2010). Adults should also undertake strength training 2x week and reduce sedentary behaviour. Those over 65 years and at risk of falls should also

incorporate PA to improve balance and co-ordination twice a week. Those not meeting these guidelines have higher risk of all-cause mortality (Fogelholm 2010).

The scientific evidence at the basis of the physical activity guidelines supports a dose-response relationship between PA and health benefits. In that as the volume of activity (intensity, duration or frequency) increase this yields greater or additional health benefits. Evidence indicates that all-cause mortality (Lee and Skerrett 2001), cardiovascular disease mortality (Wannamethee and Shaper 2001) and the development of type 2 diabetes (Gill and Cooper 2008) are significantly lower in adults reporting a volume of 120 to 150 minutes per week of MVPA. However, significantly lower rates of colon cancer (Samad et al. 2005), breast cancer (Monninkhof et al. 2007) and obesity (Hill and Wyatt 2005) occur at 180 to 300 minutes of MVPA per week. Due to the differing amounts require for different outcomes and the need to keep guidelines as simple as possible, the UK together with other international bodies have retained a single recommended dose of PA. Achieving the adequate volume of MVPA appears to be more important composite of health benefits than does a specific mode of activity, its intensity or session frequency (Physical activity advisory committee 2008). However, the guidelines state that for MVPA to ‘count’ towards the 150 minutes per week, it must be in bouts of at least 10 minutes. A review of the literature compared selected fitness measures, fatness parameters and biomarkers with multiply shorter bouts of exercise (10 minutes) to one longer 30-40 minute session and found there to be similar outcomes (Murphy, Blair and Murtagh 2009). Shorter bouts of

exercise are more likely to be appealing to many and easier to achieve. Evidence for shorter bouts of exercise (less than 10 minutes) is lacking and therefore national and international guidelines state bouts need to be a minimum of 10 minutes (Department of Health 2011, Nelson et al. 2007).

Another common measure of reporting PA levels is step count (Troosters et al. 2010, Waschki et al. 2012, Watz et al. 2009). This is perhaps due to ease of measuring with inexpensive pedometers and a measure that is easily interpreted by patients and the general population. Accumulating 10,000 steps has previously been reported to be the recommended daily target (Tudor-Locke and Bassett Jr. 2004). However it is difficult to quantify what this threshold equates to in terms of volume of PA. ACSM report (Nelson et al. 2007) that intensity of PA is important to stimulate a physiological adaptation and therefore a health benefit, but steps can be accumulated at all levels of intensity. Until current developments in more sophisticated PA monitors, it was unknown how many steps equated to 30 minutes of moderate to vigorous activity (MVPA). Tudor-Locke et al (2011) reported that 30 minutes of MVPA is associated with 3,000 steps. However, daily step count includes many free living activities which are incorporated into this measure. Therefore, they concluded that 7,000 to 8,000 steps per day may be a more accurate threshold to indicate 30 minutes of MVPA has been achieved.

The physical activity level (PAL) has become a recognised method of expressing total daily energy expenditure (TEE) in multiples of resting metabolic rate (RMR). PAL is calculated via the following equation:

$$PAL = \frac{TEE}{RMR}$$

An individualised PAL can give an indication of how physically active they have been during a 24 hour period. Table 2.3 show the classifications of PAL (Food and Agriculture Organization of the United Nations, 2004).

Table 2.3 Classification of PALs

Activity Level	*PAL*
Extremely Sedentary / Inactive	<1.40
Sedentary	1.40-1.69
Moderately active	1.70-1.99
Vigorously active	2.00-2.40
Extremely active	>2.4

Therefore, daily recommendations of PAL are >1.70 (Food and Agriculture Organization of the United Nations, 2004).

2.1.10 Physical activity in patients with COPD

Physical activity (PA) is defines as any bodily movement by skeletal muscle that results in energy expenditure beyond resting energy expenditure. Level of PA is an important clinical outcome and low PA levels have been shown to negatively impact on hospital admissions (Garcia-Aymerich et al. 2006), mortality (Waschki et al. 2011, Watz et al. 2008), dyspnoea (Watz et al. 2009),

exercise performance and muscle weakness (Pitta et al. 2005a). Exercise capacity and PA is reduced in patients with COPD (Pitta et al. 2005b, Sandland et al. 2005). Watz et al. (2009) reported that only patients with mild COPD (modified MRC grade 0) met the recommended guidelines (section 2.1.9), and physical activity levels declined as the severity of COPD increased. It is also apparent that these patients also walk more slowly than healthier subjects (Troosters et al. 2010, Watz et al. 2009). A review of objectively monitored PA in COPD (Vorrink et al. 2011), which analysed 11 studies concluded that patients with COPD had significantly reduced PA levels in terms of duration, intensity and activity counts of daily living in comparison to healthy controls. However, the level of PA was not strongly correlated with disease severity.

Time spent in moderate to vigorous activity has been shown to decline with age in the general population (British Heart Foundation 2012), with only 33% of 55-64 years, 20% of 65-74 years and 9% of 75+ year old men meeting the recommended guideline for self-reported PA. These figures are even lower in the female population (28% 55-64 years, 17% 65-74 years and 6% 75+ year old). Therefore, low PA levels are already a public health concern in the normal population which are further reduced in patients with COPD.

What is not clear from many of the studies is what the pattern of PA that patients with COPD partake in and whether patients are completing enough exercise to meet national guidelines and therefore improve health. The guidelines recommend that PA should be completed in bouts of at least 10

minutes, but has mainly been reported as step counts (Waschki et al. 2012), PAL (van Gestel et al. 2012, Waschki et al. 2012), total energy expenditure or time above 3 METs (van Gestel et al. 2012). It is important to be able to describe the pattern of daily PA as many short bouts (<10 minutes) of activity, despite adding up to over 30 minutes per day, may not be sufficient to meet the guideline and therefore not result in the desired health improvements. It is therefore essential that studies clearly report how activity is reported and that the data is interpreted with this in mind. Van Remoortel et al. (2013) investigated the effect of describing PA of patients with COPD and health subjects by different cut points from various guidelines. Cut points used were ≥ 3 METs for all ages, ACSM (2007); ≥ 3 METs for ≤ 65years and ≥ 50% VO_2 reserve for > 65 years, ACSM (2007); 50% VO_2 reserve for all ages, ACSM (2011); and ≥ 4 METs for ≤ 65 years ≥3.2 METs for > 65 years ACSM (2011). The data was analysed using total time above the given cut point and total time above the given cut point in at least 10 minute bouts. Findings revealed a significant difference between the bout and non-bout data and not surprising there was a difference between the different cut points used. Their data also showed that 80 minutes of non-bout PA is associated with 30 minutes of bout PA. This new threshold of 80 minutes recommended to meet the national guidelines may be of use when reporting and interpreting research trials were evaluating minute by minute data is not possible. However, it is clinically limited as the recommendations are still that adults should accumulate at least 30 minutes of moderate intensity PA in consecutive bouts of at least 10 minutes on 5+ days of the week.

One study that has attempted to describe the PA patterns of patients with COPD using bouts of PA recruited 177 participants from 9 tertiary hospitals in Spain (Donaire-Gonzalez et al. 2012). The study found that 50% met the guidelines of over 150 minutes at 3 METs in at least 10 minute bouts. They also defined moderate PA to be activity above 2.6 METs, calculated as 50% of maximal oxygen uptake on performing an incremental exercise test. When using 2.6 METs as the threshold for meeting the guidelines the figure increased to 61%. These figures appear to be considerably higher to the general UK population let alone to the reduced capacity of UK COPD patients.

Overall it is clear that PA is reduced in patients with COPD to a level which adversely impacts on health status and hence increases the demands on NHS resources. What is not fully understood is the precise pattern of PA that these patients undertake. Making what PA that they do more effectively met the guidelines could be attractive to those with limited capacity and led to health improvements. In order to monitor PA levels and patterns accurate measures need to be considered.

2.2 Measuring Physical activity

The assessment of physical activity can be challenging and methods of measuring it are currently of great interest. Although double-labelled water and calorimetry are considered the gold standard for physical activity assessment they can be time consuming, costly and not suitable for large studies. They also do no indicate the pattern and intensity of activity so

provide limited information. Common methods reported in the literature are questionnaires, pedometers and activity monitors (accelerometers).

Questionnaires

Self-reported measures such as questionnaires are regarded as not accurately quantify the amount of daily physical activity and therefore have had limited use in patients with COPD (Pitta et al. 2006). There is a great potential for either over estimation or underestimation of the amount of physical activity performed (Westerterp 2009) when using questionnaire so caution is needed when interpreting the results. Garfield et al. (2012) evaluated four questionnaires (Stanford seven day recall, Baecke, Physical Activity Scale for the Elderly and Zutphen physical activity questionnaire) with the SenseWear armband accelerometer in 43 patients with COPD. A significant correlation between methods was only seen with the Stanford seven day recall questionnaire, which is the only questionnaire delivered by a semi structured interview. Although questionnaires are relatively easy to administer and give useful data of what specific activities are being undertaken more accurate measures to quantify PA are required.

Pedometers

Pedometers provide step counts which have been shown to have some reproducibility in patients with COPD but it may not be as accurate in patients as it is in health individuals (Schönhofer et al. 1997, Tudor-Locke et al. 2002). It is possible that the pedometer is not sensitive enough to detect the lower intensity movement of the disabled patient (Morgan 2008). Turner (2012)

investigated the reliability of several pedometers to measure step count in patients with COPD. Pedometers were found to be reliable at faster walking speeds however significantly undercounted steps at slow to moderate walking speeds ($p<0.01$). Activity monitors are more sensitive and sophisticated devices that can measure movement in more than one plane and have the potential to more accurately monitor PA levels.

Activity Monitors

Activity monitors aim to capture body movement to estimate energy expenditure (EE), activity counts or vector magnitude units. They measure acceleration in either one, two or three planes (uniaxial, biaxial or triaxial activity monitors). A number of them are also able to detect step counts from the vertical plane. Several activity monitors are commercially available and have be validated in patients with COPD. It is important that they are validated in patients with COPD and not just healthy individuals as previously describe patients with COPD have lower activity levels and move more slowly (Trooster et al. 2010). Activity monitors therefore need to detect even modest changes in PA in these patients.

A multi-sensor activity monitor, SenseWear Pro Armband (SWM; BodyMedia, Pittsburg, USA) has been developed that measures physical activity in terms of EE (Kcal), METs and step counts. The monitor integrates biaxial accelerometry (longitudinal and transverse planes) with multiple physiological measures including galvanic skin resistance, heat flux, body temperature and near-body ambient temperature to calculate estimates of EE. It is worn on the

back of the upper right arm over the triceps muscle mid-way between the acromion and the olecranon processes and can collect data continuously for up to 14 days. The monitor includes a time stamp button, that when pressed, can signify specific activities and therefore aid in accurate documentation. Preliminary studies in normal healthy subjects suggest that this device is reliable and valid at estimating EE in the laboratory setting (Fruin and Rankin 2004, Jakicic et al. 2004, King et al. 2004). However, as patients with COPD have much lower activity levels and walk at slower speeds we cannot assume these devices can capture subtle changes in activity at the lower level. The increasing interest in measuring daily activity has driven the development of activity monitors to assess the effect of PR programmes and other PA interventions. However, we must first ensure the validity and reliability of such devices in the COPD population.

Patel et al. (2007) assessed the validity and reproducibility of the SWM during the 6 minute walk test (6MWT) and incremental shuttle walk test (ISWT) in patients with COPD. Although they suggested it was valid and reliable they reported cumulative activity, rather than the accuracy of the monitor at slow speed of walking and hence potentially missing out phases of reduced activity. Another trial (Furlanetto et al. 2010) evaluated the SWM for step counts and EE using a treadmill walking protocol corresponding to 30%, 60% and 100% of the average speed COPD patients and healthy adults achieved during a 6MWT. They use indirect calorimetry and videotape as criterion measures of EE and step counts. They reported that the SWM did not accurately measure step counts at any speed and that this could be due to it

being worn on the arm rather than the leg. However, they did find it to be accurate at estimating EE at all speed in the healthy adults and at the intermediate and higher speeds in the patient group. Furlanetto et al. (2010) study did not use standardised walking speeds making it difficult to conclude whether they can distinguish between speed, and subjects were only monitored for 1 minute intervals and hence steady state could not have been reached. They also used a treadmill walking to assess the SWM, but it is important to test the device during free walking on the ground as gait and energy requirements are different during treadmill walking (Murray et al. 1985, Pearce et al. 1983, Stolze et al. 1997) and may not truly reflect domestic physical activity.

Hill et al. (2010) reported the device as being able to detect changes in different types of physical activity, lying, sitting, standing and walking. These walking speeds were selected by the individual as either slow or fast so were not standardised. They concluded that the SWM was sensitive to small changes in EE and was a valid measure in comparison to indirect calorimetry. Interestingly the self-selected (mean (SD)) slow (51 (11) m/min) and fast (65 (12) m/min) speeds of walking reported in Hill and colleagues' paper generated 77 and 93 steps per minute, these values correspond roughly to levels 3 (50 m/min) and 4 (61 m/min) of the ISWT (Smith et al. 2007). Van Remoortel et al (2012) investigated the validity of 6 activity monitors including the SWM with indirect calorimetry (VO_2) in a similar study design to Hill. Participants completed a battery of structured activities included self-selected fast and slow walking speeds. Over the whole protocol the SWM had the

highest correlation with metabolic cost as measured form indirect calorimetry (r = 0.76). However the self-selected slow speeds of walking was (mean (SD)) 3.27 (0.47) km/hr. Both these studies, therefore, have not assessed the SWM in the full range of ability seen in COPD patients, and in particularly not at the low speeds of walking characteristic of patients with COPD.

Given that individuals disabled by COPD walk slowly (Troosters et al. 2010) it is essential to be confident that the device is reliable and able to register activities of a slow velocity. This is important for a number of reasons, detection of physical activity is an increasingly important outcome for this population who are fairly sedentary and adopt slow speeds of walking, and therefore the device must be sensitive to low levels of activity. The device, ideally, should also be able to discriminate different speeds of walking, within a narrow range. Within the context of rehabilitation the devices may have a number of applications. Firstly as an outcome measure but also as an aid to exercise prescription and monitoring as walking forms the foundation of many rehabilitation exercise programmes. It is therefore important to understand the properties of the devices at various slow speeds of walking commonly replicated during a rehabilitation programme and everyday life. It is not uncommon to prescribe a walking programme from performance on the ISWT (Liu et al. 2008, Sewell et al. 2005), if we can therefore generate a value for EE and steps at a particular speed, prescription and monitoring becomes more accurate.

2.3 Treatment of COPD

The management options for COPD are comprehensively described in the NICE guidelines for COPD (2010)

According to the GOLD recommendations (Vestbo et al. 2013), effective management should achieve the following objectives:

Relieve symptoms

Prevent disease progression

Improve exercise tolerance

Improve health status

Prevent and treat exacerbations

Reduce mortality

A typical treatment strategy would include the following:

2.3.1 Smoking cessation

Smoking is the leading cause of COPD and significantly contributes to reduced lung function (Anthonisen et al. 2002). Smoking cessation is one of the most important strategies in the management of the condition and has been shown to reduce the rate of decline in FEV_1 (Scanlon et al. 2000) and has a positive effect on symptoms (Kanner et al. 1999). A review of smoking cessation and mortality concluded that smoking cessation improved survival compared to those continuing to smoker but was still higher than those who had never smoked at all (Godtfredsen et al. 2008).

2.3.2 Medication (e.g. bronchodilators and corticosteroids)

The aim of pharmacological therapy is to maintain control of symptoms and prevent exacerbations. Although COPD is irreversible certain medication can improve FEV_1 and static and dynamic hyperinflation in patients with COPD (NICE, 2010). Commonly prescribed inhaled therapies include $beta_2$-agonists, anticholinergics (both short- and long-acting) and inhaled corticosteroids.

2.3.3 Oxygen therapy

Supplementary oxygen can be prescribed for COPD patients that experience extreme breathlessness and hypoxia. It can be administered as long term oxygen therapy, whereby the patient would breathe supplementary oxygen for at least 15 hours per day. Ambulatory oxygen therapy can be considered for those who oxygen levels de-saturated and become excessively breathless during exercise or activity. Short burst oxygen therapy is only considered for severe breathlessness where other treatments have failed to be of benefit.

2.3.4 Pulmonary Rehabilitation (PR)

Definition of Pulmonary Rehabilitation

The American Thoracic Society and the European Respiratory Society have adopted the following definition of pulmonary rehabilitation: "Pulmonary rehabilitation is 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 behaviour 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 behaviours." (Spruit et al. 2013).

There is overwhelming scientific evidence to support the delivery of exercise training in the form of PR. There is also increasing interest in the delivery of exercise training via a number of different modes including home based, and supportive self-management programmes.

PR is now an established treatment for patients with COPD and is recognised as such by the National Institute for Health and Clinical Excellence (2010) in the UK. The aim of PR is to return patients with COPD to optimum functional capacity, therefore the key components of a comprehensive programme are exercise testing, exercise training and education with psychological and social support. There is strong evidence for PR and is based on studies that have demonstrated improvements in exercise capacity and health status (Lacasse et al. 2007, Nici et al. 2006). Evidence suggests that a single PR course can improve exercise capacity in terms of VO_2peak (Foglio et al. 1999) , exercise duration time (Goldstein et al. 1994, Singh et al. 1998) and walk distance (Finnerty et al. 2001, Goldstein et al. 1994, McGavin et al. 1977, Singh et al. 1998). The evidence for the benefit of a single course of PR also extends to improving HRQoL (Finnerty et al. 2001, Goldstein et al. 1994, Griffiths et al. 2000, Singh et al. 1998) and decrease healthcare utilization (Garcia-Aymerich et al. 2006, Griffiths et al. 2000). Guidelines have emphasised the importance of PR in the treatment of COPD (NICE 2010). However, the precise elements of such programmes are still debated.

The focus of PR is on improving patients health related quality of life (HRQoL) by optimising exercise capacity thereby reducing the disability associated with the disease. The emphasis moves away from trying to reverse the pathophysiological effects of COPD and reflect the holistic nature of PR.

Programme Location

The British Thoracic Society (Bolton et al. 2013) state that PR is effective in numerous settings including hospital inpatient, hospital outpatient, and the home.

Inpatient Pulmonary Rehabilitation

Inpatient PR in not common in the UK but is more widespread in Europe and the USA. Goldstein et al. (1994) demonstrated that a 2 month inpatient programme followed by outpatient PR programme improved exercise capacity and dyspnoea over 6 months. Inpatient PR is considered to be more expensive than outpatient PR and is not a model of care seen in the UK. It could also be argued that inpatient care may not be an appropriate setting to instil behavioural lifestyle changes needed to adhere to regular exercise.

Outpatient Hospital Based Pulmonary Rehabilitation

Outpatient is the most common location for PR in the UK. The benefits of outpatient hospital based PR are accepted and widely reported (Lacasse et al. 2007). The BTS guidelines (Bolton et al. 2013) recommends that a PR programme should consist of at least three exercise sessions per week, 2 of

which should be supervised. Ringbaek et al. (2000) reported that 2 exercise sessions per week was inadequate at improving exercise tolerance in COPD patients, highlighting the importance of completing regular weekly sessions at the recommended frequency. A number of randomised controlled trials have demonstrated positive outcomes of outpatient PR (Griffiths et al. 2000, Ries et al. 1995, Ries et al. 2003, Spencer, Alison and McKeough 2010, Troosters, Gosselink and Decramer 2000). Outpatient programmes reduce the disruption to daily living in comparison to inpatient programmes and allow patients the comfort of being in the own environment.

Despite the substantial evidence of the benefit of outpatient PR only 58% of Acute Trusts in the UK have provision for all eligible patients (Yohannes et al. 2011). Moreover, not all patients that are referred to PR receive the treatment as intended. Up to 50% of patients refuse to attend their initial consultation (Taylor et al. 2007) , or dropout before the end of the programme. Jones et al. (2014) recently reported on referral and uptake of PR after hospitalisation for an acute exacerbation of COPD over a one year period. This study reported that of the 286 patients that were eligible, 90 were referred to PR and only 43 received and completed the PR programme. Singh et al. (1998) reported less than half of participants completed the full course of PR. Dropout rates reported from clinical trials are generally not as high as this figure, but this could be due to the effect of being part of a trial (Arnold, Bruton and Ellis-Hill 2006). Common reasons reported for non-attendance and poor adherence to PR are travel and transport (Arnold, Bruton and Ellis-Hill 2006, Fischer et al.

2007, Keating, Lee and Holland 2011, O'Shea, Taylor and Paratz 2007, Sabit et al. 2008).

Home based programmes could overcome this travel issue and potentially allow increased participation and reduced healthcare costs as programmes are based in patients own homes (Güell et al. 2008, Maltais et al. 2008, Puente-Maestu et al. 2000, Strijbos et al. 1996). Home based rehabilitation will now be discussed.

Home Based Pulmonary Rehabilitation

Literature (PICO) search terms are listed in Appendix A.

Five studies have directly compared home based programmes with outpatient PR. Strijbos et al. (1996) compared 12 weeks hospital based PR with a supervised home based programme and a control group that received standard care in 45 patients with moderate to severe COPD (mean (SD) age 61 (6), 60 (8), 63 (5) years; FEV_1 % predicted 40 (20), 46 (7), 43 (9) for the hospital based group, home based group and control group respectively). Exercise tolerance was assessed at 6, 12 and 18 months after the intervention. Data showed that exercise tolerance improved at 6 months in both PR groups, however, by 18 months the home PR group had continued to improve but the hospital group exercise tolerance had returned to baseline. The authors concluded that those completing a home based PR may have found it easier to continue unsupervised after the initial PR programme. Gűell et al. (2007) reported that a home based programme provided similar gains in

exercise tolerance and dyspnoea symptoms than hospital based PR (mean (SD) age 63 (7), 66 (6) years; FEV_1 % predicted 38 (7), 39 (8); 6MWT 448 (80), 467 (47) metres for the hospital and home group respectively). Although the 9 week home programme was unsupervised both the PR groups and home based group had 'front loaded' supervised information sessions and physical therapy sessions. Puente-Maestu et al. (2000) compared the effects of supervised training to self-monitored training in 41 patients with moderate to severe COPD (mean (SD) age 63 (4), 66 (5) years; FEV_1 % predicted 41 (6), 40 (6); $V0_2max$ 1.24 (0.24), 1.25 (0.29) $L.min^{-1}$ for the supervised and unsupervised group respectively). The self-monitored group were given a pedometer and asked to walk 3 to 4km within a 1 hour period on 4 days a week for 8 weeks (pedometer gave distance travelled). Patients were required to attend a weekly clinic to have their records checked and to encourage adherence to the programme. Both interventions had significant increase in HRQoL and exercise endurance, however, only the supervised group demonstrated improvements in peak exercise tolerance. Researchers were also not blinded to which treatment patients had received. These studies showed that home based programmes are safe, but as small numbers were involved they were highly likely to be under powered.

In a study by Maltais et al. (2008) patients underwent a 4 week education programme before being randomised into either a home based or hospital based PR group. This study was powered for noninferiority and included 252 patients with moderate to severe COPD (mean (SD) age 66 (9), 66 (9) years; FEV_1 % predicted 43 (13), 46 (13); 6MWD 368 (85), 370 (89) metres for

hospital based and home based groups respectively) . PR at home consisted of endurance and strength training 3 times per week for 8 weeks including cycling at 60% of peak workload for a target of 40 minutes. Results showed that the self-monitored home based group improved as much as the hospital based group in terms of the dyspnoea subscale of the CRQ ($P<0.001$) and cycle endurance time ($P<0.001$). This study demonstrates that patients are able to self-monitor their home exercise programme. However, the study involved an exercise specialist initiating the programme at the patients' home and patients were also loaned a portable cycle ergometer.

A Brazilian study (Mendes de Oliveira et al. 2010) compared outpatient PR with self-monitored home rehabilitation of 12 weeks in 117 patients with mild to severe COPD (mean (SD) age 66 (10), 71 (7), 71 (9) years; FEV_1% predicted 48 (23) %, 52 (24) %, 41 (18) % for the home, hospital and control groups respectively). Both intervention groups initially received an educational programme at the start of the intervention. Both groups showed a significant improvement in 6MWT (mean (SD) increase in 6MWT distance outpatient 93.6 (70.6) metres, $p<0.05$; home 73.2 (50.2) metres, $p<0.05$) and there was no difference between these groups at 12 weeks ($p=0.44$), however, the researchers were not blinded to which group the patients had been assigned.

Although these studies investigated home based programmes none were truly unsupervised and four required attendance at the hospital for education sessions (Güell et al. 2008, Maltais et al. 2008, Mendes de Oliveira et al. 2010, Puente-Maestu et al. 2000), therefore, do not address the fundamental

barrier of travel and transport to adherence to rehabilitation programmes. A comparison between outpatient hospital based PR and an equivalent home based unsupervised programme is therefore warranted. Holland et al. (2013) recently published a study protocol which aims to complete an equivalence trial of the benefits and costs of a home based programme in comparison to 8 weeks PR.

There are also a number of clinical trials of home based rehabilitation in comparison to a control group that has received usual care. These, together with the studies on home rehabilitation discussed above are summarised in Table 2.4.

Table 2.4 Summary of home based pulmonary rehabilitation studies

Study	Country	Methods	Outcome measures	Patient characteristics	Intervention	Duration	Outcome (change)
Boxall et al. (2005)	Australia	RCT, delayed treatment for control n=46	6MWT, SGRQ, Borg breathlessness, healthcare utilization	I C Age 78 76 Male 11 15 FEV_1% 41 38 6MWD 163 147.5 All housebound	Supervised education and exercise. Mean no. of home visits over 12 weeks = 11.	12 weeks	I C p 6MWD 39 4.2 0.023 SGRQ-T-5.8 -1.4 0.020 Admission 5.6 8.8 0.235
Fernandez et al. (2009)	Spain	Prospective RCT Control had 3 education sessions n=50	6MWT, SGRQ	I C Age 66 70 FEV_1% 33 38 6MWT 302 315 All LTOT	Supervised education, 2x 1hr in hospital. 1hr exercise per day, 5 days per wk. Twice monthly home visits for 2 mths. 1x mth visit for 9 mths	12 months	I C 6MWD 79 p0.0001 13 NS SGRQ -14.7p0.0001 -2.5NS
Ghanem et al. (2010)	Egypt	RCT n=39 (I: 25, C: 14). Control had usual care Post exace.	6MWD, CRQ, SF-36	I C Age 57 56 FEV_1% 36 29 6MWT 89 84	Supervised education, unsupervised exercise. 4 x 1hr education whilst inpatient	2 months	Treatment effect at 2 mths 6MWD: 58.15 (11.23), p=<0.001. CRQ-D: 5.5 3.0 to9.0), p=0.003. CRQ-F: 5.3 (1.9 to 9.8), p=0.004. CRQ-E: 8.7 (2.5-15.0), p=0.008.
Guell et al. (2008)	Spain	Prospective multicentre RCT. Control had hospital PR N=51 6mth FU	6MWT, CRQ	I C Age 63 66 FEV_1% 38 39 6MWT 448 467	Both groups had 2 information sessions and 4 physical therapy sessions. Home programme was unsupervised	9 weeks	9 wk diff; CRQ-D 0.21 (NS), 6MWT 8.69 (NS). 6 mths diff; CRQ-D 0.13 (NS), 6MWT -6.55 (NS).

Study	Country	Methods	Outcome measures	Patient characteristics	Intervention	Duration	Outcome (change)
Maltais et al (2008)	Canada	Noninferiority RCT Multicentre Control had hospital PR n=252 FU 12 mths	CRQ, 6MWT	I C Age 66 66 Male% 54 57 FEV_1% 43 46 6MWT 368 370	Supervised Education, 2x week for 4 weeks. Followed by unsupervised exercise for 8 weeks. Phone calls	12 weeks	Between gp diff at 3mths, CRQ dyspnoea 0.05, p0.74. 6MWT -3 p0.68. Between gp diff at 12 mths, CRQ dyspnoea 0.16 p=0.20, 6MWT 5 p0.62.
Mendes et al (2010)	Brazil	RCT, 3 groups; home hospital control N=117 FU 3 months	6MWT, BODE	I Hosp C Age 66 71 71 Male 27 19 19 FEV_1% 69 79 70	Supervised Education x 1. Unsupervised exercise 3x week for 3 months. Telephone calls	3 months	6MWT change at 3 months 73.21 (50.21) m p<0.05. Between group diff p0.44
Puente-Maestu et al. (2000)	Spain	RCT 2 parallel groups. Supervised (C) vs unsupervised (I) N=41	Work rate, CRQ, VO2 max	I C Age 66 63 FEV_1% 40 41 VO_{2max} 1.25 1.24	Home walking programme. Weekly visits to clinic	8 weeks	Similar increase in CRQ (C 0.72; I 0.8). C significantly increased work rate. Some effect of I, not as much as C
Strijbos et al. (1996)	Netherlands	RCT, N=45 Hosp, home and control FU 6, 12 & 18 mo	Work rate exertional dyspnoea, well-being	I Hosp C Age 60 61 63 Men 14 13 12 FEV_1 %46 40 43	Supervised exercise, supervised education	12 weeks	Equal improvements in exercise capacity and Borg dyspnoea at 3 & 6 months. I gp significantly improved to 18 months above Hosp.

I = intervention, C = control, Hosp = outpatient PR, D = dyspnoea

Home based programmes offer promised to the increasing demands on PR and increase the treatment options available to patients. In addition, they may also enhance long term adherence to positive health behaviour. There is substantial evidence that benefits for PR decline over the 12 months preceding the intervention (Arnardóttir et al. 2006, Bestall et al. 2003, Foglio et al. 1999, Griffiths et al. 2000, Maltais et al. 2008, Ries et al. 1995, Singh et al. 1998) which has been attributed to the decline in the participation of regular exercise after supervision has cessed (Griffiths et al. 2000). Programmes delivered in the home have the advantage of not having a transition period where patients have to adapt to a new environment to participate in PA. Home based programmes integrate PA in to the normal daily lives and therefore have potential to be maintained in the long term.

Home programmes need to be comprehensively developed and supported in order for long term health behaviours to improve. To modify behaviour self-efficacy and SM skills need to be enhanced. PR in the UK incorporates education sessions which aim to enhance these skills. Therefore equivalent training needs to be incorporated into home based programmes. SM could potentially be used to support home programmes to provide optimal care. A number of SM programmes have been developed in a number of countries and will now be discussed.

2.2.5 Supporting rehabilitation with Self-Management (SM)

SM has often been regarded as the way forward to reduce increasing healthcare costs and address the increasing demands on healthcare. SM is

not a goal or outcome in itself, but one element of integrated care. Interpretations of SM are diverse across the literature and the next sections of this chapter aim to define and contextualise SM and discuss various studies that have used SM to enhance rehabilitation programmes.

Definition of Self-Management

There is no 'gold standard' definition of SM. Barlow (2002) defines SM as 'individuals' ability to manage the symptoms, treatment, physical and psychosocial consequences and life style changes inherent living with a chronic condition' and health professionals play a key role in facilitating SM to patients. SM goes further than patient education, which is often information giving and development of technical skills. SM is problem focused, action orientated and emphasise patient generated care plans (Lorig and Holman 2003). Comprehensive SM programmes, therefore, aim to improve self-efficacy, problem solving and decision making skills and confidence in individuals with long term conditions to enable them to take control and management their own health. It can be argued that everyone with a long term condition self manages to an extent, but successful SM programmes support individuals to be more effective in their health behaviour decisions (Lorig and Holman 2003).

Self-Management theory

The model of SM is based on the theory of self-efficacy first proposed by Bandura (1977). Self-efficacy is a key component of social cognitive theory. It is a psychological construct denoting confidence in an individual's ability to

perform a given task or specific behaviour or successfully changing a specific cognitive state (Bandura 1977). Self-efficacy is task specific hence, an individual can have high self-efficacy for one task or behaviour but low self-efficacy for another. Perceived self-efficacy influences an individual's decision making and plays an important role in SM activities, adopting and maintaining health behaviour changes, resulting in improved health outcomes (Marks, Allegrante and Lorig 2005a).

Perceived self-efficacy can be enhanced by 4 main factors 1) past performance, 2) vicarious experiences, 3) verbal persuasion and, 4) physiological state (Bandura 1977). Using these constructs to build a behavioural intervention and education programme can effectively improve self-efficacy and SM behaviours of patients with chronic disease (Marks, Allegrante and Lorig 2005a, Marks, Allegrante and Lorig 2005b).

Self-efficacy has been demonstrated to be a significant influence on exercise initiation and adherence in the elderly population (Rhodes et al. 1999). A review of studies which monitored self-efficacy in smoking cessation, weight control, contraception, alcohol misuse and exercise concluded that self-efficacy was strongly related to health behaviour and enhancing self-efficacy impacts on improvements in health behaviour (Strecher et al. 1986). As self-efficacy is a key component to behaviour change, SM must incorporate strategies to enhance it. In addition, as self-efficacy is task specific it is essential that any measurement tool is accurately measuring what it purport to measure.

Bourbeau, Nault and Dang-Tang (2004; Figure 2.2) proposed that knowledge and skills influence self-efficacy and therefore there enhancement needs to be incorporated into intervention to improve self-efficacy.

Figure 2.2 Bourbeau, Nault and Dang-Tang (2004) model of behaviour change

Self-Management in COPD

Literature (PICO) search terms are presented in appendix A.

With the healthcare system dealing with more long term conditions there is growing interest in fostering the means by which individuals with long term conditions can participate effectively in managing their condition (Lorig et al. 2001). SM programmes are distinct from patient education or skills training, in that they are designed to encourage individuals with chronic disease to take an active part in the management of their own condition

The evidence base to support the use of COPD SM programmes is now emerging, but many of the methodological issues inherent in delivery of a complex intervention are evident. There is diversity in the interpretation of SM throughout the literature, with programmes offering a range of both exercise and education sessions from none at all to fully supervised lengthy programmes requiring a high level of healthcare professional's time. A number of the SM programmes offer a more comprehensive programme than some tradition outpatient PR programmes in the UK. In order to contextualize SM and PR Wagg (2012) has developed a model of the spectrum of COPD support (figure 2.2). The model extends from the most basic action plan through supportive SM and PR. Using Wagg's (2012) model a critical review to contextualize SM programmes will now be discussed. In the context of this thesis studies aimed at enhancing SM skills will be evaluated and not just studies 'labelled' as SM by the authors.

Figure 2.2 Wagg's (2012) Spectrum of support for COPD

A Cochrane systematic review of SM in COPD (Zwerink et al. 2014) evaluated 29 trials concluded that it is likely that SM is associated with reduced hospital admissions, improved health related quality of life and improved dyspnoea. Clear recommendations regarding the most effective form and content of SM in COPD could not be made due to the heterogeneity of SM interventions, outcome measures and follow up times among the studies. This review highlights the need for large randomised controlled trials with long term follow ups to increase the understanding of SM in COPD.

A summary of the SM studies discussed in this chapter are presented in table 2.4. Studies are listed alphabetically and those highlighted in grey show those with generally positive findings.

Table 2.4 Summary of SM studies

Study	Country	Methods	Outcome	Patient characteristics	Intervention	Duration	Outcome
Bischoff et al. (2012)	Netherland	RCT SM, routine care & usual care Assessor blinded N=165	CRQ exacerbations	SM RC UC Age 66 66 64 Male% 67 76 51 FEV_1% 66 63 67	Supervised education for 2-4 sessions. Phone calls x6. Action plan. No exercise	24 months	Treatment differences CRQ D: -0.6 (-0.54 to 0.21), CRQ F: -0.17 (-0.62 to 0.27), CRQ E: -0.31 (-0.66 to 0.039), CRQ M: -0.20 (-0.55 to 0.14)
Bourbeau et al. (2003)	Canada	Parallel-group, randomised, multicentre trial. Assessor blinded n=191 C=usual care	Hospital admission, A&E and physician visits, SGRQ, 6MWD	I C Age 69 70 Male% 52 59 FEV_1 1.0 0.98 6MWD (m) 282 280	Supervised education, 1hr per week for 7 to 8 weeks at home followed by unsupervised exercise. Weekly phone calls for 8 wks, monthly calls for remainder of study	12 months	Treatment difference at 12mths for COPD admission -39.8, p0.01. Bed days -42.4, p0.01. SGRQ 4mths treatment diff in impact -6.2 and total score -4.2, at 12mths only impact score -4.7
Bucknall et al. (2012)	UK	RCT Post hospital admission. Assessor blinded n=464 C=usual care	Readmission, death, SGRQ, HADS, CSES	I C Age 70 68 Male% 38 35 FEV_1% 41 40	Supervised education Fortnightly visits for 2 months, every 6 weeks fo 10 months (40 mins per visit)	12 months	No effect on readmission or death, treatment effect 1.05, (95% CI 0.80 to 1.38 p=0.725). SGRQ total: -4.52 (-9.07 to 0.04), p=0.052. HADS-A: -1.06 (-2.08 to -0.03) p=0.044. No change HADS-D or CSES

Table 2.4 continued..

Study	Country	Methods	Outcome	Patient characteristics	Intervention	Duration	Outcome
Effing et al. (2011)	Netherlands	RCT n=159 C=SM programme only + usual care	ISWT, ESWT, CRQ, CCQ, HADS, PA	I C Age 63 64 Male% 58 58 FEV_1% 50 51 ISWT (m) 388 341	Supervised education and exercise 3x week for 6mths, 2x week for 5mths. Control had 4 weekly 2hr education sessions	11 months	12 mo treatment effect: ISWT:35.1m (8.4 to 61.8) sig ESWT:145.8sec (-26.2 to 317.8) CRQ-D:0.32 (-0,03 to 0.67) sig
Fan et al. (2012)	USA	RCT, multi centre. Telephone calls blinded n=426 mean FU 250 days	Time to first hospitalization SGRQ, SF-12, Satisfaction, Depression, knowledge, self-efficacy	I C Age 66 66 Male% 98 96 FEV_1% 38 38	4 weekly 90 min education session. Phone call once per mth for 3 mos, then every 3 mos. Action plan.	12 months	Study terminated early due to higher mortality in SM group Deaths: 28 (SM), 10 (C), hazard ratio 3.00 (1.46 to 6.17), p=0.003. SGRQ NS
Khdour et al. (2009)	UK	RCT C= usual care. Assessor not blinded N=173	Hospital admission, SGRQ, COPD knowledge	I C Age 66 67 Male% 44 44 FEV_1% 52 52	Unsupervised education, unsupervised exercise. Manual, MI, telephone contact	12 months	Treatment effect at 6mth, hospital admission: I -15, C-34, p0.01. SGRQ(T): -5.2 p0.04. Treatment effect at 12 months Hospital admission: I –26, C-64, p0.01. SGRQ(T):-3.8 p0.17

Table 2.4 continued..

Study	Country	Methods	Outcome	Patient characteristics	Intervention	Duration	Outcome
Koff et al. (2009)	USA	RCT C=usual care. Assessor not blinded N=40	SGRQ Healthcare cost	I C Age 67 65 Male% 45 50 FEV_1% 34 31	Education, SM techniques, enhanced communication, remote home monitoring ('health buddy system')	3 months	Treatment effect SGRQ -10.3 (-17 to -3.1) p=0.018 compared to C. Costs US$ -1401 (-6566 to 3764) p=0.21 compared to C
McGeoch et al. (2006)	New Zealand	RCT C=usual care Assessors not blinded N=159	SGRQ, healthcare utilization, HADS	I C Age 70 72 Male% 52 67 FEV_1% 55 53 Primary care	Action plan	12 months	Treatment effect SGRQ 1.7 (SD 1.6; p=0.58 compared to change in C) HADSA 0.15 (SD 0.7; p=0.87 compared to change in C). HADSD 0.29 (SD 0.29; p=0.57 compared to change in C)
Monninkhof etal.(2003)	Netherlands	RCT C=usual care N=248	SGRQ, 6MWT	I C Age 65 65 Male% 85 84 FEV_1 % 56 58 6MWT (m) 428 442	Supervised Education, 5x 2hr sessions over 4 mo Supervised Exercise, 1-2x week for 1 hr for 2 yrs	2 years, but only up to 1year reported	Treatment effect at 12 months. SGRQ (T) -0.6 (-2.8 to 1.7) NS 6MWT-13 (7) m (I) vs -2 (5) m (C) NS
Moore et al. (2009)	UK	Pilot RCT C=educational booklet N=27	ISWT, CRQ	I C Age 70 71 Male % 40 60 FEV_1 % 40 42 ISWT 110 160	Unsupervised Education & Exercise. Booklet and DVD 4x week for 6 weeks	7 to 8 weeks	Within group diff : ISWT 45m p0.021 (I) vs -15m p0.256 (C): CRQ dyspnoea 0.5 p0.027 (I) vs -0.1 p0.326

Table 2.4 continued..

Study	Country	Methods	Outcome	Patient characteristics	Intervention	Duration	Outcome
Ninot et al. (2010)	France	RCT C=usual care Assessors blinded N=45 FU 12 months	6MWD, SGRQ, VO2peak	I C Age 65 61 Male 90 78 FEV_1 % 56 54 6MWD (m) 450 397	Supervised education and exercise, 2 x week for 4 weeks	1 month	Between group diff at 12 months: 6MWT 50.5m p0.04. SGRQ -14 p<0.01
Rice et al. (2009)	USA	RCT multicentre C=usual care Assessors blinded N=743	Hospitalization SGRQ	I C Age 69 71 Male% 98 98 FEV_1% 36 38	Group education x1 Action plan Monthly phone calls	12 months	Treatment difference hospitalizations 0.34 (0.15 to 0.52 visits (p=<0.0001 in comparison to C). I ↓ hospitalization by 28% all causes; 49% COPD.
Watson et al. (1997)	New Zealand	RCT C=usual care N=69	SGRQ	I C Age 68 67 Male % 62 67 FEV_1% 37 36 Primary care	Action plan	6 months	SGRQ change -4 NS with C

I = intervention, C = control, FEV_1% = FEV_1% predicted, D = dyspnoea, F = fatigue, E = emotion, M = mastery, CSES = COPD Self-Efficacy Scale, HADS-A = HADS anxiety, HADS-D = HADS depression, CCQ = clinical COPD questionnaire, NS = not significant, …… = positive outcome of trial

In the 1990's Jean Bourbeau and Diane Nault developed a SM programme for COPD in Canada called 'Living Well with COPD'. The course consists of weekly 1 hour sessions of skill-orientated teaching delivered by a health professional for 7 to 8 weeks. The sessions aim to develop patients' knowledge and skills required to adjust and maintain behaviour changes. Exercise training does not begin until approximately 7 weeks into the programme and is initiated by a supervised session at the patients' home. Exercise training is based on walking, stair climbing and cycling, with stationary cycles being loaned to patients. Patients also receive a workbook which includes the 7 modules below:

Keeping a healthy and fulfilling lifestyle

Preventing your symptoms and taking your medication

Managing your breathing and saving your energy

Integrating a plan of action into your life

Long-term home oxygen therapy

Managing your stress and anxiety

Integrating an exercise programme into your life

A number of studies have been presented using this model of SM in COPD. Bourbeau et al. (2003) first reported a randomised multicentre trial in 191 patients with COPD (mean (SD) age; 69 (7), 70 (7) years; FEV_1 1.00 (0.33), 0.98 (0.31) litres; baseline 6MWT 282 (91), 280 (90) metres for the SM and usual care group respectively) and compared usual care with the Living well with COPD SM programme (as described above). The study demonstrated that hospital admissions for exacerbation of COPD were reduced by 39.8%

(p=0.01) in the SM group compared with the usual care group over 12 months. The SM group also had a reduction in; hospital admissions for other health problems (57.1% p=0.01), visits to the emergency room (41% p=0.02) and unscheduled physician visits (58.9% p=0.003). The authors found that in the SM group the activity and impact subscale and total scores of the SGRQ significantly improved at four months. At 12 months only the impact subscale and total score was improved compared to baseline and the only difference between treatments was on the impact subscale. Interestingly, exercise capacity as measured by the 6MWT did not change significantly within or between the SM and usual care group at four and 12 months. These findings would question the effectiveness of the exercise training component of their programme. Bourbeau et al. (2006) also presented the economic benefits of the study showing that cost savings could be made on the reduced hospital admission even when accounting for the cost of the SM programme. Gadoury et al. (2005) did a follow up of these patients 2 years after the SM programme. This study found that all cause hospital admissions had reduced by 26.9% and all cause emergency room visits reduced by 21.1% in the SM group as compared to usual care group.

A number of further trials have shown a positive effect on various patient outcomes (Effing et al. 2011, Khdour et al. 2009, Koff et al. 2009, Moore et al. 2009, Rice et al. 2010). Effing et al.(2011) reported on a comprehensive SM programme involving 159 patients with COPD (SM and Control respectively, mean (SD); age 63 (8), 64 (8) years; FEV_1% predicted 50 (14)%, 51 (17)%; ISWT 388 (165), 341 (152) metres). This intervention involved four two hour

SM sessions a six month ‘compulsory’ period of three exercise sessions per week delivered in the community by a physiotherapist and subsequently twice weekly exercise sessions for five months which was ‘optional’. At 12 months there was a statistically significant difference in the change in ISWT in comparison to the control group (mean (95% CI) 35.1 (8.4 to 61.8) metres) and CRQ dyspnoea (0.32 (-0.03 to 0.67) p=0.04), although neither of these improvements met the MCID for their relative measures. A significant treatment effect was also reported in the number of steps at 12 months (mean (95%) CI 1,190 (255 to 2125)) as measured by a pedometer. Only a small improvement in the ISWT was detected in the intervention group in this study, at seven months the ISWT distance had increased by a mean of 12 meters and by 12 months it was 11 meters, therefore the difference seen between the intervention group and control group (35 m; 95% CI 8 to 62 m) was largely due to the decline in the control group. In principle this is of value, but in regards to the comprehensive intervention this would be considered a rather limited improvement in exercise capacity.

Although a number of studies have shown positive effects of SM programmes these intervention have not included an exercise component as part of the intervention (Khdour et al. 2009, Koff et al. 2009, Rice et al. 2010). Considering the importance place on exercise and physical activity in the management and long term outcome of patients with COPD (NICE, 2010) this is a significant downfall in the design of these interventions.

A novel approach to SM and exercise training was adopted by Moore et al. (2009). This study delivered exercise training and SM via a DVD and therefore was unsupervised. This study was based in the UK and although small (n=29; mean (95% CI or SD) control and intervention respectively; age 71 (58 to 79), 70 (13) years; FEV_1 % predicted 42 (30 to 55), 40 (37 to 49) %; ISWT 190 (45 to 85), 110 (30 to 270) metres) at six weeks detected a significant improvement in ISWT in the SM group compared to the control. This improvement in the SM was also seen in the CRQ domains of dyspnoea, fatigue and emotion.

In contrast to these studies demonstrating a positive impact of SM training a number of studies have reported mixed or negative results. Monninkhof et al (2003a) evaluated a comprehensive SM and fitness programme in comparison to standard care and involved 248 participants (mean (SD) Age 65 (7) years; FEV_1 % predicted 57 (15)%; 6MWT 428 (91) meters in the SM group). The intervention consisted of five two hour education sessions completed over four months and a supervised exercise programme that was assessed over the year. Patients were also provided with a booklet with background information on their condition. Exercise sessions were supervised by a physiotherapist near the patients' home and exercise was recorded in an exercise log book. Despite regular contact with health professionals and supervised exercise sessions this study failed to influence either HRQoL or exercise capacity. It is possible that an impact did not occur with these patients as they had mild disease severity (FEV_1% predicted 56%) and a relatively higher mean (SD) 6MWT distance (428 (91) m) at baseline. It may

also be likely that exercise capacity did not change due to the intensity of the exercise programme not being high enough to elicit a training response. Patients determined their training goals with their physiotherapist and it was not standardised or clinically prescribed. Furthermore, they also concluded that the SM was twice as expensive and was not economical due to no measurable benefits (Monninkhof et al. 2004).

Bucknall et al. (2012) completed a SM study in Scotland with 464 patients with COPD (mean (SD) Age 69 (9) years; FEV_1 % predicted 41 (14)). This study used the 'Living well with COPD' model of intervention as reported by Bourbeau et al (2003). This study involved no formal exercise again a significant limitation to the study design. Bucknall found no difference in COPD hospital admissions or deaths. However, this study did identify 42% of its intervention group as successful self-managers that were characterised by being younger (p=0.012), and more likely to be living with others (p=0.010). This subgroup had a significant reduction in hospital admission (p=0.003). A number of other studies using SM theory to enhance health behaviour but no exercise also found no significant effect (Bischoff et al. 2012, Fan et al. 2012, McGeoch et al. 2006, Watson et al. 1997). Although exercise performance was not an outcome measure in these studies, physical activity is an important component in the treatment and management of COPD and has been shown to be a predictor of all-cause mortality (Waschki et al. 2011).

With the contradictive outcomes of these SM trials it becomes apparent that the precise components of these programmes need further consideration. An

important observation is that patients in the positive trials tend to have advanced COPD and lower baseline outcome scores and therefore had more potential for improvement. Perhaps the only exception to this is Effing and colleagues study who had patients with moderate COPD (mean (SD) age 63 (8), 64 (8) years; FEV_1% predicted 50 (14), 51 (17); ISWT 388 (165, 341 (152) meters for the SM and control groups respectively), however, although a significant improvement was detected in the SM group increases were small and did not meet the MCID for each measure. Furthermore, patients in these positive studies had a high level of health professional contact (e.g. phone calls) and perhaps acted proactively under the guidance of a healthcare professional and not as a result of their own behaviour. It is clear that supervision can enhance outcomes (Puente-Maestu et al. 2000) and perhaps these programmes have not clearly developed patients SM skills. The complex nature of SM and the diversity of SM trials reported makes it difficult to determine the most effective strategy to improve patient SM. Interestingly Bischoff et al (2012) and Bucknall (2012) reported that even though no overall effect was detected in their SM groups there was a sub-group of apparently successful self-managers, representing about 40% of patients with COPD. This sub-group was characterised by being relatively younger, living with others and having severe airflow obstruction. Bucknall et al. (2012) also showed that dedicated health professional, spouse or family member makes all the difference in the successful management of complex disease such as COPD.

Despite recruiting similar patients to Bourbeau et al. (2003) and Rice et al. (2010), who reported positive findings the Fan et al. (2012) study was stopped early due to increased mortality in the SM group. The reason for this excessive mortality is poorly understood, although one school of thought is that the SM was 'too' effective as medication was stable and did not change during the intervention. One important difference in the Fan and colleagues study might have been the number of telephone calls received. Bourbeau and Rice called patients every month for one year, whereas Fan made calls on a monthly basis for the first three months then only every three months thereafter. Therefore, patients may have delayed reporting their symptoms as they were waiting for a telephone call to report them. SM should not replace integrated care but should be an adjunct which enhances health behaviours and teaches patients when it is appropriate to seek healthcare advice. SM support should be integrated into the mode of delivery of rehabilitation and not an isolated component.

In order to enhance home based rehabilitation it may be important to support this mode of delivery by improving patients SM skills. A model that is feasible in the UK system and incorporates PA training, which has been shown to reduce hospital admissions (Garcia-Aymerich et al. 2006) and all-cause mortality (Waschki et al. 2011), improve dyspnoea (Watz et al. 2009) in patients with COPD has not been fully examined and therefore such studies are warranted.

2.4 Summary

COPD is a disabling, irreversible airways condition characterised by dyspnoea, chronic cough, sputum production, muscle weakness and reduced daily physical activity. It poses a significant burden to the individual and the healthcare system in the UK. There are a number of treatment options available including smoking cessation, pharmacotherapy and PR. PR has a strong evidence base for improving and managing commonly experienced symptoms. Despite this accumulation of convincing evidence there is an inadequate provision of pulmonary rehabilitation in the UK. There is not the capacity in the UK for all patients with COPD to be offered such a model of care. It could also be argued that not all patient's need to follow the 'hospital based' model especially those with mild disease, and due to local geography it may not be practically possible for all patients to access hospital or community based services. There are also limited options for patients with COPD and there is a need to increase choice for these patients. In cardiac disease there is a 'menu' of treatments available and together with outpatient hospital rehabilitation, home based rehabilitation, and the 'Heart manual' is available (Lewin et al. 1992) which is fully integrated into patient care. Home based PR programmes have shown some initial promise, but the present studies are not fully based in the patients' home and require attendance for part of the programme at hospital.

Alongside this increased demand for rehabilitation there is a philosophical shift within the healthcare system encouraging patient to become more involved in his or her own care. There are subtle shifts of responsibilities from

the healthcare provider to the individual. This is particularly important for long term disease management requiring individuals to engage actively in health related decisions and moving away from the paternalistic model of healthcare. Although every patient with a long term condition self-manage their health, supportive SM could provide patients with the knowledge and skills require to make decisions that optimise their health and quality of life. Comprehensive SM programmes should promote the knowledge and skills for patients to make informed decisions in regards to smoking cessation, physical activity, breathing control, chest clearance and managing exacerbations.

There are a number of studies published on SM in patients with COPD with varying interpretations and interventions. Studies that are labelled as SM vary from simple action plans to programmes involving supervised education and exercise sessions over a substantial period of time. A number of the SM programme which involve high levels of supervision offer a more comprehensive programme that what is offered under outpatient PR in the UK and other countries. Moreover, it appears that the more comprehensive and longer interventions do not necessarily result in greater gains. Studies with a positive impact tend to have recruited patients that are more severe and have poorer baseline outcome measures and hence have more to gain. Therefore, it is still not clear in the literature as to the optimum content and delivery of such programmes. As the definition and interpretation of what SM is and what it involves is different from country to country and the fact that healthcare systems vary greatly around the world, it is important to investigate SM strategies within the UK model of healthcare.

As the studies on home based rehabilitation and SM are either not appropriate for the UK healthcare system, have shown a lack of improvement or had poor methodical quality there is a need for evidence of a comprehensive home based SM programme which is suitable in the UK. Therefore, the aim of this thesis is to evaluate the effect of a novel home based SM programme called a **S**elf-management **P**rogramme of **A**ctivity **C**oping and **E**ducation (SPACE for COPD). The programme was developed to be delivered without supervision after an initial introductory session and aims to promote exercise, knowledge and the skills required to successfully manage COPD symptoms. The programme is described in more detail in chapter 3. The outcome measures chosen enable the assessment of skill development and behaviour change that may be reflected in clinical outcomes. It was hypothesised that SPACE for COPD would be noninferior to traditional PR. Noninferiority trials seek to determine whether a new treatment, in this case SPACE for COPD, is not worse than the reference treatment, PR, by more than an acceptable amount. This acceptable amount referred to as the noninferiority margin is set as the minimal clinical important difference (MCID) where available. The study was designed to determine whether SPACE for COPD was noninferiory to PR at 7 weeks.

Chapter 3 – Methods of the Randomised Control Trial

3.1 Introduction

This chapter will describe the methods utilised in the main study design (chapters 5, 6, 7 and 8). These chapters explore the main components of the randomised controlled noninferiority trial described in this thesis, including collection of the baseline data, outcome measures of the 7 week trial (chapter 6) and outcome measures six months after the intervention (chapter 7). The scope of this chapter is to address the study design, details of patient recruitment, and a description of all outcome measures used. It also describes the pulmonary rehabilitation (PR) programme and the self-management (SM) manual (SPACE for COPD) used in the controlled trial. An outline of statistical methods will also be explained. The CONSORT checklist for noniferiority trials is presented in Appendix B

3.2 Study design

This was a single blinded randomised noninferiority trial. Patients were randomised into either a hospital base PR programme (usual care) or a home based group which was supported by a SM manual (SPACE for COPD). Due to ethical reasons no true control group, with no treatment, was considered appropriate. Patients randomised to the PR group completed the usual prescribed treatment of a twice weekly hospital based supervised exercise and education programme over seven weeks. Patients randomised to the SPACE for COPD group had an initial introductory session explaining the

manual and were given their exercise prescription. Patients in this group received two calls from the researcher over seven weeks to assess their progress, give motivation to continue and to answer any questions. Outcome measures were taken in all patients at three time points; at baseline on referral to PR, seven weeks post intervention and six months after completion of the intervention. The researcher conducting the outcome measures were blinded to which treatment group the patient was assigned to. All patients completed the outcome measures relating to health status and exercise performance (unless stated). Figure 3.1 summarizes the study.

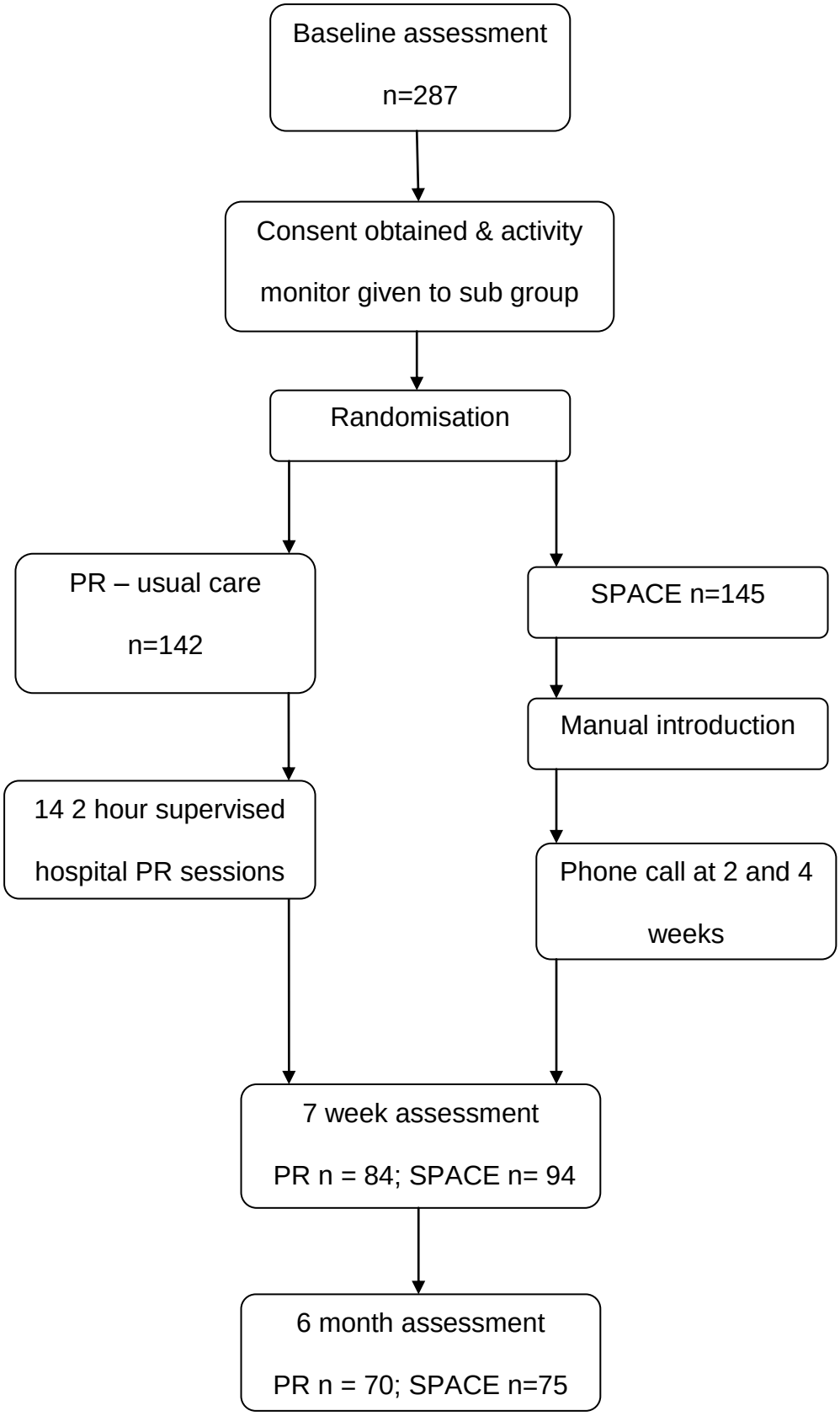


Figure 3.1 Study design

3.3 Study recruitment

Ethical approval for the study was obtained from the Leicestershire, Northamptonshire and Rutland Research Ethics Committee in 2007 (Appendix B). Recruitment took place from November 2007 to July 2012. Patients presenting for pulmonary rehabilitation were asked by a member of their health care team to consider taking part in the study. A patient information sheet (Appendix C) was given to each patient along with a verbal explanation of the study. An appointment was then made with each patient to see the researcher the following week (A minimum of 48 hours were allowed). Informed written consent (Appendix D) was then obtained from each subject willing to take part. It was made clear to the patients at this point that refusal to take part in the study would not affect their future treatment.

Inclusion criteria

The principle inclusion criteria were patients presenting for a course of rehabilitation with a diagnosis of COPD and had an MRC (Medical research council) of grade of 2-5 on the dyspnoea scale.

Exclusion criteria

Patients excluded from the study were those patients that would routinely be excluded from rehabilitation if they had significant neurological or locomotive disorders or an unstable psychiatric history. Those patients who had poor English language skills were also excluded due to the manual only being available in English.

3.4 Assessments

Baseline assessment (Usual treatment)

Prior to recruitment to the study patients attended an initial assessment conducted by a healthcare professional. Patients were referred to the pulmonary rehabilitation team via a number of routes including their GP, consultant, REDS (Respiratory Early Discharge Service) and SPRINT (Specialist Respiratory Intervention Team) and came from across Leicestershire and neighbouring counties. The initial assessment lasted approximately 1.5 hours during which demographic (height, weight, date of birth) and clinical data was recorded, along with past medical and smoking history. Forced expiratory volume in 1 second (FEV_1) and forced vital capacity (FVC) were measured using a portable spirometer. Resting levels were also taken for heart rate, oxygen saturation and a rating of dyspnoea using the Borg breathlessness scale. Patients then completed the ISWT (Incremental Shuttle Walk Test) twice to allow for habituation to the test, the ESWT (Endurance Shuttle Walk Test) and each of the three questionnaires (CRQ-SR, HADs and PRAISE). During this assessment the patients were asked to consider taking part in the study.

Consent Appointment

Patients that had shown an interest in taking part in the study were given the patient information sheet and an appointment with the researcher (Elizabeth Horton: EH) for the following week. During the consent appointment the study was explained in more detail including why the patient had been asked to take

part, the aim of the study, what would be required of them if they took part, and highlighting that the study was voluntary. Patients were given the opportunity to ask questions and written informed consent taken. If available, a Senswear® activity monitor was given to each patient and they were asked to wear it for five full days (including 2 weekend days) and collection of the monitor was arranged at either their manual introduction for the SPACE group or their first PR session. The patient's details were then passed on to another researcher (Vicki Warrington; VW) for randomisation to enable EH to be blinded as to which group each patient was recruited to.

Randomisation and Blinding

Patients were randomised into a group by using sealed envelopes. VW an unblended member of the clinical and research team completed the randomisation. If they were randomised into the hospital based pulmonary rehabilitation group they would be given an appointment to start PR the following week. If they were randomised into the SPACE for COPD group they were given an appointment for the following week for an introduction to the SPACE for COPD manual, how to use it, and prescription of their initial walking time and speed. This appointment was either in the patient's home or at Glenfield Hospital (the introduction to the SPACE for COPD manual is described in section 3.5, further on in the chapter). This appointment was completed by either Lindsay Apps (LA) or Katy Mitchell (KM) who were trained in motivational interviewing. Re assessment at seven weeks and six months were performed by a blinded member of the research team (EH and other team members on EH's absence) who were unaware of which group

they were in. Participants were advised not to inform the assessor which intervention they had received.

3.5 Intervention

3.5.1 Pulmonary Rehabilitation (PR) Programme

Patients recruited and randomised into the usual care hospital based group received a course of outpatient PR in the physiotherapy gym at Glenfield Hospital, University Hospitals of Leicester NHS Trust.

The PR programme lasts for 7 weeks and patients attend twice weekly. Each session is divided into an hour of supervised exercise and an hour of education. The exercise sessions comprise of aerobic and resistance exercise training. Patients are encouraged to walk daily at home on the days they do not attended their PR programme. Their aim is to increase the duration of their walk by 10 to 15 seconds each day. They were also advised to complete their strength training programme once per week at home. Home diaries are reviewed at the beginning of each PR and progression encouraged, however not documented in this study.

Exercise Sessions

Aerobic training

Each patient had an individually prescribed training programme including walking (figure 3.2) and cycling exercise. Training intensity was prescribed at 85% of predicted VO_2 peak from the ISWT (see section 3.6). Patients were

provided with a daily walking diary to record walking times and Borg breathlessness scores. Instructions were given about walking at the correct speed (intensity) and guidance given about increasing walking time. Walking speeds and times are checked weekly and time targets set for the following week. Each patient also completed 5 minutes on a cycle ergometer ensuring progression of intensity over the 7 weeks.

Fig 3.2 Patients completing their walking programme

Resistance training

Resistance training was completed once per week within the supervised session and patients were also encouraged to complete their programme once at home (a conversion table was given to them as to how much liquid is needed in a milk bottle for their prescribed weight; i.e. 2 pints = 1.2kg) . The programme consists of upper and lower body resistance training of the major muscle groups (figure 3.3). Resistance exercises included biceps curls, sit-to-stands, pull ups and step-ups. Each patient's resistance was individually

prescribed and were encouraged to complete three sets of eight repetitions. Patients recorded their progress over the seven weeks as well as their Borg breathlessness scores.

Figure 3.3 Patient completing his strength training programme

Education sessions

During each rehabilitation session patients received 1 hour of education. These sessions were delivered by members of the respiratory medical team and support services, including physiotherapists, occupational therapists, pharmacists, respiratory physicians, respiratory physiologists and health psychologists. The following topics were provided:

- Disease education
- Energy conservation
- Relaxation training
- Benefits of exercise
- Dietary and healthy eating advice

Medication advice

Chest clearance advice

Introduction to the respiratory physiology department

Introduction to Breathe Easy

Managing breathlessness

Avoidance and Exacerbations

Living with COPD

3.5.2 SPACE for COPD - Self-Management Manual

The Self-management Programme of Activity Coping and Education (SPACE for COPD) manual (figure 3.4) was developed by the multidisciplinary pulmonary rehabilitation team at Glenfield Hospital, Leicester. The aim of the manual is to help patients with COPD manage living with their chronic condition, and develop their self-management skills to control their symptoms, increase their physical activity levels and reduce the effect of their condition on their everyday life. The SPACE for CPOD manual is based on the PR programme delivered at Glenfield Hospital and is crystal marked by the Plain English Campaign to ensure clarity for a reading level of age 8 years.

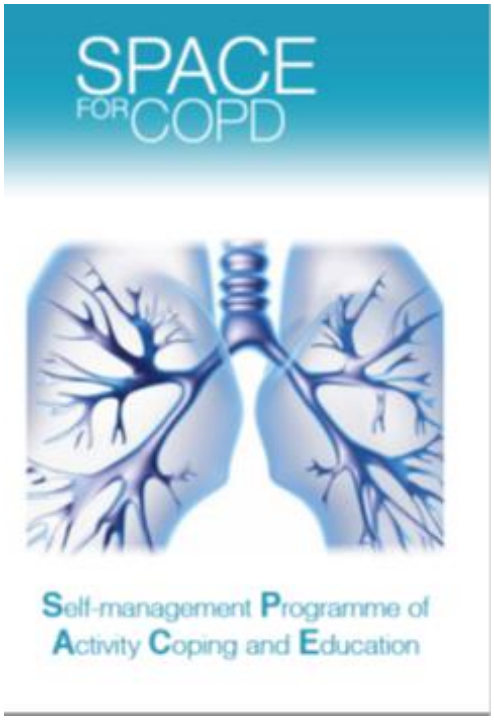


Figure 3.4 Front cover of the SPACE manual

The SPACE for COPD manual is divided into four stages including an exercise programme which progresses throughout the stages and a number of education topics. The manual also has a FAQ's (Frequently asked Questions), Appendix section and an action plan. The manual is designed for patients not only to be used as a reference but provides interactive sections for patients to complete to encourage engagement and adherence to the programme. The education part of each section can be dipped into as required and doesn't need to be read in order. Each section begins with the patients' exercise programme and includes advice about how to progress and keep motivated to exercise. 'Top tips' are also highlighted which offer useful advice and summaries on each topic. Each section also follows a number of case studies through their experiences of PR giving insight and reassurance to patients. There is no time period for each section and patients are

encouraged to progress at their own pace, but is designed for the average patient to reach stage 4 (Maintenance) in approximately 7 weeks.

Introduction to SPACE for COPD

The manual was explained to the patients highlighting to them the key areas it covered and also how to use it. The manual was introduced to the patient by a healthcare professional trained in motivational interviewing (MI) techniques to engage the patient in the process and to encourage adherence. MI aimed to facilitate behaviour change by identifying the individuals' willingness to participate in the SPACE for COPD programme, how important it was to them, how confident they were in taking part and any possible barriers. The duration of the MI was approximately one hour, but varied from patient to patient depending on their level of ambivalence (The healthcare professional spent longer with those with greater ambivalence). The exercise programme was then explained to the patient which was based on a daily walking programme in which the intensity / speed was prescribed from 85% of their maximal walking speed from the ISWT. Their walking time was initially set from the time they completed during the ESWT. It was suggested that they purchased a stopwatch and encouraged to build up their daily walking time by approximately 10-20 seconds a day. Patients who were only walking for short periods were encouraged to do a number of bouts of exercise per day. Exercise time and perceived exertion scores were recorded in their manual diaries. Strength exercises (Bicep curls, sit-to-stand, pull ups and step-ups) were also shown to the patient and an initial starting weight prescribed to them using a milk bottle conversion chart. Each strength exercise was done 3

times with 8 repetitions. Patients were encouraged to complete their strength exercises once they were familiar with their daily walking programme.

Telephone support

Patients were called twice during the 7 week programme, at week 2 and week 4 (schedule in Appendix E). Telephone calls were completed by LA or KM. Each time it was established if they were having any problems with the manual or their exercise programme. Their walking time was discussed and were encouraged to continue increasing their walking time. It was established if they had started their strength exercises and encouragement was also given to progress with this part of the programme. Any GP, hospital visits or medical problems were also recorded. During the second telephone call an appointment for the next assessment was made.

Content of the SPACE for COPD manual

Stage 1

Stage 1 of the SPACE manual gives patients some background information on their lung condition, covering how the lungs work, what causes the COPD, and how the condition is diagnosed and treated. It also introduces exercise training in terms of what is exercise and why everybody needs to participate in regular exercise and physical activity. It explains the components of an exercise session describing a warm-up, cool down and a number of stretching exercises. Patients were encouraged to read this stage before starting their exercise programme. The manual includes a walking diary (figure 3.5) and a number of interactive boxes to individually prescribe patients walking

programme and to highlight some walking targets with the aim to motivate. It explains how to progress with the exercise programme to achieve the aim of completing a total of 30 minutes of walking. In order for patients to judge whether they are working at their prescribed intensity a scale of 1 to 10 is provided with 1 being very easy and 10 being almost impossible. Patients are encouraged to walk at a pace that is moderate and that would score around 4-6. It also addresses barriers to exercise encouraging the patient to reflect and identify their own barriers and adherence issues to exercise and then to complete a goal setting exercise. Stage 1 concludes with some information on managing stress, Breathing control and medication. Sections of stage 1 are listed below:

What's happened to your lungs?

How to get fitter

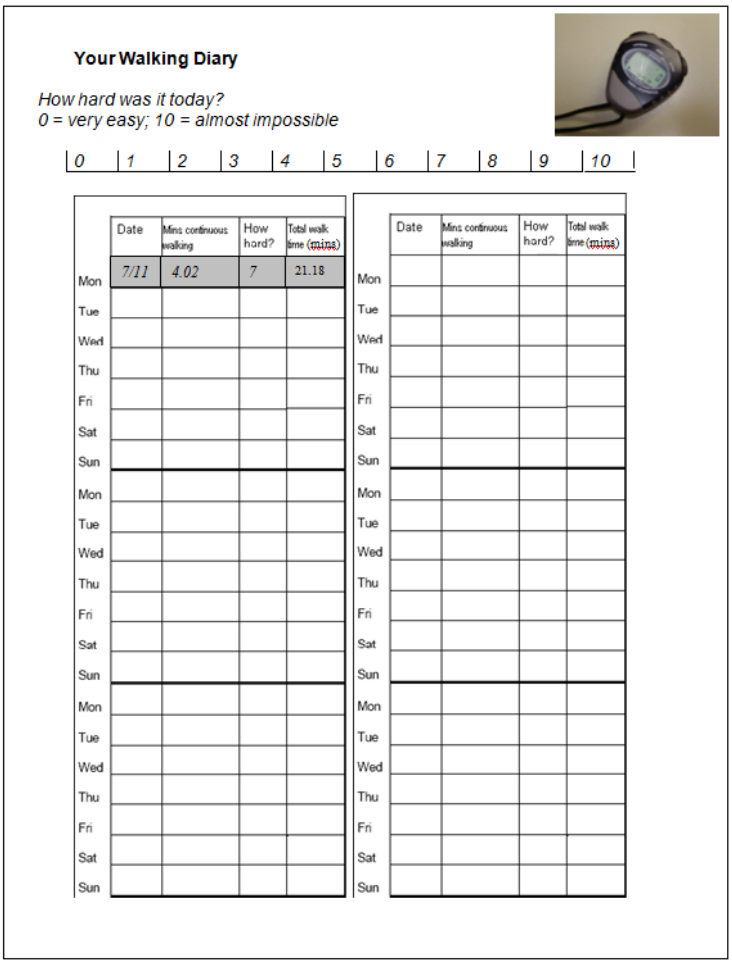
Setting your goals

Managing your stress

Your emotions

Controlling your breathing

Your medication



Your Walking Diary

How hard was it today?
0 = very easy; 10 = almost impossible

0	1	2	3	4	5	6	7	8	9	10

	Date	Mins continuous walking	How hard?	Total walk time (mins)
Mon	7/11	4.02	7	21.18
Tue				
Wed				
Thu				
Fri				
Sat				
Sun				
Mon				
Tue				
Wed				
Thu				
Fri				
Sat				
Sun				
Mon				
Tue				
Wed				
Thu				
Fri				
Sat				
Sun				

	Date	Mins continuous walking	How hard?	Total walk time (mins)
Mon				
Tue				
Wed				
Thu				
Fri				
Sat				
Sun				
Mon				
Tue				
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Thu				
Fri				
Sat				
Sun				
Mon				
Tue				
Wed				
Thu				
Fri				
Sat				
Sun				

Figure 3.5 Walking Diary from Stage 1 of the SPACE manual

Stage 2

The second stage aims to progress the patients exercise by increasing their total walk time with a target of walking 30 minutes in 1 session (figure 3.6). It provides a number of 'Top Tips' for people struggling to keep motivated to exercise regularly. In addition this stage covers how to avoid feeling unwell and what to do if an exacerbation occurs, how to identify a severe attack and what happens if they do have to go to hospital. Energy conservation is also addressed in this stage encouraging patients to become more aware of their daily routine and where they can save energy. The interactive boxes help

identify activities that they find difficult and some examples are given about how to make activities easier to manage (figure 3.6). This stage also gives advice on the right foods to eat when unwell and advice on clearing their chest.

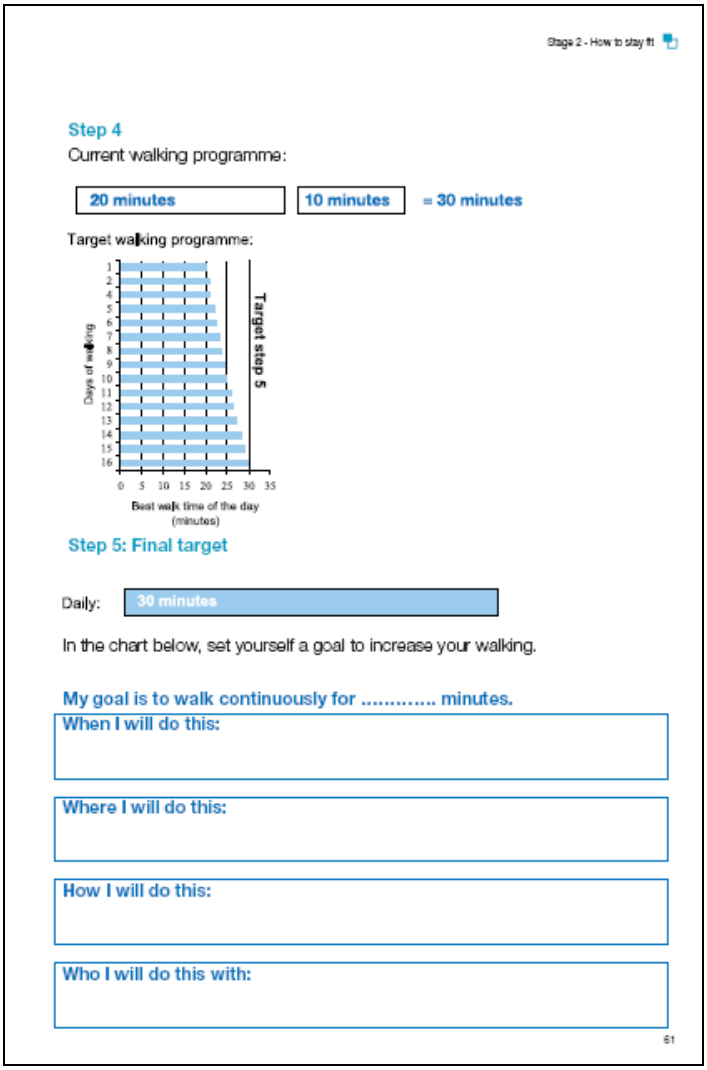


Figure 3.6 Example pages from stage 2 of the SPACE manual

The sections covered in stage 2 of the SPACE manual are listed below:

How to stay fit

Saving your energy

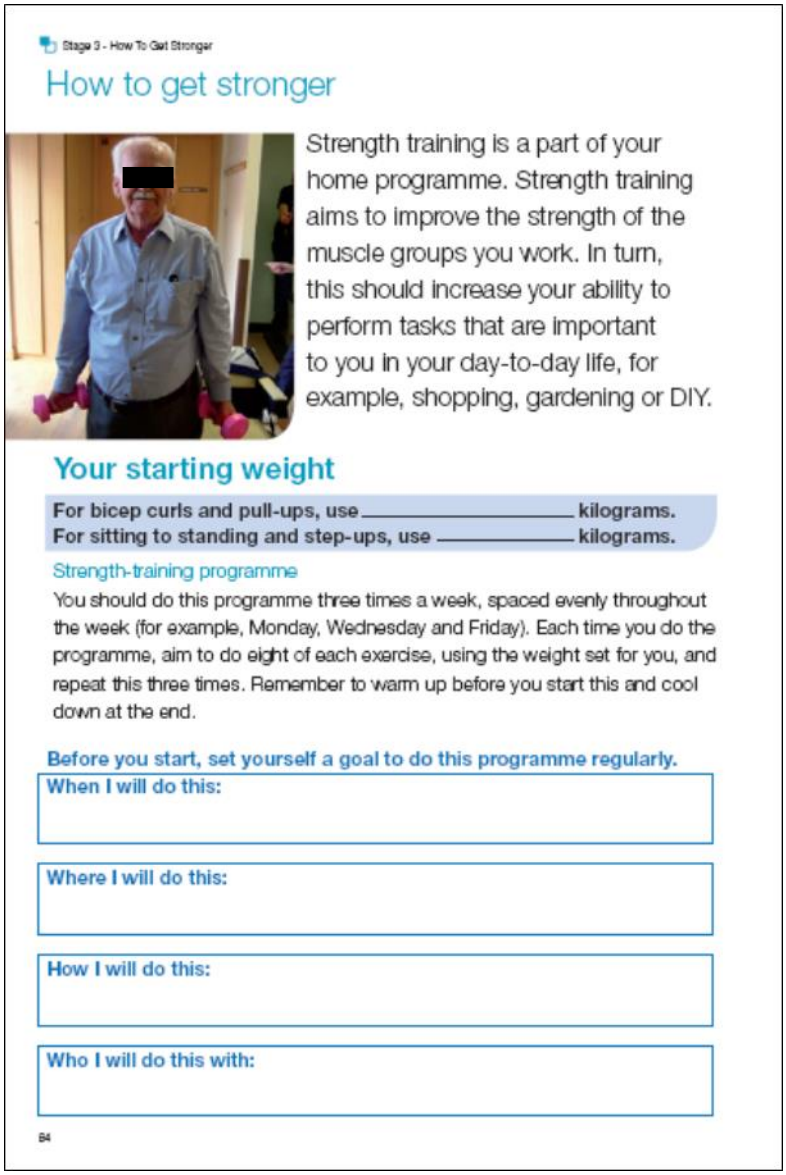
Avoiding and managing days when you feel unwell

The right foods when you feel unwell

Clearing your chest

Stage 3

Strength training is introduced in stage 3 (figure 3.7). Starting weights are prescribed to patients in their introductory session to the manual. Four exercises are advised; bicep curls, sit to stands, pull ups and step ups. A handy guide is provided to convert their prescribed weight to volume of water in milk containers so that they were not obliged to buy dumbbells. Top tips and advice are given about managing stress and some relaxation techniques are given. Goal setting is then addressed, reviewing if the patient had found anything that had made achieving their goal difficult or easy and a number of ideas are presented about how to overcome such obstacles. This stage also includes what comprises a healthy diet and some advice about travelling and going on holiday.



Stage 3 - How To Get Stronger

How to get stronger

Strength training is a part of your home programme. Strength training aims to improve the strength of the muscle groups you work. In turn, this should increase your ability to perform tasks that are important to you in your day-to-day life, for example, shopping, gardening or DIY.

Your starting weight

For bicep curls and pull-ups, use _____ kilograms.
For sitting to standing and step-ups, use _____ kilograms.

Strength-training programme

You should do this programme three times a week, spaced evenly throughout the week (for example, Monday, Wednesday and Friday). Each time you do the programme, aim to do eight of each exercise, using the weight set for you, and repeat this three times. Remember to warm up before you start this and cool down at the end.

Before you start, set yourself a goal to do this programme regularly.

When I will do this:

Where I will do this:

How I will do this:

Who I will do this with:

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Fig 3.7 How to get stronger from stage 3 of the SPACE manual

Stage 3 covers the topics listed below:

How to get stronger

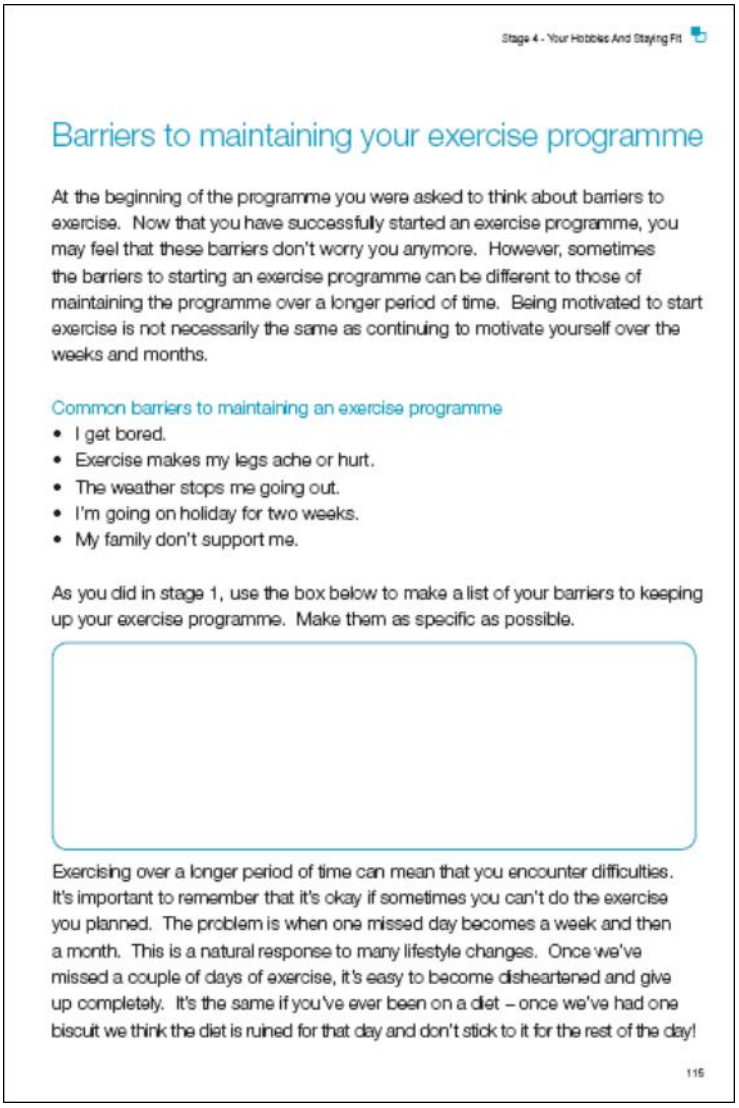
Managing your stress

Healthy eating

Travelling and your lung disease

Stage 4

Once the patients are completing 30 minutes of walking a day, they moved onto stage 4 which focuses on how to maintain improvements in their walking programme. The manual encourages patients to highlight any barriers they have found in completing the walking programme (figure 3.8) and they are prompted to address how these barriers could be overcome. Returning to other sports and hobbies that patients had previously enjoyed are dealt with encouraging patients to draw up an action plan of how to being these activities again. Also included in this section is coping with changing relationships with family members and friends, how to deal with setbacks and sexual relationships. This section includes a number of quotes and case studies from patients who have previously gone through PR with advice given and some suggested links to other parts of the manual (figure 3.8). Stage 4 concludes with information about Breath Easy which a support group for anyone with a lung condition.



Stage 4 - Your Hobbies And Staying Fit

Barriers to maintaining your exercise programme

At the beginning of the programme you were asked to think about barriers to exercise. Now that you have successfully started an exercise programme, you may feel that these barriers don't worry you anymore. However, sometimes the barriers to starting an exercise programme can be different to those of maintaining the programme over a longer period of time. Being motivated to start exercise is not necessarily the same as continuing to motivate yourself over the weeks and months.

Common barriers to maintaining an exercise programme

- I get bored.
- Exercise makes my legs ache or hurt.
- The weather stops me going out.
- I'm going on holiday for two weeks.
- My family don't support me.

As you did in stage 1, use the box below to make a list of your barriers to keeping up your exercise programme. Make them as specific as possible.

Exercising over a longer period of time can mean that you encounter difficulties. It's important to remember that it's okay if sometimes you can't do the exercise you planned. The problem is when one missed day becomes a week and then a month. This is a natural response to many lifestyle changes. Once we've missed a couple of days of exercise, it's easy to become disheartened and give up completely. It's the same if you've ever been on a diet – once we've had one biscuit we think the diet is ruined for that day and don't stick to it for the rest of the day!

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Figure 3.8 Barriers to exercise from stage 4 of the SPACE manual

Stage 4 focuses of the topics below:

Your hobbies and staying fit

Your relationships

Dealing with setbacks

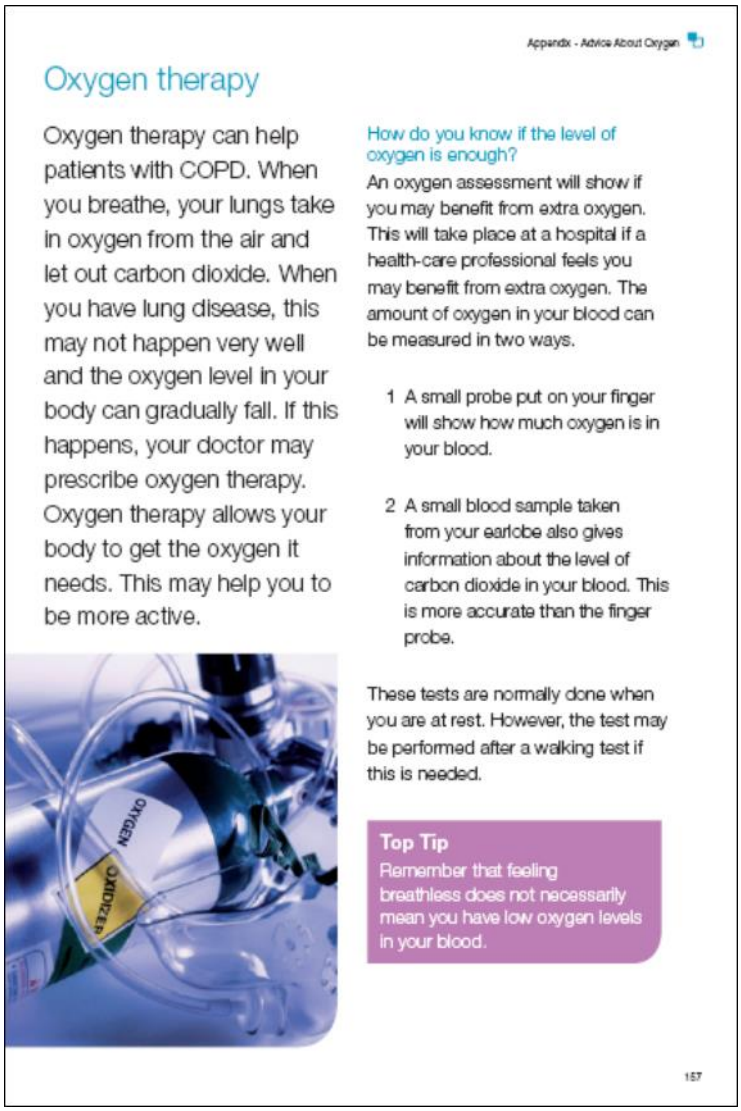
Sex and your lungs

Breathe easy

Conclusion

FAQs and Appendix

This section includes frequently asked questions, addition information; such as how to set your walking speed (in miles per hour as well as kilometres per hour), types of activities that could be completed for the different speeds of walking, spare walking and strength training diaries, and information that may be useful to only a proportion of the patients, for example oxygen therapy, smoking cessation and medication (figure 3.9).



Appendix - Advice About Oxygen

Oxygen therapy

Oxygen therapy can help patients with COPD. When you breathe, your lungs take in oxygen from the air and let out carbon dioxide. When you have lung disease, this may not happen very well and the oxygen level in your body can gradually fall. If this happens, your doctor may prescribe oxygen therapy. Oxygen therapy allows your body to get the oxygen it needs. This may help you to be more active.

How do you know if the level of oxygen is enough?

An oxygen assessment will show if you may benefit from extra oxygen. This will take place at a hospital if a health-care professional feels you may benefit from extra oxygen. The amount of oxygen in your blood can be measured in two ways.

1 A small probe put on your finger will show how much oxygen is in your blood.

2 A small blood sample taken from your earlobe also gives information about the level of carbon dioxide in your blood. This is more accurate than the finger probe.

These tests are normally done when you are at rest. However, the test may be performed after a walking test if this is needed.

Top Tip
Remember that feeling breathless does not necessarily mean you have low oxygen levels in your blood.

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Figure 3.9 Appendix section of the SPACE manual

The FAQs and Appendix is divided into the following section:

Frequently asked questions

Setting your walking speed

Advice about oxygen

Help for carers

Smoking: advice on giving up

Information about your medication

Spare walking diaries

Spare strength training diaries

At the back of the SPACE manual is a one page action plan (Appendix F) for patients to use as a quick reference. It includes spaces for patients to put information about their condition, their GP contact details and a list of their medication. It gives advice about how to determine if they are having a moderate or severe exacerbation, a sputum colour chart is included to aid this decision and what to do in each of those situations.

3.6 Outcome measures

Outcome measures were assessed before the commencement and immediately after completion of either the seven week PR programme or home based SPACE for COPD programme. Each patient was then assessed six months after completion. The outcome measures can be divided into three main categories: Health status, exercise performance and daily physical activity.

Health Status

Chronic Respiratory Questionnaire – Self Report (CRQ-SR; Williams et al. 2001; Williams et al. 2003; Appendix G).

This is a reliable and valid measure of health status in patients with COPD. The CRQ-SR consists of 20 questions and is completed by the patient. The questions are categorised into four domains: dyspnoea, fatigue, emotional functioning and mastery. Responses reflect the patient's experiences in the previous two weeks. Higher scores reflect a 'better' status. The dyspnoea scale is individualised where they are required to identify five activities that have made them breathless in the past two weeks and then rate that level of breathlessness on a seven point scale. Higher scores indicate more favourable HRQoL (Health Related Quality of Life), and a change in the domain score of ≥ 0.5 has been identified as being clinically significant (Jaeschke, Singer and Guyatt 1989). The dyspnoea domain of the CRQ was used as the primary outcome measure.

Hospital Anxiety and Depression Scale (HADs; Zigmond and Snaith 1983; Appendix H)

This is a questionnaire that measures psychological status. It consists of fourteen questions; seven contribute to anxiety scores and seven to depression. Each question is scored from 0 to 3. Scores from each of the questions in each domain are added together to give a score for anxiety and depression, high scores indicate poor psychological state. The authors report that scores above 10 are indicators of a clinical significant level of anxiety or depression.

Pulmonary Rehabilitation Adapted Index of Self-Efficacy (PRAISE: Vincent et al. 2006; Appendix I)

This questionnaire measures self-efficacy in patients with COPD undergoing PR. It consists of 15 statements, to which the respondent has to respond to how much they agree with on a scale from 1 to 4 (1 = not at all true, 2 = hardly true, 3 = moderately true, 4 = exactly true). Each score is added together to give a total score of self-efficacy. Higher score indicate higher self-efficacy.

Exercise performance

Incremental Shuttle Walk Test (ISWT: Singh et al. 1992)

This is a maximal field based walking test of exercise performance validated in COPD. All procedures for the test were completed according to the standardised instructions. Patients were required to walk around a 10 meter course at a speed paced by an audio signal. Every minute during the test the speed increased. The aim of the test was for the patient to continue until they were too breathless or fatigued to continue or could no longer maintain the required speed. Each patient completed 2 ISWT, the first a practice walk and the second, from which the results were recorded. Sufficient rest was allowed between each test to allow heart rate to return to resting levels. Results from the test are measured in metres (i.e. number of shuttles completed). Resting and post exercise heart rate and oxygen saturation were recorded using a portable pulse oximeter with finger probe (PULSOX-3: Konica Minolta, Osaka, Japan). Borg ratings of perceived exertion and breathlessness scores were also taken post-test (Borg 1982).

Endurance Shuttle Walk Test (ESWT: Revill et al. 1999)

This is a sub-maximal field based walking test of exercise performance also validated in COPD. It was completed after the ISWT according to the standardised instructions. Again sufficient rest was allowed between the ISWT and the ESWT to allow heart rate to return to resting levels. The test follows a similar procedure to the ISWT where patients walk around a 10 meter course at a speed dictated by an audio signal. For this test the walking pace was constant. Following a warm up period of 1 minute 30 seconds, patients walked at a constant speed which had been calculated at 85% of their predicted VO_2peak estimated from the ISWT. This was determined using a regression equation. The aim of the test was to continue walking until the patient was too breathless or fatigued, could not keep up with the set walking pace or had reached the end of the 20 minute test. Resting and post exercise heart rate and oxygen saturation were recorded. Resting and post-test Borg breathlessness and perceived exertion scores were also obtained. The ESWT is measured in seconds (excluding the warm up). A score of zero was recorded if a patient was unable to complete the warm up.

Daily physical activity

During the consent appointment patients were asked if they would be willing to wear the SenseWear® armband (SWM; BodyMedia, Pittsburg, US, figure 3.10) for 5 days (reproducibility and sensitivity of which is presented in chapter 4). Patients were given instruction on how to use the monitor (chapter 4) and wore it for 5 day including 2 weekend days from waking to retiring in the evening (figure 3.10). Patients were required not to wear the

SWM during personal hygiene activities or if they went swimming. Arrangements for the collection of the SWM were then made.

Figure 3.10 The SenseWear Armband

Data from the SWM was downloaded using the InnerView™ software (figure 3.11) as described in chapter 4. Patient characteristics were loaded into the data file so that energy expenditure could be estimated. For each day recorded, total and 12 hour data was extracted from the SWM. The MET value was also customised to the prescribed level for each patient in order to identify how long and how many calories the patient had expended within their prescribed activity level. The follow data was recorded from each patient;

- Total time SWM worn
- Total daily step counts
- Total time <2 METs (sedentary)
- Total time 2-3 METs (light physical activity: LPA)
- Total time 3-6 METs (moderate to vigorous physical activity: MVPA)
- Total time 6+ METs (vigorous activity)

- Total energy expenditure above 3 METs

The 10 minute bout data was calculated by exporting the minute by minute data from the professional software into excel. A formula was used to add up the time spent in moderate activity of at least 10 minutes duration.

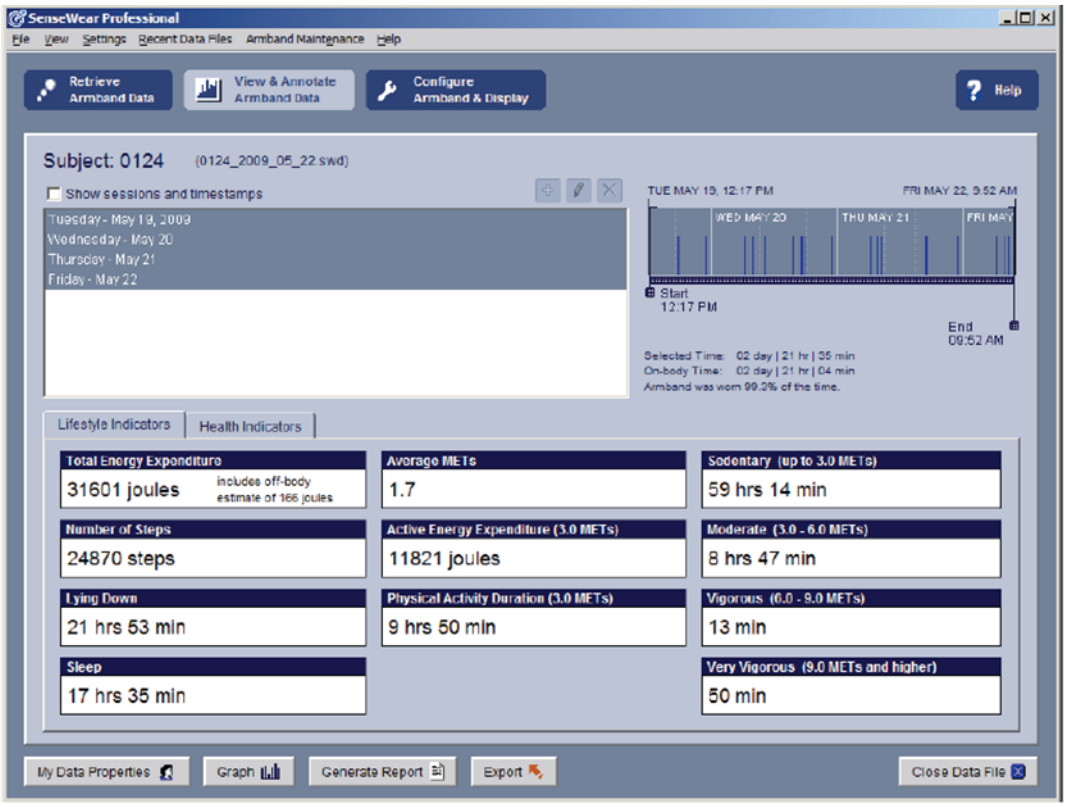


Figure 3.11 Example of the Sensewear professional output.

The analysis of the physical activity component of this study is fully described in chapter 7.

3.6 Statistical analysis

Power calculation

Advice on the sample size was taken from Statistics Advisory Service at Coventry University at the point of the protocol being written. The primary outcome measure was dyspnoea from the CRQ-SR questionnaire at seven weeks. A difference of 0.5 has been recognised as the minimum clinically important difference to detect change (Jaeschke, Singer and Guyatt 1989), with a common SD of 1.1 (Sewell et al. 2006). By using these values in the sample size calculation to assess noninferiority, with an alpha level of 0.025, and a 1 sided test with 80% power, the required sample size was 77 per group. Based on an attrition rate of 15% typically seen in the Glenfield hospital PR group, 89 patients per group were targeted for recruitment. This figure was subsequently increased as drop-out rate experienced was higher than anticipated.

Data Analysis

Data was analysed using IBM SPSS statistics 20. An intention to treat and per protocol analysis was completed at seven weeks. SPSS was used to impute missing data. This was a pragmatic trial and therefore a pre-specified definition of compliance to the intervention protocol was not stated. This results in only an intention to treat analysis being completed. All tests of statistical significance were 2-sided, therefore the level of significance was set

at $p<0.05$. All data was assessed for normality so that appropriate parametric or non-parametric tests could be conducted. Normally distributed data are described as mean and standard deviation and non-normally distributed data and categorical data are described as median, frequency or percentage.

For the primary outcome measure, CRQ-SR dyspnoea score, within group differences from baseline and 95% confident intervals (CI) are presented. The secondary outcome measures were analysed in the same way. Previously reported minimally clinical important difference (MCID) was 0.5 units for each of the 4 CRQ-SR domains (Jaeschke, Singer and Guyatt 1989), 1.5 units for the HADs (Zigmond and Snaith 1983), 48m for the ISWT (Singh et al. 2008) and 186 seconds for the ESWT (Pepin et al. 2011). The MCID was used as the noninferiority margin for each outcome measure. In order to declare noninferiority the mean change (difference in SPACE minus difference in PR) and the 95% CI must not breach this margin.

Within group differences at seven weeks were analysed with a paired t test and between group differences at seven weeks were analysed using independent t tests. Correlations between variables were explored using a Pearson's correlation.

At six months between group differences and within group differences were analysed using repeated measures of analysis of variance (ANOVA).

Chapter 4 - Reproducibility, Sensitivity and Validity of Activity Monitors

4.1 Introduction

Daily physical activity (PA) levels in patients with COPD is low (Pitta et al. 2005a, Watz et al. 2009) and has been associated with hospitalization and mortality (Garcia-Aymerich et al. 2006, Waschki et al. 2011). The aim of PR is to improve exercise capacity and increase daily PA (Bolton et al. 2013) and hence enhance health status. PA is a central focus for PR and therefore the ability to monitor it is necessary in determining the effectiveness of clinical practice. In regards to this thesis it is also essential that an accurate measure of PA is available to determine if the SPACE for COPD programme is effective at increasing PA and is sensitive to detect subtle changes in PA levels.

Although the pedometer has been shown to be reliable in providing a step count for patients with COPD, it may not be as accurate as it is in healthy individuals (Schönhofer et al. 1997, Tudor-Locke et al. 2002). Moreover, pedometers may not be sufficiently sensitive to detect step performance at slow walking speeds (Turner et al. 2012) .

Accelerometers are more sophisticated and sensitive devices which measure motion in more than one plane (bi-axial or tri-axial). In addition to step count

accelerometers are able to measure and quantify levels and durations of PA in terms of energy expenditure (EE: kcals) and metabolic equivalents (METs).

Various PA monitors are commercially available but the multi-sensor activity monitor, SenseWear Pro 2 Armband (SWM) has recently been found to have the greatest validity when compared to other activity monitors during standardized bouts of PA (Van Remoortel et al. 2012).

The SWM has been described as being a reliable and valid way of monitoring step count and EE in patients with COPD during standard exercise tests such as the ISWT and 6MWT (Patel et al. 2007). However, due to cumulative reporting of data it is not confirmed whether the monitors can detect slow speeds of walking. It is known that patients with COPD sacrifice speed of walking for duration (Evans et al. 2011), yet there is still uncertainty as to the ability of the SWM to accurately detect steps and EE at very slow walking speeds (less than 3.27 km.hr (Hill et al. 2010, Van Remoortel et al. 2012)) which are commonly adopted by individuals with COPD.

The data presented in this chapter contributed to the paper published in Heart and Lung (Harrison et al. 2013a)

4.2 Aim

Daily physical activity is a key outcome of this study and therefore, it is essential to have a reliable measure to detect changes in activity during the randomised control trial that can be attributed to the intervention and not any

monitor errors. There were nine SWMs available for this study and it was important to determine if each monitor was equivalent to one another so monitors could be used interchangeably. Therefore, the aims of this chapter were to assess the SWM for:

1. Reproducibility of different SWMs over 5 repeat tests at a given speed
2. Between monitor reproducibility at a given speed
3. The ability of the monitors to discriminate between speeds of walking
4. Validity with indirect calorimetry at a given speed

4.3 Methods

The protocol required the subject to complete a large number of assessments at speeds varying from slow to fast and also to wear a face mask for a number of assessments, therefore it was completed on a healthy adult.

Subjects

A healthy female subject (EH: 33 yrs, 1.74m, 57kg) completed all the test-retest and indirect calorimetery assessments of the SWM.

Ethical approval

All procedures for the experimental methods were approved by Coventry University Ethics Committee, approval no. S12.07 (Appendix J).

SenseWear® Pro_2 Armband

The SenseWear® Pro_2 Armband (SWM; BodyMedia®, Inc., Pittsburgh, USA) is a commercially available device to estimate energy expenditure. It is worn on the back of the upper right arm over the triceps muscle mid way between the acromion and the olecranon processes. The SWM contains a biaxial accelerometer (longitudinal and transverse planes) and collects physiological data via a number of sensors (skin temperature, heat flux, near-body ambient temperature and galvanic skin response). It has a mark button on the front to highlight set time points. Demographic characteristics (gender, age, height and weight) are also required to be programmed into the device to estimate energy expenditure using a generalized propriety equation (InnerView™ Software Version 6) developed by the manufacturer. A view of the data output window is presented in figure 4.1. From this screen data can be manipulated to look at specific times, for example, between two marked time points.

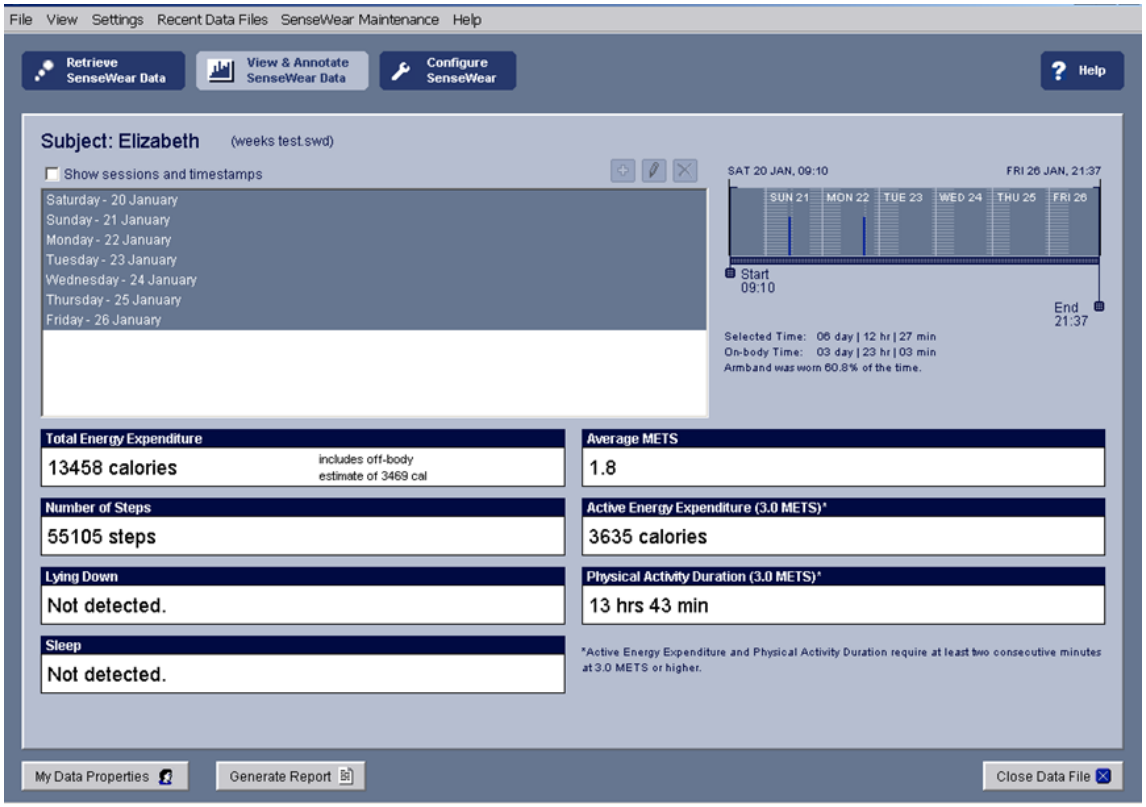


Figure 4.1 InnerView™ Software

Experimental methods

The subject wore a heart rate monitor (Polar Accurex Plus™, Finland) and a SWM for each of the tests. The heart rate monitor was worn to ensure recovery was achieved between consecutive walk tests and was not used for analysis. The SWM (figure 4.2) was worn for 15 minutes before data collection to allow acclimation to skin temperature. On separate occasions, nine different SWM's were worn by the subject. For each SWM, the subject performed five, five minute bouts of walking, at five different speeds in random order paced by the signals from the endurance shuttle walk test (ESWT;1.78, 2.44, 3, 4.65 and 6km.hr), which is commonly used as an outcome measure for COPD patients. The ESWT has been shown to be a valid method of

estimating endurance capacity in COPD patients (Revill et al. 1999). Speed 2.44km.hr was not completed on monitor 1 as this speed was not added to the protocol until this monitor had been completed. The walking course was a standard 10m shuttle distance with constant walking speeds determined by an audio signal. During one of the 5 trials with each of the SWM expired gases were collected and analysed to calculate energy expenditure via indirect calorimetry. A portable gas analysis system (Cosmed K4b^2; COSMED, Rome, Italy) was used to measure minute-by-minute oxygen uptake and the respiratory exchange ratio (RER). Energy expenditure (kcal.min^{-1}) was calculated by multiplying the oxygen uptake (L.min^{-1}) by the caloric equivalent based on the RER. The walks completed whist wearing the gas analysis equipment were completed over 7 minutes and only the last 5 minutes analysed to allow a physiological steady state to occur. In order to ensure measurement periods were synchronized both the SWM and the metabolic cart were time marked. During each trial, EE and step count were recorded for each minute.

Figure 4.2 The SenseWear Armband

4.4 Outcome Measures

Energy expenditure was recorded from the activity monitor and indirect calorimetry. Step count was also used from the activity monitors.

4.5 Statistical analysis

As the data was not normally distributed, non-parametric statistical tests were utilized. Analysis was completed on the step counts and the estimated energy expenditure for the within and between monitor data. Descriptive statistics are presented to display within monitor variation of the five tests, at five different speeds (mean ± standard deviation (SD), ninety-five percent confidence intervals (95% CI), and the coefficient of variation (CV)). The CV is a measure of the relative variation of distribution, independent of the unit of measurement. It is calculated by dividing the standard deviation by the mean and is expressed as a percentage. Acceptable variability is considered to be <5%. 95% CI and CV is used as an indicator of the reproducibility of a measure.

A non-parametric Kruskal-Wallis test (with post-Hoc Mann-Whitney U tests) was used to assess between reproducibility and to explore if all monitors could distinguish between the five speeds of walking.

The agreement between measures were analysed using a Bland and Altman (1986) plot.

4.6 Results

Within monitor Reproducibility

Data was recorded every minute during each of the five minute trial, each trial was repeated five times, therefore, 25 data points were collected for each monitor at each speed. However, 2.44km/hr was not completed in monitor 1. The mean value represents the average step count or EE collected in one minute for each trial. The descriptive statistics for the within monitor data for steps is shown in table 4.1 and figure 4.3 and for EE in table 4.2 and figure 4.4. The mean data presented in table 4.1 and 4.2 represents the mean minute by minute data calculated by averaging each individual minute of each of the five trials (five minutes, five trials, therefore a mean of 25 data points).

Table 4.1 Descriptive statistics and within monitor variation for step counts

Monitor	*Speed (km.hr)*	*Mean (SD)*	*95%CI*	*CV %*
1	1.78	39.67 (9.86)	27.42 to 51.97	24.86
1	3	85.4 (3.36)	81.23 to 89.75	3.93
1	4.56	106.27 (2.39)	103.30 to 109.23	2.25
1	6	120.73 (6.67)	112.45 to 129.01	5.52
2	1.78	36.2 (11.98)	21.32 to 51.08	33.09
2	2.44	75.17 (1.65)	60.36 to 89.97	2.20
2	3	82.85 (4.81)	76.88 to 88.84	5.81
2	4.56	104.53 (7.17)	95.62 to 113.44	6.86
2	6	118 (13.83)	100.83 to 135.17	11.72
3	1.78	21.93 (4.43)	16.44 to 27.43	20.20
3	2.44	69.53 (14.72)	51.25 to 87.81	21.17
3	3	73.87 (9.12)	62.54 to 85.20	12.35
3	4.56	102.47 (5.05)	96.19 to 108.75	4.94
3	6	109.27 (16.52)	88.75 to 129.78	15.12
4	1.78	23.8 (15.12)	5.03 to 42.57	63.53
4	2.44	67.4 (7.14)	58.54 to 76.26	10.59
4	3	83.07 (5.86)	75.80 to 90.34	7.05
4	4.56	106.20 (2.71)	102.83 to 109.57	2.55
4	6	122.07 (5.75)	114.93 to 129.20	4.71
5	1.78	28.20 (8.69)	17.41 to 38.99	30.82
5	2.44	68.89 (3.40)	60.43 to 77.34	4.94
5	3	79.60 (3.49)	75.26 to 83.94	4.38
5	4.56	106.60 (1.48)	104.76 to 108.43	1.39
5	6	121.00 (7.87)	111.23 to 130.78	6.50
6	1.78	26.13 (11.15)	12.30 to 39.97	42.67
6	2.44	68.50 (5.9)	15.52 to 121.48	8.61
6	3	84.20 (1.54)	82.29 to 86.11	1.83
6	4.56	108.33 (2.13)	105.68 to 110.98	1.97
6	6	120.40 (6.23)	112.66 to 128.13	5.17

Monitor	*Speed*	*Mean ± SD*	*95%CI*	*CV%*
7	1.78	32.40 (10.72)	19.08 to 45.71	33.09
7	2.44	69.00 (1.23)	67.48 to 70.52	1.78
7	3	80.87 (4.11)	75.77 to 85.97	5.08
7	4.56	97.60 (17.93)	75.34 to 119.86	18.37
7	6	100.40 (46.67)	42.44 to 158.35	46.48
8	1.78	31.73 (11.8)	17.08 to 46.39	37.19
8	2.44	71.07 (3.81)	66.33 to 75.80	5.36
8	3	83.74 (3.88)	78.92 to 88.55	4.63
8	4.56	103.33 (5.01)	100.11 to 112.55	4.85
8	6	120.33 (1.73)	118.18 to 122.48	1.44
9	1.78	33.93 (6.59)	25.74 to 42.12	19.42
9	2.44	69.53 (6.13)	61.92 to 77.15	8.82
9	3	80.73 (3.02)	76.98 to 84.48	3.74
9	4.56	99.6 (20.47)	74.18 to 125.02	20.55
9	6	113 (20.54)	87.49 to 138.5	18.18

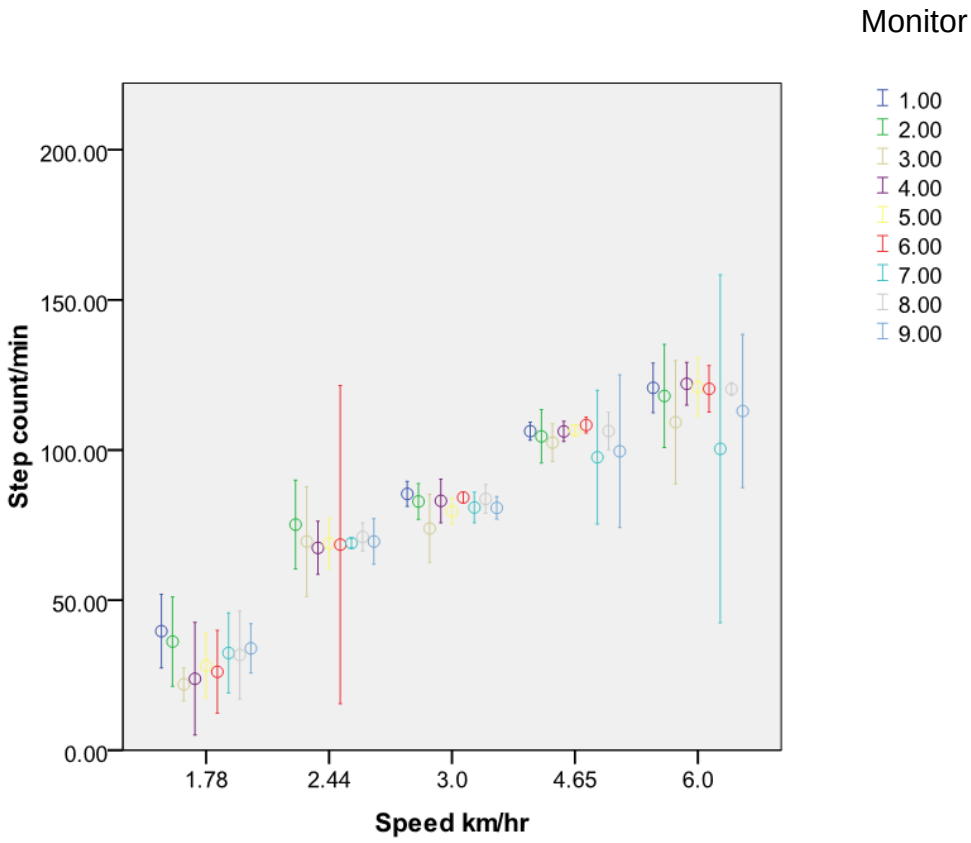


Figure 4.3 Monitor reproducibility for steps at the 5 different speeds of the ESWT (mean ± 95% CI)

Figure 4.3 shows step counts increasing with increasing speed. Monitor 6 at speed 2.44km.hr and monitor 7 at 6km.hr have larger 95% CI than the other monitors and other speed. One of the five walks at 2.44km/hr in monitor 6 had a very high mean step count (120 steps/min), and monitor 7 also had one outlying reading from one of the five walk tests. This reading (monitor 7) was lower than the other four at a mean of 18 steps/min. Each of these single readings account for the high 95% CI. For each of the SWM's SD also increases as the speed increases. This increase in the variability of the measure as speed increases is also reflected in the 95% CI and the CV (table

4.1). The CV is highest at the slowest speed of 1.78km.hr in the majority of the monitors and all monitors demonstrate unacceptable variability at this speed. Monitors 2, 3, 7 and 9 also high values for CV at the highest speed of 6km.hr, with monitor 7 having a CV value of 46.48%. However, monitor 8 has its lowest CV at 6km.hr of 1.44%. The middle speed of 2.44, 3 and 4.56km.hr tend to have CV values that are acceptable with the majority being below 5%.

Table 4.2 Descriptive statistics and within monitor variation for energy expenditure.

Monitor	*Speed (km.hr)*	*Mean (SD)*	*95%CI*	*CV%*
1	1.78	13.24 (7.07)	4.46 to 22.02	53.40
1	3	14.28 (1.51)	12.40 to 16.16	10.57
1	4.56	13.52 (2.31)	10.64 to 16.4	17.09
1	6	17.52 (1.58)	15.55 to 19.49	9.02
2	1.78	10.96 (4.38)	5.52 to 16.4	39.96
2	2.44	10.90 (0.71)	4.55 to 17.25	6.51
2	3	14.08 (2.33)	11.19 to 16.97	16.55
2	4.56	14.28 (4.00)	9.37 to 19.19	28.01
2	6	21.24 (3.20)	17.27 to 25.21	15.07
3	1.78	11.96 (4.44)	6.45 to 17.48	37.12
3	2.44	13.00 (3.66)	8.45 to 17.55	28.15
3	3	14.44 (1.88)	12.10 to 16.78	13.02
3	4.56	15.44 (3.91)	10.58 to 20.30	25.32
3	6	19.36 (4.88)	13.30 to 25.41	25.21
4	1.78	16.56 (5.08)	10.26 to 22.86	30.68
4	2.44	11.48 (1.90)	9.12 to 13.84	16.55
4	3	14.08 (2.00)	12.00 to 16.56	14.2
4	4.56	13.76 (2.37)	10.82 to 16.70	17.22
4	6	19.16 (3.78)	14.46 to 23.86	19.73
5	1.78	15.00 (4.17)	9.82 to 20.17	27.8
5	2.44	11.20 (1.60)	7.22 to 15.17	14.29
5	3	12.48 (0.81)	11.48 to 13.48	6.49
5	4.56	14.40 (2.16)	11.72 to 17.08	15
5	6	18.00 (2.05)	15.46 to 20.55	11.39

Monitor	*Speed*	*Mean ± SD*	*95%CI*	*CV%*
6	1.78	9.40 (3.72)	4.78 to 14.02	39.57
6	2.44	9.90 (0.42)	6.09 to 13.71	4.24
6	3	13.24 (1.57)	11.29 to 15.19	11.86
6	4.56	15.4 (2.1)	12.79 to 18.01	13.64
6	6	17.44 (2.7)	14.04 to 20.84	15.48
7	1.78	12.56 (6.61)	4.35 to 20.76	52.63
7	2.44	10.80 (2.26)	7.99 to 13.61	20.93
7	3	13.44 (2.35)	10.52 to 16.36	17.49
7	4.56	14.88 (4.70)	9.04 to 20.72	31.59
7	6	25.40 (12.83)	9.47 to 41.33	50.51
8	1.78	9.36 (3.44)	5.09 to 13.63	36.75
8	2.44	10.96 (1.49)	9.12 to 12.81	13.59
8	3	12.24 (0.82)	11.22 to 13.25	6.7
8	4.56	14.48 (2.87)	10.91 to 18.05	19.82
8	6	15.96 (1.23)	14.44 to 17.48	7.71
9	1.78	10.32 (3.64)	5.80 to 14.84	35.27
9	2.44	12.16 (2.61)	8.93 to 15.40	21.46
9	3	14.92 (4.35)	6.51 to 20.32	29.16
9	4.56	14.08 (1.25)	12.52 to 15.64	8.88
9	6	21.76 (7.02)	13.05 to 30.47	32.26

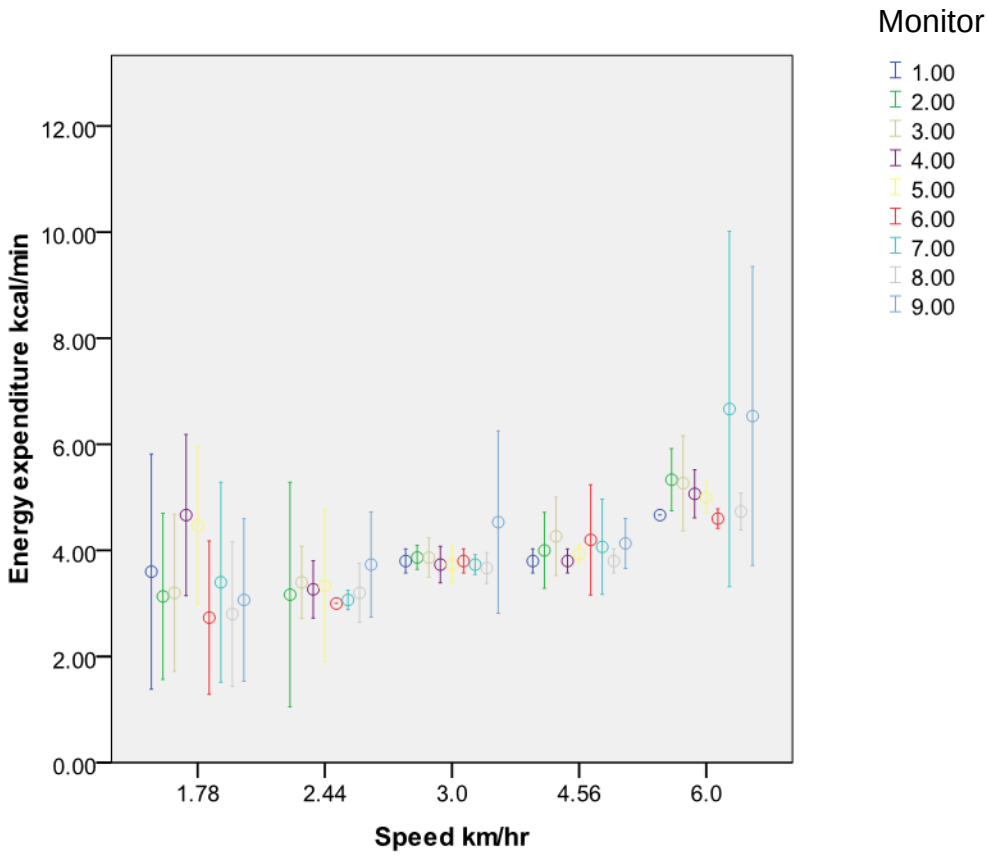


Figure 4.4 Monitor reproducibility for energy expenditure at the 5 different speeds of the ESWT (mean ± 95% CI)

Figure 4.4 shows the reproducibility of the 9 SWM's at increasing speeds when measuring EE. The slowest speed of 1.78km.hr shows a larger 95% CI in all of the monitors compared to the other speeds, indicating lower reliability in these measures. At the fastest speed of 6km.hr monitors 7 and 9 have also got high 95%CI. Monitor 7 has one of the five walk at 6km.hr reporting a mean EE of double the other readings (47.4 kcal.min^{-1}). Monitor 9 also reported one of the five walks to be higher than the others at a mean of 33.6kcal.min. Table

4.2 shows high CV in all the 9 SWM's, with only monitor 6 at 2.44km.hr having an acceptable value of 4.24%.

Summary of within monitor reproducibility

In general, the 9 SWM's do demonstrate higher step counts and EE at increasing speeds (figures 4.3 and 4.4). However, SD, 95% CI and CV is consistently higher at the lowest speeds of 1.78km.hr for both step count and EE. The highest speed of 6km.hr also show high variability in a number of monitors. The middle range of speeds (2.44, 3, 4.56km.hr) demonstrate more acceptable values for 95% CI and CV. However, the data suggest that there is improved reproducibility when using step counts in comparison to EE (data not shown).

Between monitor reproducibility

As the data was not normally distributed, non-parametric statistical analysis was chosen. Kruskal-Wallis analysis indicated there was no significant difference between each monitor at a given speed for both step counts and EE. This suggesting good between monitor reproducibility and equivalent values generated at each speed.

Sensitivity

A Kruskal-Wallis test was also completed on the data reported by each monitors to determine if they could distinguish between each speed. When considering EE monitors 2, 5, 6, 7, 8, and 9 could distinguish between each of

the speeds (Table 4.3). Post Hoc Mann-Whitney U test revealed monitors 1, 3 and 4 could not distinguish between each of the speeds show in table 4.3. The Kruskal-Wallis test for sensitivity in step counts at different speeds revealed each monitor to be able to distinguish between each speed (all P=<0.001).

Table 4.3 Monitor sensitivity when measuring EE

Monitor	***Significance (P)***	***Speeds monitors can't distinguish between (Post Hoc test)***
1	NS	3 and 6 km/r; 4.56 and 6 km/hr
2	0.014	
3	NS	3 and 6 km/hr
4	NS	2.44 and 6 km/hr; 3 and 6 km/hr; 4.56 and 6 km/hr
5	0.021	
6	0.008	
7	0.031	
8	0.009	
9	0.010	

Validity

Figure 4.5 shows the agreement between total EE per speed for each monitor as measured by SWM and the calculated EE from the portable metabolic cart. EE as estimated from indirect calorimetry was measured during one of the

five repeated trials at each speed for each of the monitors. The Bland-Altman limits of agreement for ±2SD were 7.9 and -15.7kcal with a mean difference of -3.9kcal. There was a significant difference between the EE as measured by SWM compared to indirect calorimetry (p=0.001).

Figure 4.5 Bland Altman plot of agreement in total energy expenditure between the SWM and estimated via indirect calorimetry.

4.7 Discussion

This chapter presented the finding of one of the first studies to examine the ability of the SWM to accurately detect slow speeds of standardised walking. In general, the SWM is a reproducible and sensitive method of monitoring physical activity levels. This means that the SWM can detect slow velocities of walking which is of great importance when monitoring patients with COPD as they have reduced physical functioning (Watz et al. 2009). The SWM can also detect when small changes in activity occur, such as volume and intensity of activity. This is an essential requirement of a monitor as changes may be small but they may equate to significant proportional changes in activity. Also the data indicates that as each of the monitors report equivalent values at each speed the monitors can be used interchangeable so each subject in the main trial doesn't necessarily need to have the same monitor each time. However, reproducibility and sensitivity is more acceptable when using step counts rather than EE.

These results support Patel et al. (2007) who found the SWM to be a reliable measure of EE during exercise testing in patients with COPD. However, they have reported cumulative activity during the 6 minute walk and the Incremental Shuttle Walk Test (ISWT), rather than the accuracy of the monitor at various speeds of walking, potentially missing out phases of reduced activity.

Although the SWM has been shown to detect changes in different types of PA, including walking, the walking speeds used were selected by the individuals as either fast or slow. The slow and fast speeds of walking reported in the Hill et al. (2010) study generated 77 and 93 steps/minute respectively. These values correspond broadly to the middle speeds of the ESWT (2.44 and 3 km.hr; figure 4.3) and therefore do not represent a wide range of speeds as seen in the current study. More recently Van Remoortel et al. (2012) tested the monitor at slower walking speeds (3.27 km.hr) but this still does not equate to the slower speeds of the ESWT. Uniquely this study reports the accuracy of the SWM in detecting even slower speeds from 1.78km.hr to 6 km.hr.

Furlanetto et al. (2010) reported that the SWM was inaccurate at counting steps but accurate at estimating EE, however, this is in contrast to this study which found step count to be more sensitive to a change in walking speed compared to EE. Furlanetto et al. (2010) did not use standardised walking speeds making it difficult to conclude if the SWM can distinguish between walking speeds and subjects were only monitored for 1 minute, therefore, steady state could not have been reached. They also used treadmill walking to assess the SWM, but it is important to test the device during free walking on the ground as gait and energy requirements are different during treadmill walking (Murray et al. 1985, Pearce et al. 1983, Stolze et al. 1997) and may not truly reflect domestic physical activity and activity replicated in PR.

Despite the accuracy of the SWM in detecting differences between walking speeds in step count the CV were higher at the slowest speed (1.78 km.hr; table 4.1). This supports previous research which found the SWM to significantly undercount steps when compared with a visual count (Turner et al. 2012). This may be related to the amount of force generated during faster walking speeds, as low forces generated by a slow gait may not be sufficient to overcome the inertia with the accelerometer device.

It is of interest to note that this the first study to report between monitor differences. It was important to establish if different SWM give the same reading at the same walking speeds. This study found that there was no significant difference between each monitor at each speed. This, therefore, means that the SWM's can be used interchangeably and for each subject in the main trial they do not need to wear the same monitor at each data collection point.

There appears to be some discrepancy in the literature looking at the validity of the SWM as a measurement of EE. Patel et al. (2007) found the SWM to underestimate cumulative EE compared to indirect calorimetry in COPD patients during the 6 minute walk test and the ISWT, whereas Van Remoortal et al (2012) reported a high correlation between METs reported by the SWM and $VO_{2.}$ This current study indicates that the SWM demonstrates fair validity in measuring EE supporting findings by Hill et al. (2010). Other authors presented their findings as METs whereas this study has reported data as EE. Hill et al. (2010) reported a mean difference of -0.2 METs which was not

significant, whereas this study found a mean difference between the 2 methods of -3.9kcal which was a significant difference. From this study protocol it can be conclude that the SWM demonstrates fair validity during standardised tests of exercise performance unlike Hill et al. (2010) who did not examine validity of the device at standardised walking speeds. Fruin and Rankin's (2004) conducted their testing at faster walking speeds in healthy individuals which is not representative of velocities seen in patients with COPD. Previous work has suggested that patients with COPD have increased resting and total daily EE and greater oxygen consumption for a given workload compared to healthy subjects (Creutzberg et al. 1998). This may account for some of the variation between the results from this study and Fruin and Rankin's (2004) results. The differences in comparison to Hill et al.'s (2010) study could be due to the differences in walking velocities. They reported their fastest speed to be 93 steps/min which roughly relates to 3 km.hr (figure 4.3), this current study has completed 2 faster speeds than this (4.56 and 6 km.hr) which makes it difficult to do direct comparison.

4.8 Limitations

Although the protocol design enabled the detailed examination of the measurements properties of different SWM's during various walking speeds, all the assessments were conducted by a healthy subject and not a patient with COPD. It was believed that a COPD patient may be unable to take part in the full range of speeds undertaken, in particular the fast speed of 6 km.hr. Also the large number of repetitions required for the study protocol may have been too much for a patient with COPD and would also have meant many

additional hospital visits. In addition, as there was only one subject in this study it may have given rise to bias results, due to less biological variability.

Indirect calorimetry was used as the criterion measure for EE which is a widely reported reference measure used in the literature (Fruin and Rankin 2004, Hill et al. 2010, Patel et al. 2007). Cost and access prevented the use of direct calorimetry or doubly labelled water.

Walking is the main activity performed by patients with COPD (Pitta et al. 2005b) and is the basis of our pulmonary rehabilitation programme. However, the current protocol did not look at other activities of daily living such as housework, food preparation, climbing stairs and dressing which all contribute to the daily EE of patients with COPD.

Another potential limitation of this study is that actual step count was not recorded. Therefore the validity of the step counts was not analysed and we cannot be certain that as speed increased more steps were taken. It is possible that as the monitor is worn on the arm it is better at recording data at faster walking speeds when upper arm movement is included.

4.9 Conclusion

This study supports the use of the SWM after evaluating the reproducibility, sensitivity and validity in detecting different walking speeds in 9 monitors. The device is an acceptable method for measuring slow standardised speeds of

walking and by considering both step count and EE it can be confidently used as an outcome measure for describing PA and detecting change in PA in individuals who commonly have a slow walking pace.

Chapter 5 – The effectiveness of the SPACE for COPD programme in comparison to Pulmonary Rehabilitation at seven weeks

5.1 Introduction

There is considerable evidence for the benefits of Pulmonary Rehabilitation (PR) and the NICE (2010) guidelines recommend that it should be offered to all patients who consider themselves functionally disabled by COPD. Despite this accumulation of convincing evidence there is an inadequate provision of PR in the UK and a lack of choice of how rehabilitation is delivered. The SPACE for COPD programme was developed as a home based supportive self-management (SM) intervention (described in chapter 3) to increase the scope of delivery and increase patient choice. There is potential for the SPACE for COPD programme to offer an alternative supportive SM model to conventional PR.

As discussed in chapter 2.3, home based and SM studies that have been published have been inconsistent in not only their overall findings, but also their interventions and outcome measures. Unlike cardiac rehabilitation there has been no Cochrane review of home based rehabilitation for patients with COPD. However, the Cochrane review of SM (Zwerink et al. 2014), as previously discussed, contains elements of exercise training and home based exercise

monitoring, highlighted the issue of differential treatment time and heterogeneity of interventions.

It is important to asses and report on new and novel approaches over a short period of time so that any initial benefits can be measured, and to allow for understanding of how these benefits may change over different durations of interventions. Studies that have only reported long term follow-up may have missed vital evidence on the effectiveness of their programmes and as a consequence patient requirements for maintenance and support strategies may not be addressed.

The SPACE for COPD programme consists of four stages to progress through at the patient's own pace, However, the intervention period for this study was seven weeks to match the PR programme based at Glenfield hospital which, acted as the comparison group.

This chapter will describe the short term (seven weeks) outcomes of the noninferiority, randomised control trial. Patients with COPD were recruited from those referred to PR and were randomised into either a usual care PR programme (control) group or a supported SM programme which involved using the SPACE for COPD manual. Patients were assessed at baseline and then again seven weeks later. This chapter will focus on the following:

- Baseline characteristics
- Between group differences from baseline to seven weeks
- Within group changes from baseline to seven weeks

5.2 Aim

The aim was to determine whether the seven week outcomes of SPACE for COPD programme were noninferior (as good as) to usual care PR in the treatment and management of patients with COPD at seven weeks.

5.3 Methods

A full description of the methods of this study can be found in chapter 3. Chapter 3 gives details related to the power calculation, recruitment, randomisation, blinding, outcome measures and a description of the intervention and control group treatments. A flowchart of this section of the study is shown in figure 5.1 below;

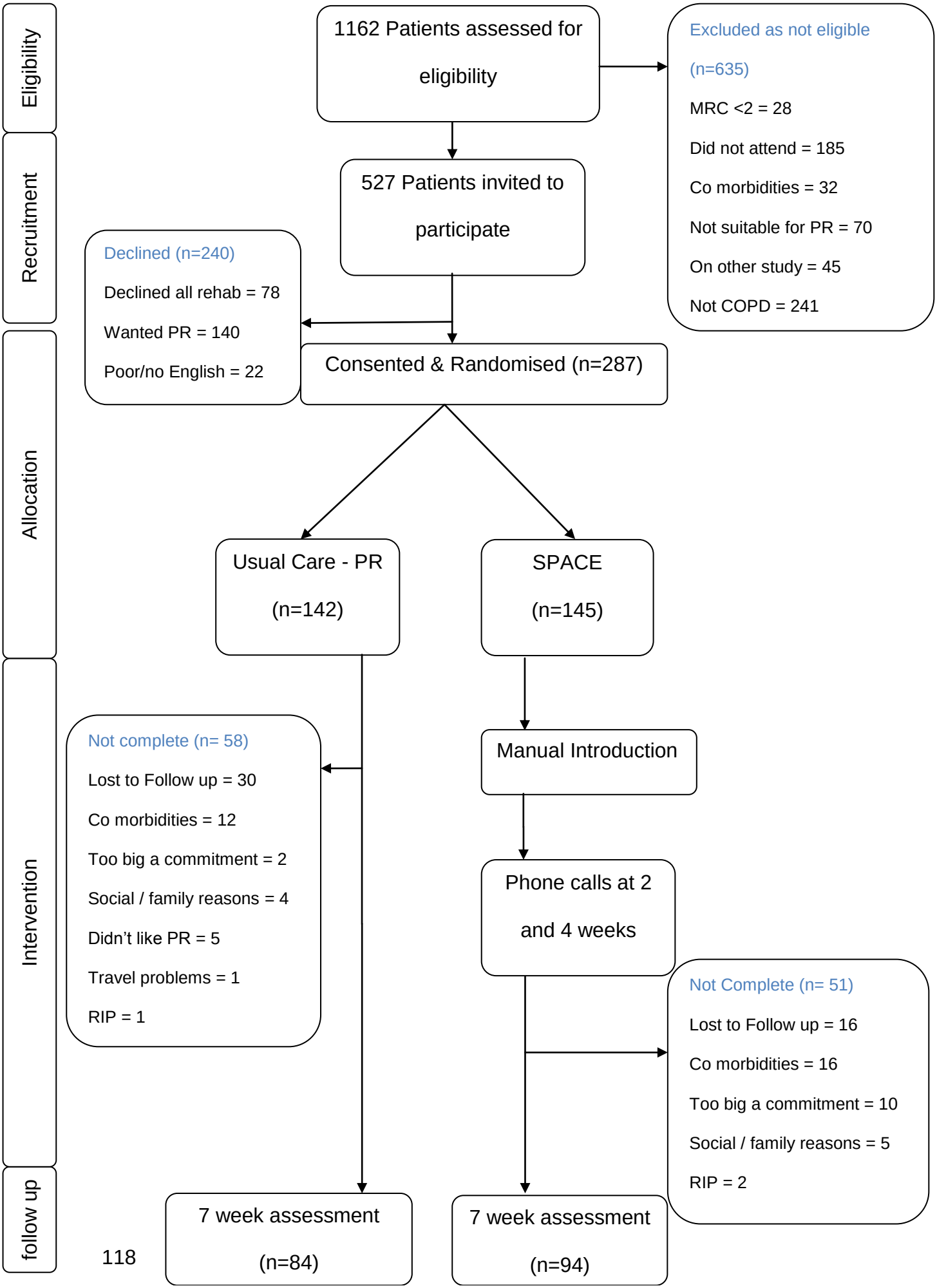


Figure 5.1 CONSORT diagram of study design, patient recruitment, randomisation and withdrawal

5.4 Outcome measures

A full description of the outcome measures used in this study is described in Chapter 3.6. The key outcome measures at seven weeks explored in this chapter are

- Chronic respiratory questionnaire – self reported (CRQ-SR)
    - Dyspnoea, fatigue, emotion and mastery
- Hospital Anxiety and Depression Scale (HADS)
- Incremental shuttle walk test (ISWT)
- Endurance shuttle walk test (ESWT)
- Pulmonary Rehabilitation Adapted Index of Self Efficacy (PRAISE)

The primary outcome for this study, to which it was powered, is the dyspnoea domain of the CRQ-SR.

5.5 Statistical analysis

Statistical analyses were completed using the statistical package IBM SPSS Statistics version 20. Baseline characteristics were analysed for group differences using an independent t-test for continuous data and chi square test for categorical data. The within and between group data changes over 7 weeks were analysed using paired t-test and independent t-tests respectively. The primary analysis is the between group differences and the secondary analysis is the within group differences.

Noninferiority was determined using the primary outcome of CRQ-SR Dyspnoea, if the mean improvement in CRQ-SR dyspnoea score in the SPACE for COPD group was no worse than the mean improvement in CRQ-SR dyspnoea score in the PR group, by a margin of 0.5 units. The noninferiority margin of 0.5 units was chosen as this is the minimal clinical important difference (MCID) for the CRQ-SR (Jaeschke, Singer and Guyatt 1989). If the 95% CI breaches this 0.5 units then this may be interpreted as having some uncertainty as to its noninferiority (Piaggio et al. 2012). Pearson's correlation was also used to determine the relationship between baseline score and the change in score at 7 weeks for dyspnoea and the ISWT.

As the protocol did not specify what was an acceptable level of adherence to the programme an Intension To Treat (ITT) analysis was adopted. This data is labelled at ITT completers in the results section. In addition multiple imputations using SPSS was used to impute missing seven week data due to drop out. Five models of imputed values were produced, with analysis completed on the pooled data. Results from this analysis is labelled at ITT imputed in the results section.

5.6 Results

287 patients were recruited and randomised to the study, 142 to PR and 145 to SPACE for COPD. A total of 109 patients withdrew from the study. Reasons for withdrawal from the study are outlined in table 5.1. Withdrawal

was classified as those subjects not completing the seven week assessments. 58 people (41%) did not complete the seven week assessment in the PR group and 51 people (35%) did not complete the seven week assessment in the SPACE for COPD group. Therefore, similar dropout rates were seen with both interventions. Those that did not attend their appointments were contacted to rearrange. If two appointments were missed without any contact they were withdrawn from the study. An independent t-test showed there was no statistically significant difference in baseline characteristics of those that did or did not complete the seven week assessment (data not shown).

Table 5.1 Reasons for study withdrawal

Reason for withdrawal	*PR*	*SPACE*
Lost to Follow up	30	16
Co morbidities	12	16
Too much of a commitment	2	10
Social / family reasons	4	5
Didn't like PR	5	N/A
Travel problems	1	N/A
RIP	1	2
Wanted other form of treatment	3	2

Baseline characteristics are outlined in table 5.2. Data are presented as Mean (SD) for continuous data and absolute values for categorical data. There were no statistically significant differences in baseline characteristics between those randomised to PR or SPACE.

Table 5.2 Baseline characteristics presented as means (SD) unless otherwise stated

	PR *n=142*	*SPACE* *n=145*	*p value*
Age (yrs)	67 (8)	68 (9)	0.54
Male:Female (n:%)	94 (66%):48(34%)	93 (64%):52 (36%)	0.78
BMI (m/kg^2)	27.84 (6.39)	27.40 (6.03)	0.55
FEV_1 (litres)	1.26 (0.60)	1.26 (0.51)	0.99
FEV_1 (% predicted)	48.79 (17.19)	47.89 (18.67)	0.68
FVC (litres)	2.67 (0.90)	2.73 (0.84)	0.59
MRC (n;%)			0.33
2	20 (14.08%)	28 (19.31%)	
3	57 (40.14%)	52 (35.86%)	
4	39 (27.46%)	47 (32.41%)	
5	26 (18.31%	18 (12.41%)	
SpO_2 rest %	93.91 (3.66)	94.54 (2.32)	0.86
Smoking status (%)			0.11
Current smoker	28 (20%)	45 (31%)	
Never smoked	5 (3%)	8 (6%)	
Ex smoker	109 (77%)	92 (63%)	
Pack years	45.78 (26.00)	47.22 (36.21)	0.67
CRQ-SR			
Dyspnoea	2.42 (0.91)	2.58 (0.93)	0.199
Fatigue	3.36 (1.20)	3.42 (1.19)	0.613
Emotion	4.37 (1.24)	4.41 (1.24)	0.789
Mastery	4.36 (1.30)	4.50 (1.40)	0.250
HADS			
Anxiety	7.91 (3.97)	7.39 (4.00)	0.250
Depression	6.67 (3.32)	6.11 (3.59)	0.097
PRAISE	44.81 (7.00)	47.24 (8.09)	0.917
ISWT (m)	268.61 (149.89)	260.24 (147.91)	0.764
ESWT (sec)	189.14 (96.25)	231.42 (231.00)	0.440

A one way ANOVA was used to assess differences in baseline measures per MRC grade (table 5.3). Differences were detected between CRQ-SR dyspnoea, fatigue, emotion, mastery, HADS depression, PRAISE, ISWT and ESWT. Each measure had the 'best' score in MRC 2 and the 'worst' score in MRC 5.

Table 5.3 Mean (SD) baseline measures by MRC grade

	MRC grade				*p value*
	2 n=48	3 n=109	4 n=86	5 n=44	
CRQ-SR					
Dyspnoea	2.94 (1.02)	2.49 (0.90)	2.40 (0.83)	2.28 (0.94)	0.006
Fatigue	3.95 (1.23)	3.64 (1.08)	3.13 (1.07)	2.59 (1.15)	<0.0001
Emotion	4.81 (1.13)	4.63 (1.11)	4.00 (1.38)	4.09 (1.08)	<0.0001
Mastery	5.03 (1.27)	4.64 (1.27)	4.12 (1.36)	3.89 (1.30)	<0.0001
HADS					
Anxiety	6.50 (3.30)	7.41 (3.93)	8.16 (4.41)	8.24 (3.81)	0.105
Depression	4.52 (3.16)	6.49 (3.15)	6.83 (3.46)	7.14 (3.90)	0.001
PRAISE	47.27 (6.73)	45.43 (7.20)	41.75 (7.41)	43.64 (7.59)	<0.0001
ISWT (m)	399 (137)	285 (125)	196 (124)	124 (89)	<0.0001
ESWT (sec)	331 (260)	201 (93)	180 (156)	118 (69)	<0.0001

Part way through the study those recruited were ask to give a preference as to which treatment group they would like to be assigned. 155 (54%) of patients were asked and of these patients 80 (51%) wanted SPACE for

COPD, 38 (25%) wanted PR, and 37 (24%) had no preference to a treatment group. Table 5.4 below shows the number of patients that were assigned to their desired treatment group and those that didn't.

Table 5.4 Patient preference of treatment choice

	PR *n = 76*	*SPACE* *n = 79*
Were assigned the treatment group they preferred	34 (45%)	58 (73%)
Were assigned the treatment group they did not prefer	22 (29%)	4 (5%)
No preference given	20 (26%)	17 (22%)

Health related Quality of Life (HRQoL)

Chronic Respiratory Questionnaire – Self Report

Health related quality of life was measured by the CRQ-SR which is divided into 4 domains: dyspnoea, fatigue, emotion and mastery. Between group changes were analysed using an independent t-test. The results are show in table 5.5 and figure 5.2

Table 5.5 Primary analysis - Between group differences in the change in CRQ-SR from baseline to seven weeks (SPACE minus PR)

CRQ	*Between group Difference (95%CI)*	ITT completer P Value	ITT imputed P value
Dyspnoea	-0.32 (-0.71 to 0.08)	0.113	0.103
Fatigue	-0.41 (-0.79 to 0.03)	0.033	0.015
Emotion	-0.52 (-0.88 to 0.17)	0.004	0.004
Mastery	-0.43 (-0.77 to 0.09)	0.014	0.009

The primary outcome of this noninferiority trial is the dyspnoea score of the CRQ-SR. Between group differences were small (-0.32, 95% CI -0.71 to 0.08) and not statistically significant. However, as the noninferiority margin (0.5 units) is exceeded by the 95% CI there is still some uncertainty as to the effectiveness of the SPACE for COPD intervention on dyspnoea (figure 5.2)

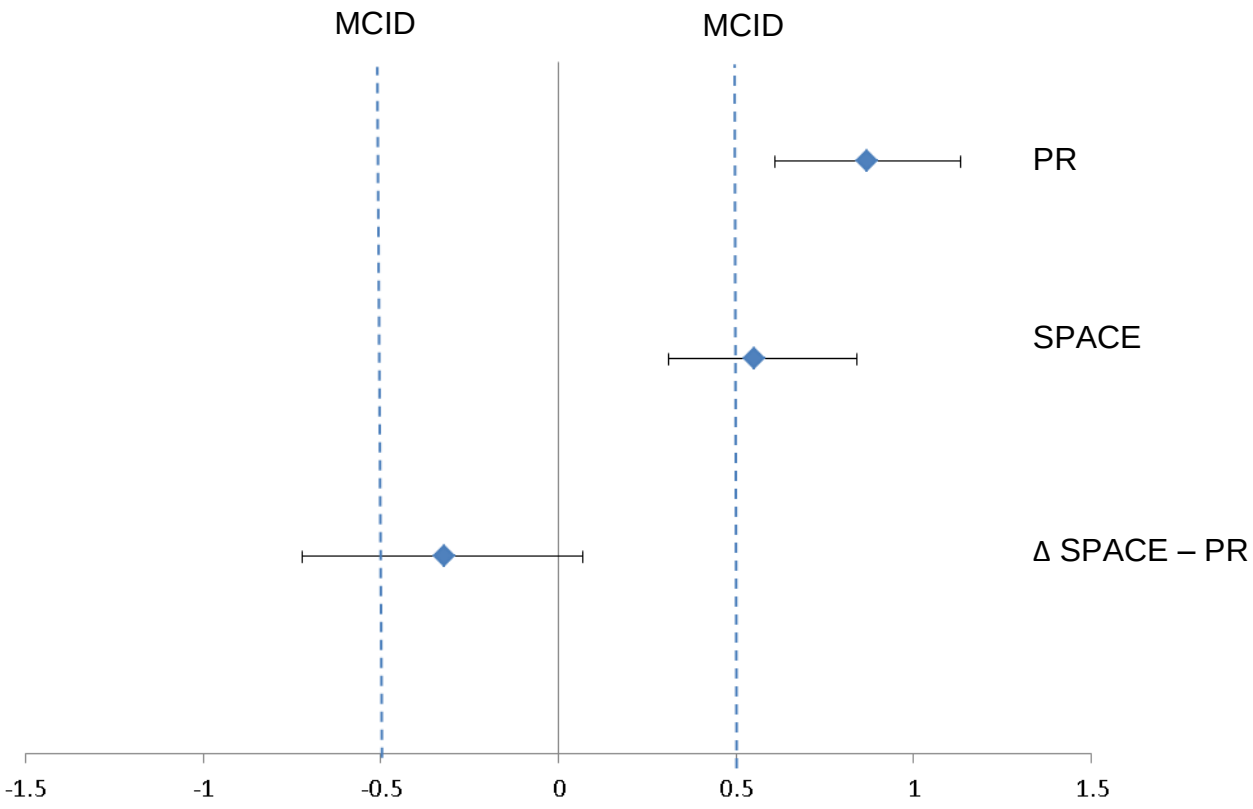


Figure 5.2 Change in CRQ –SR Dyspnoea at 7 weeks

The minimal clinical important difference (MCID) for the CRQ-SR is a change of 0.5 units (Jaeschke, Singer and Guyatt 1989). Table 5.6 shows the percentage of participants in each group meeting this threshold for the dyspnoea domain.

Table 5.6 Participants meeting the MCID (0.5 units) for the CRQ-SR dyspnoea domain in PR and SPACE groups

	Change <0.5 *%*	*Change ≥ 0.5* *%*	*Range (-7 to 7)*
PR	41.10	58.90	-1.60 to 3.2
SPACE	46.05	53.95	-3.0 to 4.6

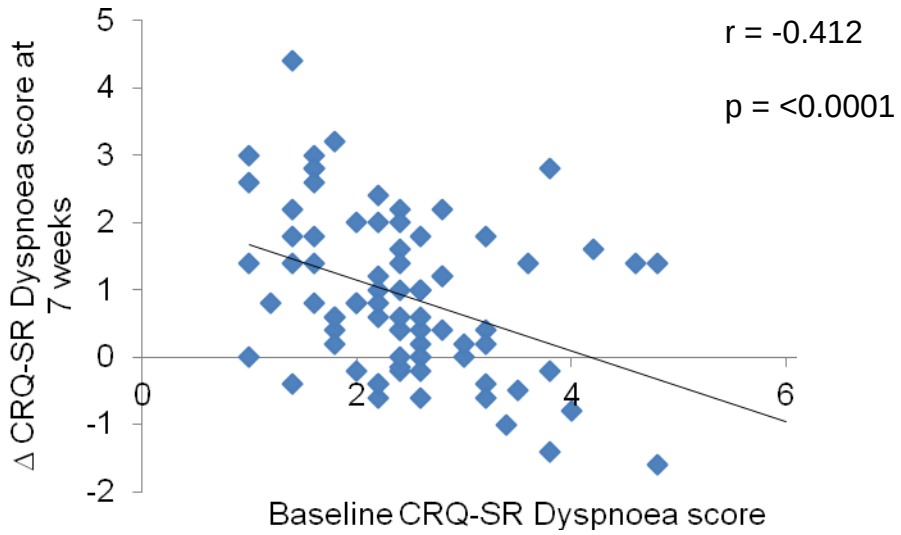


Figure 5.3 The relationship between baseline CRQ-SR Dyspnoea score and change at 7 weeks in the PR intervention group.

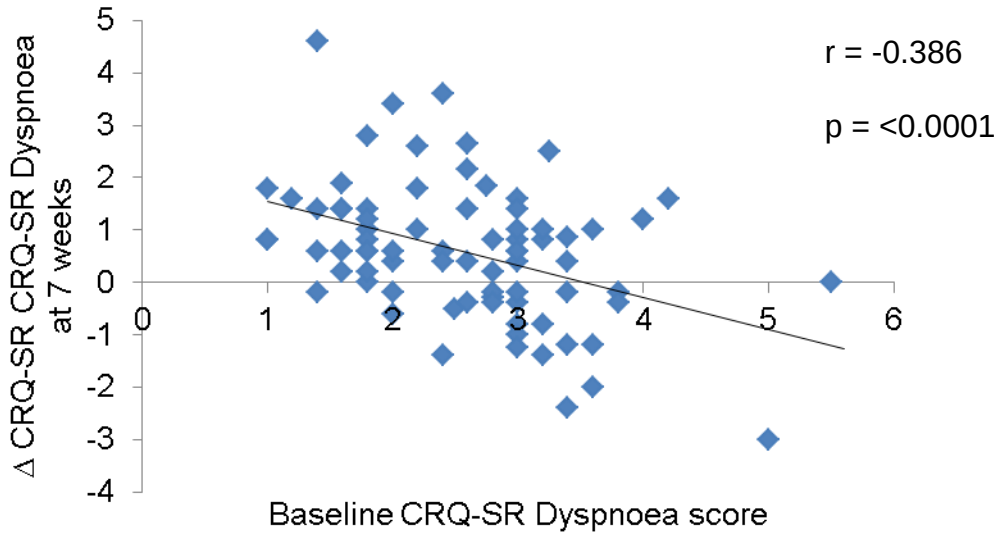


Figure 5.4 The relationship between baseline CRQ-SR Dyspnoea score and change at 7 weeks in the SPACE for COPD intervention group.

A Pearson's correlation was used to determine if there was a relationship between baseline CRQ-SR Dyspnoea score and the change in scores at seven weeks. This was completed to determine if those with lower baseline scores improved more than those with higher baseline scores. Results demonstrated that there was a significant negative relationship in both groups (PR, r = -0.412, p= <0.0001 figure 5.3; SPACE, r = -0.386, p = <0.0001 figure 5.4). Highlighting that those with lower baseline scores tended to have greater improvements in CRQ-SR Dyspnoea.

A paired t-test was completed on the within group changes in the CRQ-SR from baseline to seven weeks and the results presented in table 5.7. Results showed that there was a significant improvement in all domains in the PR group and a significant improvement in the dyspnoea domain only of the SPACE group (figure 5.5).

Table 5.7 Within group changes in CRQ-SR from baseline to 7 weeks in PR and SPACE

		Mean Baseline Score (SD; n=287)	**Mean 7 weeks Score (SD; n=178)**	**Change (95% CI)**	**p Value**
PR	**Dyspnoea**	2.44 (0.86)	3.34 (1.16)	0.91 (0.64 to 1.17)	<0.001
	Fatigue	3.43 (1.05)	4.02 (1.23)	0.59 (0.33 to 0.85)	<0.001
	Emotion	4.41 (1.20)	4.92 (1.08)	0.51 (0.25 to 0.76)	<0.001
	Mastery	4.40 (1.27)	4.97 (1.21)	0.57 (0.35 to 0.80)	<0.001
SPACE	**Dyspnoea**	2.58 (0.89)	3.16 (1.25)	0.58 (0.28 to 0.88)	<0.001
	Fatigue	3.54 (1.19)	3.67 (1.19)	0.14 (-0.13 to 0.40)	0.305
	Emotion	4.52 (1.23)	4.52 (1.20)	0.003 (-0.23 to 0.24)	0.977
	Mastery	4.61 (1.39)	4.74 (1.30)	0.13 (-0.12 to 0.39)	0.297

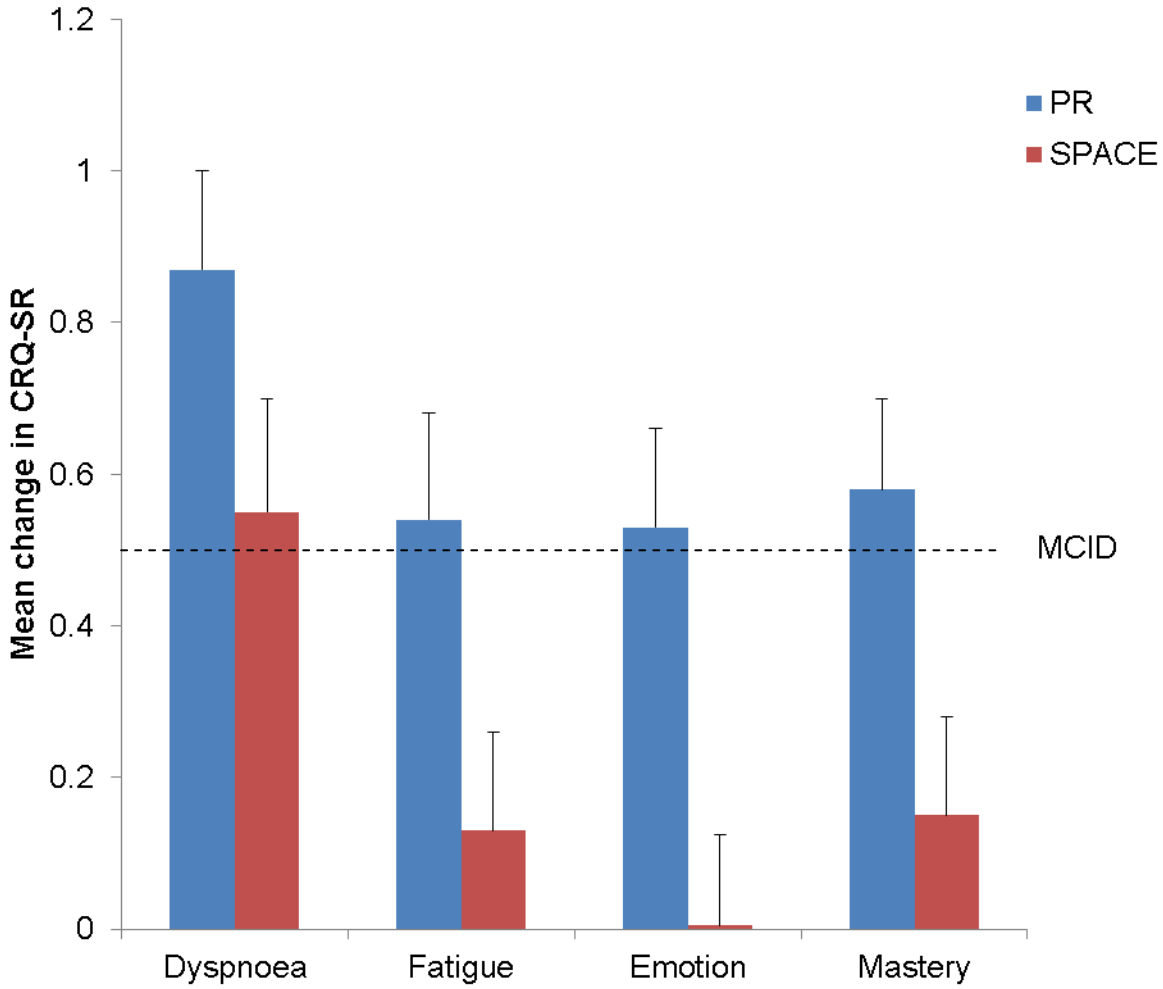


Figure 5.5 Mean (SD) changes in CRQ-SR from baseline to 7 weeks

Pearson's correlation was also completed on the fatigue, emotion and mastery domains of the CRQ-SR. Table 5.8 highlights that in both groups there is a relationship between those with lower baseline score to have greater increases in scores at seven weeks.

Table 5.8 Relationship between baseline CRQ-SR score and change in score at 7 weeks

	PR		*SPACE*	
	r	p	r	p
Fatigue	-0.395	<0.0001	-0.502	<0.0001
Emotion	-0.577	<0.0001	-0.459	<0.0001
Mastery	-0.448	<0.0001	-0.495	<0.0001

Hospital Anxiety and Depression Scale (HADS)

Between group changes in anxiety and depression is presented in table 5.9 and within group changes in HADs is presented in table 5.10

Table 5.9 Between group differences in HADS scores (SPACE minus PR)

HADS	**Between group Difference (95%CI)**	**ITT completers P Value**	**ITT imputed P value**
Anxiety	-0.97 (-1.98 to 0.04)	0.06	0.07
Depression	-0.79 (-1.63 to 0.04)	0.06	0.04

Between group differences for anxiety (-0.97, 95%CI -1.98 to 0.04) and depression (-0.79, 95% CI -1.63 to 0.04) were not significant (both p=0.06).

However, the noninferiority margin (1.5 units) is breached by the 95% CI and therefore there is still uncertainty as to the effectiveness of SPACE for COPD on anxiety and depression (figure 5.6 and 5.7)

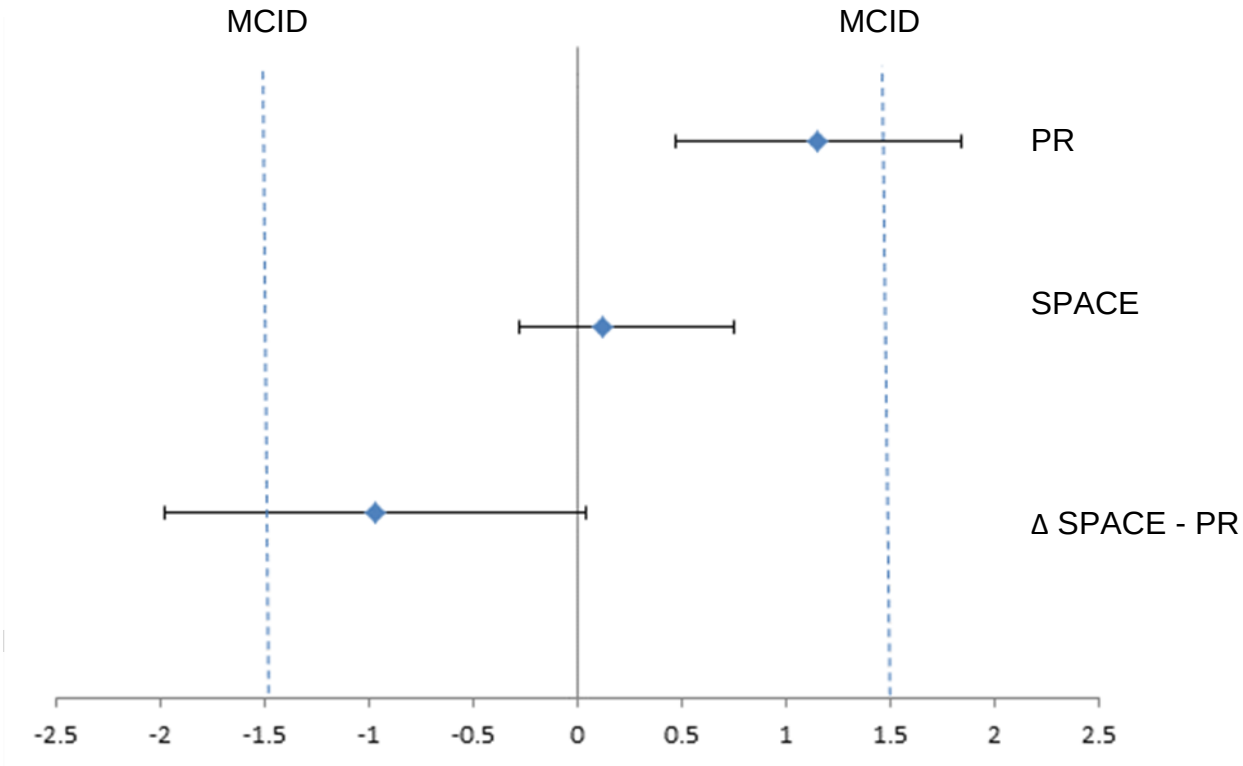


Figure 5.6 Change in HADS Anxiety at seven weeks

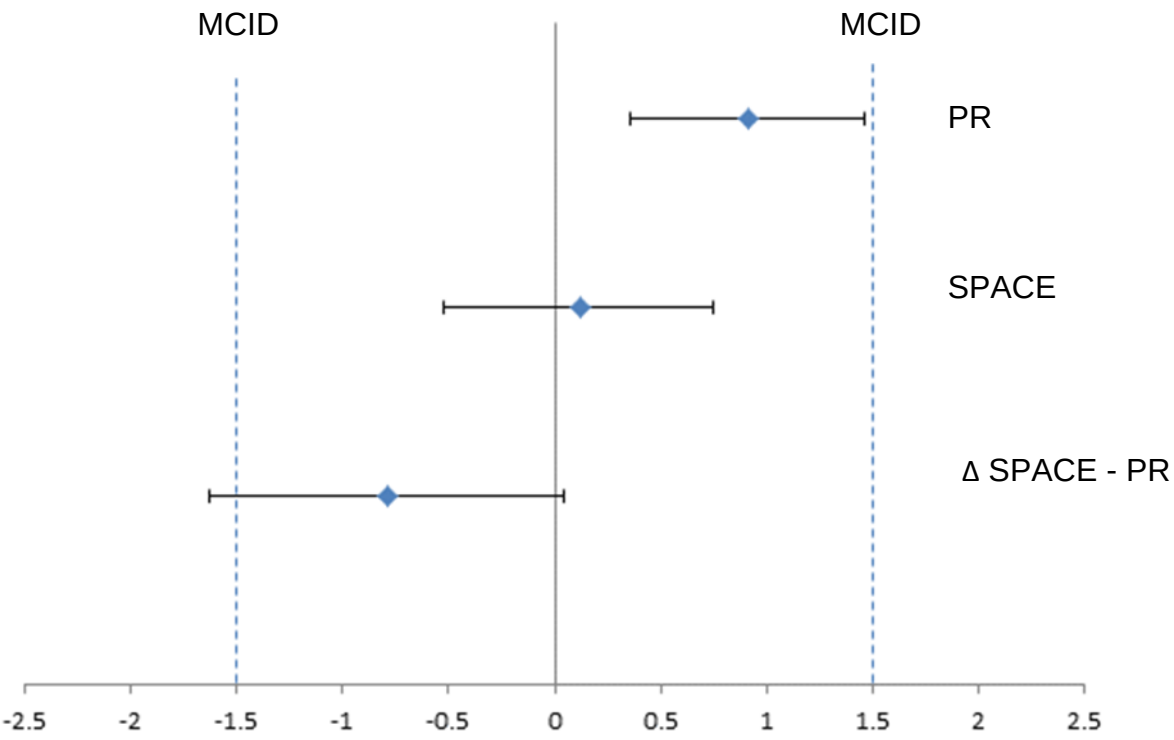


Figure 5.7 Changes in HADS Depression at seven weeks

Table 5.10 Within group changes in HADS from baseline to 7 weeks in PR and SPACE

		Mean Baseline Score (SD; n=287)	**Mean 7 weeks Score (SD; n=178)**	**Change (95% CI)**	**p Value**
PR	**HADS Anxiety**	7.74 (3.89)	6.65 (3.75)	-1.08 (-1.74 to -0.43)	0.001
	HADS Depression	6.38 (3.08)	5.49 (3.19)	-0.89 (-1.42 to -0.36)	<0.001
SPACE	**HADS Anxiety**	7.21 (3.82)	7.03 (4.00)	-0.18 (-0.93 to 0.56)	0.628
	HADS Depression	6.18 (3.41)	6.18 (3.37)	0.00 (-0.67 to 0.67)	1.00

Between group differences in anxiety and depression show no statistically significant difference between PR and SPACE. However, PR shows a significant improvement from baseline to 7 weeks (change anxiety -1.08, 95% CI, -1.74 to -0.43 units; Depression 0.89 95% CI, -1.42 to -0.36) and SPACE for COPD shows no statistical difference during the same time period.

Further analysis was completed on 2 subgroups, those patients who scored ≥8 for at least a possible indication of anxiety, and those patients who scored ≥8 for at least a possible indication of depression. These thresholds were

chosen as standard cut points of possible presence of anxiety or depression and is an approach previously described in the literature (Harrison et al. 2012). Mean changes in anxiety was found to be significant in both intervention groups with no significant between group differences (table 5.11). No significant changes were seen in PR (p=0.895), or SPACE for COPD (p=0.075) for those with depression scores ≥ 8 (data not shown in table).

Table 5.11 Within and between group changes in Anxiety scores in those with baseline scores ≥ 8

	Mean change (95%CI)	*Within group p value*	*Between group p value*
PR (n=43)	2.07 (0.05 to 2.60)	<0.001	0.34
SPACE (n=34)	1.32 (1.10 to 3.04)	0.042	

Self-efficacy

Self-efficacy was measured using the PRAISE questionnaire. Between group differences in table 5.12 and within group changes are shown in table 5.13.

Table 5.12 Between group differences in PRAISE scores (SPACE minus PR)

	Between group Difference (95%CI)	***ITT completers p value***	***ITT imputed p value***
PRAISE	-2.29 (-0.02 to 5.16)	0.051	0.043

The change in self-efficacy between the two groups is shown to be not significant. PR shows a statistically significant difference from baseline to seven weeks, whereas SPACE shows no statistically significant change in scores. No MCID has been established for the PRAISE questionnaire to date therefore clinical significance has not been explored.

Table 5.13 Within group changes in PRAISE scores from baseline to 7 weeks in PR and SPACE

PRAISE	**Mean Baseline Score (SD; n=287)**	**Mean 7 weeks Score (SD; n=178)**	**Change (95% CI)**	**p Value**
PR	44.84 (6.99)	47.30 (7.89)	2.46 (0.67 to 4.25)	0.008
SPACE	44.76 (7.42)	44.67 (8.60)	-0.09 (-1.84 to 1.67)	0.920

A Pearson's correlation was used to analyse the relationship between baseline PRAISE scores and change in scores at seven week. This was completed to determine if those with higher baseline score improved more than those with lower baseline scores. Results highlighted a statistically significant relationship between these scores in both intervention groups (PR, $r = -0.437$, $p = <0.000$; SPACE $r = -0.365$, $p = 0.001$), suggesting that those with lower baseline score have greater increases in seven week scores

Exercise Capacity

As described in the methods section 3.6 exercise capacity was measured by the ISWT and the ESWT. Between group differences are shown in table 5.14

and figures 5.6 and 5.7. The MCID for the ISWT is considered to be 48m (Singh et al. 2008) , and 186 seconds for the ESWT (Pepin et al. 2011). As the test is measured in 10m increments the MCID is reported here as 50m. Table 5.15 shows the percentage of participants in each group meeting this threshold. In the PR group 43.04% met this threshold and 33.34% in the SPACE for COPD group. The within group changes are presented in table 5.18.

Table 5.14 Between group differences in exercise capacity (SPACE minus PR)

	Between group Difference (95%CI)	**ITT completer p Value**	**ITT imputed P value**
ISWT (m)	-23.90 (-46.33 to -1.47)	0.038	0.039
ESWT (seconds)	-132.78 (-244.63 to -20.94)	0.020	0.011

Table 5.15 Percent of patients meeting the MCID of 50m in the ISWT

	Change <50m *%*	*Change ≥ 50* *%*	*Range (m)*
PR	56.96	43.04	-240 to 290
SPACE	67.86	33.34	-150 to 210

The between group differences in ISWT distance was -23.9m (95% CI -46.33 to -1.47) and was statistically significant (p=0.038; Table 5.14). However, the noninferiority margin of the ∆SPACE-PR (50m) was not breached by the 95% CI (figure 5.8). This infers that the SPACE for COPD programme is noninferior (as good as) PR when considering the ISWT. The between group difference in ESWT time was -132.78sec (95% CI -244.63 to -20.94) and was also statistically significant (p=0.020). The noninferiority margin of ∆SPACE-PR (186 seconds) was breached by the 95% CI (figure 5.9), implying there is still some uncertainty as to the noninferiority of the SPACE for COPD programme in comparison to PR when considering the ESWT.

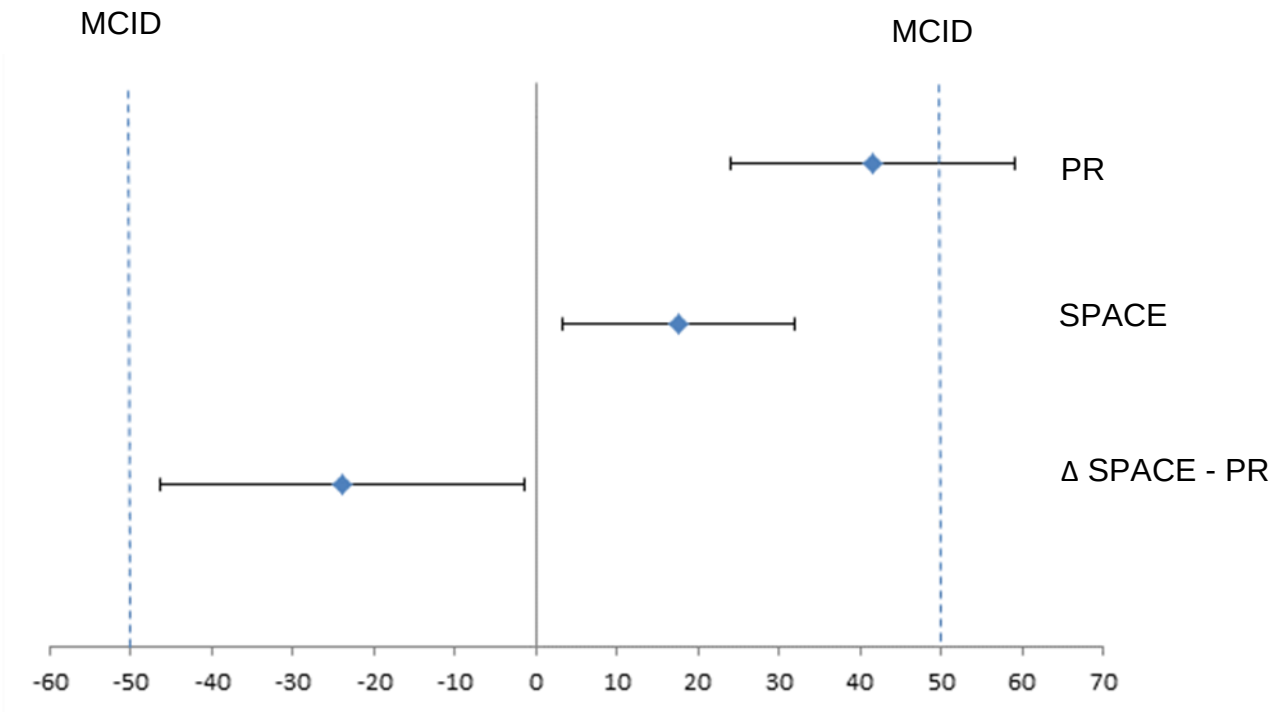


Figure 5.8 Change in ISWT distance (m) at seven weeks

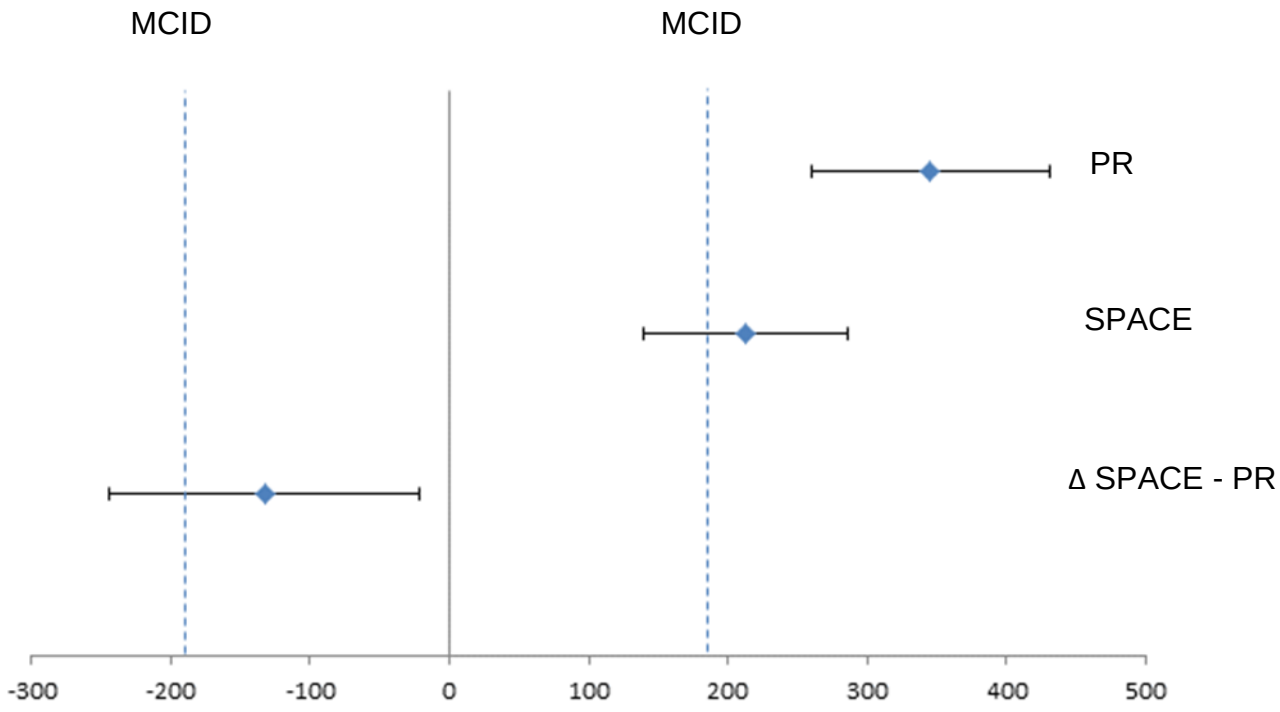


Figure 5.9 Changes in ESWT time (seconds) at seven weeks

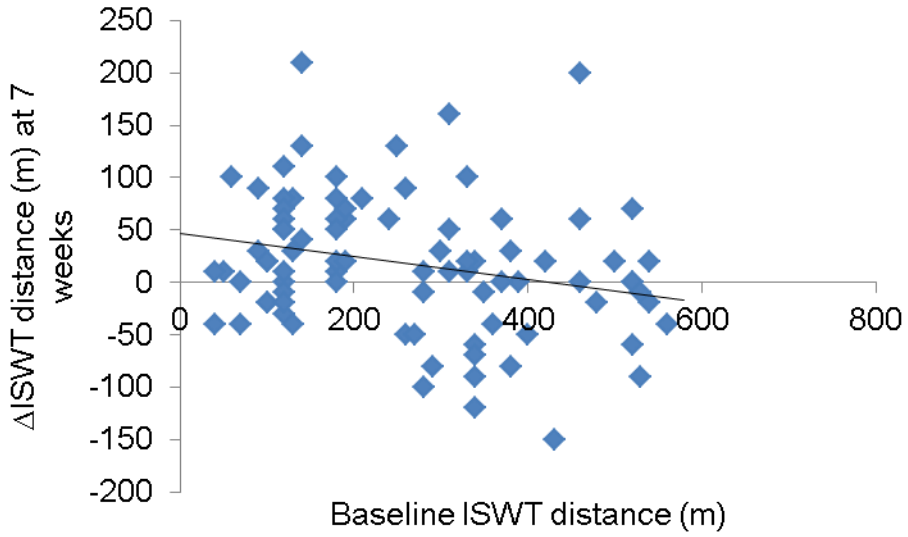


Figure 5.10 The relationship between baseline ISWT performance (m) and change at seven weeks in the SPACE for COPD intervention group

Table 5.16 Relationship between baseline exercise performance score and change in score at 7 weeks

	PR		*SPACE*	
	r	p	r	p
ISWT	-0.141	0.198	-0.253	0.020
ESWT	0.159	0.154	-0.084	0.447

Statistical analysis demonstrated that there was only a significant relationship in baseline score to change in score at seven weeks in the ISWT of the SPACE for COPD group (r = -0.253, p = 0.020; figure 5.8 and table 5.16). No relationship was see in either exercise performance test in the PR group

The significance of change for ESWT is reported to be between 186 seconds (Pepin et al. 2011). The number meeting the minimal threshold is reported in table 5.17.

Table 5.17 Patients meeting the MCID of 186 sec for the ESWT

	Change <186 sec *%*	*Change ≥ 186 sec* *%*	*Range (sec)*
Pulmonary Rehab	43.4	56.6	- 349 to 1071
SPACE	65.5	34.5	-493 to 1100

Table 5.18 Within group changes in exercise capacity from baseline to seven weeks in PR and SPACE groups

		Mean Baseline Score (SD; n=287)	**Mean 7 weeks Score (SD; n=178)**	**Change (95% CI)**	**P Value**
PR	**ISWT (m)**	269 (146)	310 (156)	41 (24 to 58)	<0.001
	ESWT (seconds)	193 (98)	546 (409)	353 (270 to 437)	<0.001
SPACE	**ISWT (m)**	264 (150)	281 (148)	18 (3 to 32)	0.015
	ESWT (seconds)	230 (230)	442 (391)	212 (139 to 284)	<0.001

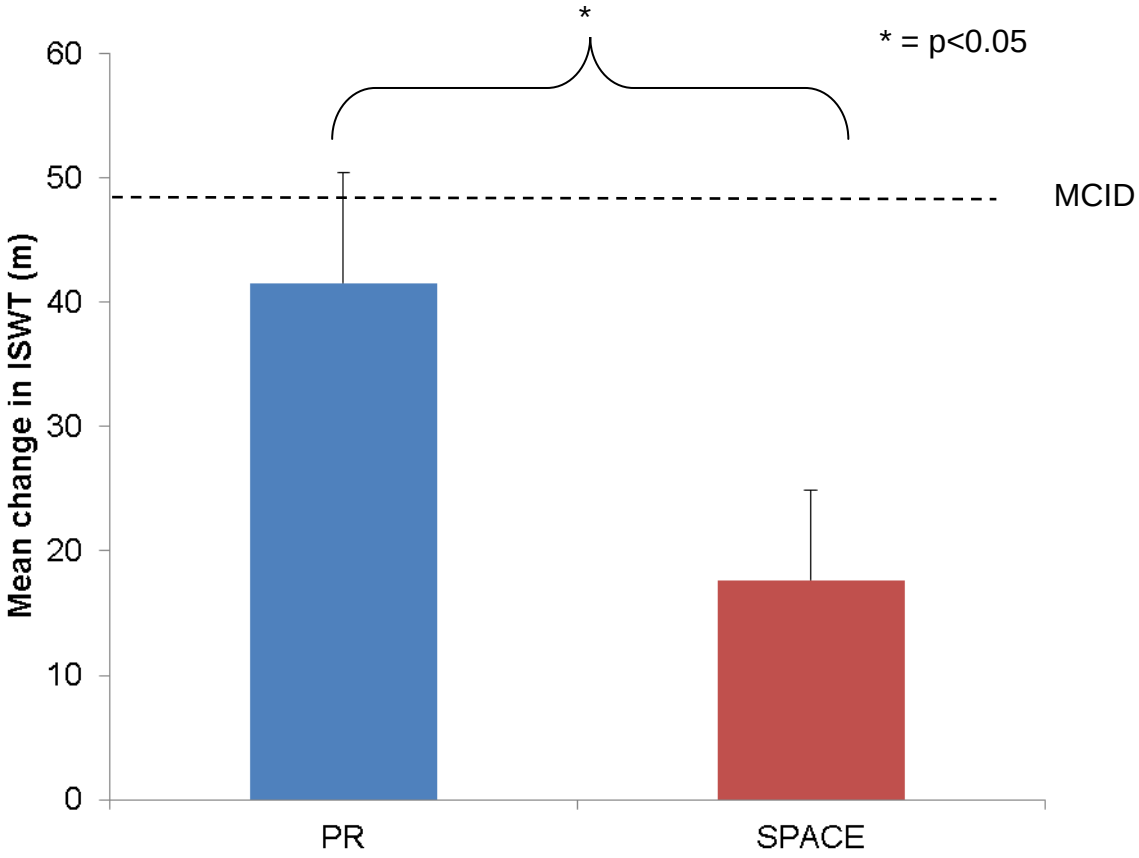


Figure 5.11 Mean change in ISWT distance from baseline to seven weeks

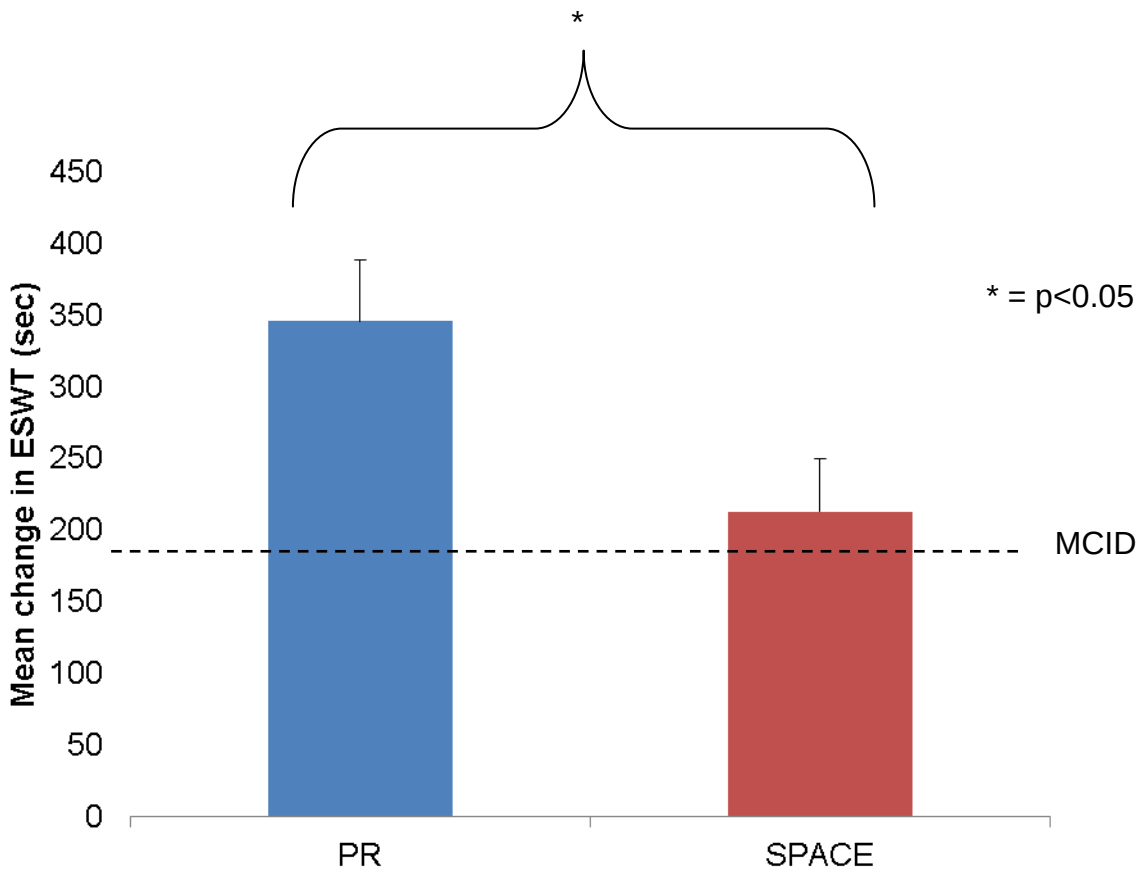


Figure 5.12 Mean change in ESWT time (sec) from baseline to 7 weeks

The changes in the ISWT show there is a statistically significant difference between PR and SPACE for COPD from baseline to seven weeks. Within group changes of both PR and SPACE for COPD show a statistically significant difference from baseline to 7 weeks in the ESWT, and both the PR and SPACE group showed a statistically significant improvement in ISWT. However, the mean change in ISWT in the PR group was 41m and for SPACE 18m which does not met the MCID for this test.

Change in outcome measures by MRC grade

Change in baseline to seven week scores per MRC grade were analysed using ANOVA. Results suggested there was no difference in the changes seen between the MRC grades (data not shown). The exception was CRQ-SR fatigue in the PR group where there was a significant difference between the change in scores at seven weeks between MRC grades 2 and 4 (p=0.045) and MRC grades 3 and 4 (p=0.04).

5.7 Discussion

The data presented in this chapter focuses on the effectiveness of the SPACE for COPD manual as a noninferior alternative to PR. The primary outcome for this study was the dyspnoea domain of the CRQ-SR. Measures of health related quality of life, psychological functioning, exercise capacity and self-efficacy were also used to determine if SPACE for COPD was 'no worse' than PR at seven weeks.

There was a large number of patients (n= 240) that declines to take part in the study. Twenty two declined as they felt their English was not strong enough to follow the SPACE for COPD manual if that was the group they were randomised to, 140 wanted the certainty of PR and 78 did not want any form of rehabilitation. The premise of SPACE for COPD is that it may be suitable for those who would not normally participate in usual care PR, therefore completing the study with those already referred to and considering PR is a limitation. It may have been more appropriate to recruit patients from those

who had declined PR at the point of referral. Allowing patients to choose which group there were assigned to was considered, however preference based randomisation may not be considered to be rigorous enough and it has not been previously reported in PR like it has been in cardiac rehabilitation (Dalal et al. 2007). This is therefore a constraint of this study as it is not reflective of potential clinical practice. However, this trial does demonstrate a proof of concept for the SPACE for COPD programme and future directions for the programme will be discussed in chapter 9.

Health Related Quality of Life (HRQoL) CRQ – SR Dyspnoea, Fatigue, Mastery and Emotion

The SPACE for COPD programme is similar to interventions used by Moore et al. (2009) and Khdour et al. (2009) and their findings are of interest for a number of reasons, including the minimal, light touch nature of the interventions. Each study demonstrated a significant improvement in HRQoL with only limited healthcare input. At a similar time point Moore et al. (2009) had a median (interquartile range) improvement of 0.5 (0.2-0.6) for CRQ-SR dyspnoea. Moore's study consisted of 27 patients so is therefore likely to be underpowered, but Khdour's study reported results from 173 patients and also used a similar research design in terms of a manual delivered by motivational interviewing and telephone support. However, this study did not report on any exercise or PA outcome measure. Both the SPACE for COPD and the Khdour programmes showing an improvement in HRQoL it may be that a manual, introduced in a one hour motivational interview, and telephone support is an

important component of a home based SM programme. However, as exercise and PA are important outcomes, it is a limitation of these studies not to have considered exercise or PA in their trial design as a more comprehensive approach may be more desirable.

The improvements in the other domains of the CRQ were not statistically significant from baseline. Generally, home based SM programmes that have shown significant improvements in HRQoL tend to be those that involve patients with greater disease severity and 'poorer' baseline outcome measures (Bourbeau et al. 2003, Boxall et al. 2005, Fernández et al. 2009, Ghanem et al. 2010, Khdour et al. 2009, Maltais et al. 2008, Moore et al. 2009). It is, therefore, possible to surmise that it may be difficult to impact on patients with milder disease as they have little room for improvement, whereas those studies that have recruited more severe patients with lower baseline scores have a greater capacity for improvement. One possible exception to this is the COPE II study (Effing et al. 2011). As previously described, patients recruited to this study had mild disease (FEV_1 1.4L; FEV_1% predicted 50%) and also had higher baseline HRQoL scores (e.g. CRQ-Dyspnoea 4.4 units), but still reported a significant improvement in HRQoL. The COPE II study was a comprehensive 11 month intervention involving supervised exercise and education, whereas the SPACE for COPD programme, which also had patients with similar disease severity (FEV_1 1.26L; FEV_1% predicted 48%) saw significant improvements in CRQ-SR dyspnoea scores from only a 7 week unsupervised programme. The SPACE for COPD programme also breached the MCID for the dyspnoea domain of

the CRQ questionnaire whereas Effing's study, although statistically significantly improved did not meet the MCID for this domain at seven or 12 months of supervised SM.

Correlations were completed on baseline CRQ-SR scores with the change in score at seven weeks. Results suggested that there was a statistically significant negative relationship between baseline score and change in score in both intervention groups and all domains of the CRQ-SR (figures 5.3, 5.4 And table 5.7). This means that those with lower baseline scores improved more than those with higher baseline scores. This supports the notion that those with higher baseline scores have reduced room for improvement and supports the use of the SPACE for COPD programme in patients with low baseline CRQ dyspnoea scores. However, when comparing the difference in scores between the different MRC grades no statistically significant difference was detected, apart from fatigue in the PR group. This is not fully understood why, but could be due to smaller numbers in MRC groups 2 and 5.

Maltais et al. (2008) is the only other relevant study that has reported their study in line with the CONSORT guidelines for noninferiority studies. It is, therefore, useful to compare this study with SPACE for COPD. Maltais et al. (2008) used the CRQ-SR to compare an eight week home based exercise programme with outpatient PR after four weeks of self-management education in both groups. Patients in this study were similar in age to SPACE for COPD, but had slightly more severe disease (FEV_1% predicted 46%). After three months this study found the home based programme to be noninferior to

the PR group in the primary outcome measure of dyspnoea on the CRQ-SR scale (between group difference 0.05 95% CI, -0.21 to 0.29). Similarly, the SPACE for COPD study found no difference between groups at seven weeks but the result is inconclusive regarding noninferiority. For the other domains in the CRQ-SR the Maltais et al. (2008) study found a statistical improvement in all domains but only the Mastery subscale was clinically significant (mean change 0.51 units, $p<0.001$). This is in contrast to SPACE where no statistical or clinical improvements were seen in fatigue, mastery or emotion sub scale. The findings of this current study is in line with a previously published pilot study of the SPACE for COPD programme in primary care (Apps et al. 2013). It is not known why significant changes were not seen in these domains of the CRQ, but it could be speculated that the exercise training has driven the change in dyspnoea and the a supervised programme is need to influence changes in the other domains, as apparent in the PR group. Maltais et al. (2008) home based intervention consisted of a comprehensive four week SM educational programme delivered in hospital on an outpatient basis and then an eight week home programme where and exercise specialist initiated the programme in the patients home. Each patient was also loaned a cycle ergometer to complete their programme and called every week to encourage adherence and detect any problems. It could be this contact with healthcare professional staff that has resulted in the statistically significant changes seen. Whereas The SPACE for COPD programme involved a ‘one off’ introduction to the SM manual with a healthcare professional and two telephone calls. The SPACE for COPD programme is less demanding on staff and participant time which may account for the difference seen. It is also worth noting that the

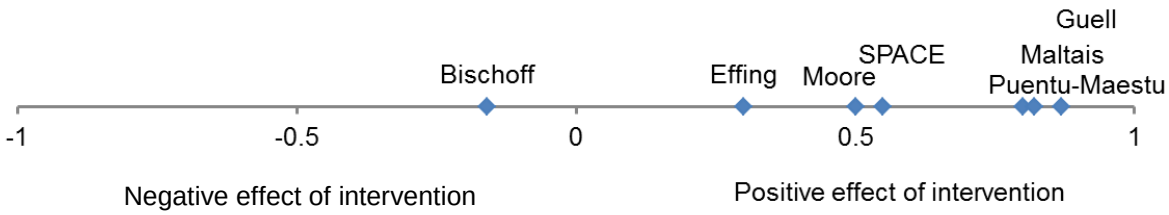
actual scores for the CRQ-SR are not presented in the study by Maltais et al. (2008), only the change from baseline to 3 months is reported. If baseline scores were low then these patients would have more to gain in comparison to those on the SPACE for COPD programme. Patients on this study reported higher mean baseline CRQ-SR dyspnoea scores (2.58± 0.93 units) than those normally seen in PR at Glenfield Hospital. Two studies recently published by Harrison report lower mean CRQ-SR Dyspnoea scores (2.37 units (Harrison et al. 2013b) and 2.35 units (Harrison et al. 2012)) in comparison to this study, despite being conducted from the same site. Therefore, as dyspnoea score in the SPACE for COPD group could be regarding as slightly higher than normally seen in patients referred to rehabilitation and therefore a 'ceiling' affect could have occurred as higher scores have limited opportunity for improvement. It is possible that the participant's recruited to this study were not representative of COPD patients normally seen. Those with more limiting disease may have preferred the security of a fully supervised programme and therefore not volunteered for this trial.

One study that found no improvement with CRQ dyspnoea was Bischoff et al. (2012) who compared a SM group (mean (SD) age 66 (12) years; FEV_1% predicted 66 (17)%) with routine monitoring and usual care. The SM group received 4 tailored sessions with ongoing telephone support and the routine monitoring group received 2-4 consultations a year with a practice nurse. This programme involved no exercise training. At 24 months there was no statistically significant improvement in CRQ dyspnoea (mean change (95%

CI) -0.16 (-0.42 to 0.11) in the SM group and no differences between the other treatment groups in change in scores. Although baseline scores for dyspnoea could be considered very high (mean (SD) 5.68 (1.21) units) the lack of a exercise component may have effected the potential for change.

Both Effing et al. (2007) and Maltais et al. (2008) studies have shown an improvement in HRQoL in patients with mild to moderate COPD. However, these studies had longer interventions of 11 months and 12 weeks respectively. Although Maltais reported results at three months on completion and Effing at seven months part way through the intervention any earlier changes may not have been detected. With assessments conduced after a longer period the trajectory of any change may not be detected, this might be important as to detect components that are successful and to identify suitable support strategies. Moore et al. (2009) reported a significant improvement after only eight weeks but as previously mentioned was underpowered. Ghanem et al. (2010) also reported a significant impact on HRQoL at eight weeks but the profile of these patients were different than the SPACE for COPD patients as they were post exacerbation and therefore potentially had greater capacity for change. The evidence based guidelines from NICE (2010) suggest improvements can be seen in 6 weeks after supervised rehabilitation.

A summary of how the SPACE for COPD programme compares to other home based and SM studies based on the CRQ dyspnoea output is presented in figure 5.13.



Mean change in CRQ dyspnoea

Figure 5.13 Mean change in CRQ dyspnoea reported in studies from baseline to post intervention

Hospital Anxiety and Depression Scale – (HADS)

COPD is associated with an increased risk of anxiety and depression (Brenes 2003, van Manen et al. 2002), and increased anxiety can lead to inferior clinical outcomes (Eisner et al. 2010). It has been reported that level of dyspnoea is a significant precursor to anxiety (Hill et al. 2008). This link between level of anxiety and health outcomes makes it a key area to be addressed to optimise COPD treatment.

The SPACE for COPD programme showed no significant improvement in either anxiety or depression. However, no significant between group differences were found between PR and SPACE for COPD. Effing et al. (2011) and Bucknell et al. (2012) used the HADS questionnaire. Effing found no difference at 12 months in anxiety (mean difference (95%CI) 0.05, -1.00 to 0.90) and depression scores (-0.41, -1.31 to 0.49), however patients had low baseline scores (mean anxiety 4.82 units, depression 4.6 units) so would not be classified as having a presence of or symptoms associated with anxiety or depression. Mean baseline scores for this current study were also below the

threshold of 8 for possible signs of anxiety and depression, this could, in part, explain why no improvements were seen. However, as significant improvements were seen in the PR group it may be that supervision and support from others in similar situations is needed to impact on these domains. Indeed, Bucknall et al. (2012) reported a significant within group improvement in anxiety treatment effect (95% CI) -1.06 (-2.08 to -0.03)), but not depression. Their programme involved supervised education sessions, with several home visits by healthcare professionals. However, only 61% of patients returned the follow up questionnaire, therefore those that may have felt they had not made any improvement may be more inclined not to return the questionnaire and the data could perhaps be biased. The baseline profiles of these patients are different to those in the SPACE for COPD programme. Bucknall et al. (2012) subjects were those who had been admitted to hospital after an acute exacerbation of COPD and had higher (mean; SD) baseline anxiety (10.0; 4.5) and depression scores (8.5; 3.9).

Interestingly, in this current study when sub analysis was completed on only those with scores of ≥ 8 a significant treatment effect was seen in anxiety scores for both PR (-2.07; 95% CI 0.05 to 2.60; $p<0.001$) and SPACE for COPD (-1.32; 95% CI 1.10 to 3.04; $p=0.042$), and for this subgroup analysis there was no between group differences ($p=0.34$). This highlights that those with a possible or probable presence of anxiety secure benefits by using the SPACE for COPD programme. No treatment effect was observed with the depression score in either PR ($p=0.895$) or SPACE ($p=0.075$) group when analysing those with possible or probable presence. Therefore, when

adjusting for baseline anxiety profile (HADS Anxiety ≥8) these findings support Bucknall et al. (2012) for the home based SM group. However, the finding that PR did not affect patients with scores ≥8 for depression is not in line with current literature. Harrison et al. (2012) reported that those with higher baseline depression scores had greater improvements in scores after a course of PR. As an overall significant change was detected in the PR group it could possibly due to the subgroup being underpowered to detect any changes, with only 39 participants in both groups who had scores ≥8 at baseline.

Self-efficacy

Self-efficacy was measured using the PRAISE questionnaire. No significant difference was found between groups at seven weeks (mean difference -2.29 95% CI, -0.02 to 5.16, p=0.051). However, PR showed a significant improvement in PRAISE scores (mean change, 95% CI; PR 2.46, 0.67 to 4.25, p=0.008; SPACE -0.09, -1.84 to 1.67, p=0.920) whereas SPACE for COPD did not. The PRAISE questionnaire was developed specifically to measure self-efficacy for PR (Vincent et al. 2011) and may not be suitable for home based SM, for example the question “I feel confident that I will be able to perform the exercises asked of me during the course of rehabilitation, even if I find them difficult” may only be relevant for those in the PR setting. However at the start of the trial the questionnaire was viewed to be appropriate. As benefits in other variables, such as dyspnoea, are apparent in the SPACE for COPD group you might expect self-efficacy to also improve as

it is theorised that improvements in self-efficacy drive changes in health behaviour. This will be discussed in relation to PA in chapter 8.

No other study has used the PRAISE questionnaire to measure self-efficacy in a SM trial and despite it being a corner stone of self management improvement few studies have measured it. Bucknall (2012) used the COPD self-efficacy scale (CSES) and found no significant improvement or treatment effect (95% CI; 2.65 (-5.85 to 11.14), p=0.540). It may also be argued that patients willing to volunteer for research studies would have a reasonable level of self-efficacy in order to participate, so it may be a difficult concept to monitor.

Exercise Capacity

The ISWT was used to assess functional exercise capacity. The group difference was statistically significant (-23.90m, 95% CI -46.32m to -1.47, p=0.038). Both SPACE for COPD and PR significantly improved from baseline to seven weeks (PR, p= <0.001; SPACE, p= 0.015). It is interesting to note that the mean change in the ISWT did not meet the MCID in either group. It is possible that patients may not have been walking fast enough during their training walks and moreover, a lack of progression in the training intensity (speed) may have contributed to the limited improvement seen particularly in the SPACE for COPD group. Previous work has shown patients with COPD can improve their ISWT distance with the same exercise programme (Evans et al. 2009) it is therefore, most likely that limited improvements in the ISWT

was due to non-adherence to the prescribed speed of walking during home training sessions which has not been monitored.

The ESWT was used to measure endurance capacity. The between group difference (-132.78sec, 95% CI -244.63 to -20.94sec) was significant, and both groups significantly improving from baseline to seven weeks (mean change, (95% CI); PR 345.70sec (260.20 to 431.20) sec; SPACE 212.91, (139.49 to 286.34) sec). The mean group change was above the MCID threshold for both groups. These results were are expected and are in line with previous reports (Apps et al. 2013, Sewell et al. 2006, Evans et al. 2009).

The COPE II study (Effing et al. 2011) used the ISWT as their primary outcome measure and found similar improvements to the SPACE programme, reported at seven months (12.2m, SE 10.6, within group change). They found a significant between group difference (35m.1m; 95% CI 8.4 to 61.8) with their control group who received a single 2 hour SM session. The SPACE for COPD programme had a larger increase in ISWT (18m 95% CI 3 to 32) at seven weeks. The SPACE for COPD study is a noninferiority trial and therefore does not have a control group which receive no intervention. It has been reported that patients with COPD gradually decline over time in their exercise capacity (Griffiths et al. 2000) and therefore even though only small improvements have occurred, if no intervention had been received a decline may have been observed.

This is the first study to show an improvement in ESWT after only seven weeks of a home based SM programme. Effing et al. (2011) found no significant improvement in ESWT as measure by distance in the COPE II study at 7 months (mean (SD) baseline ESWT 679 (553) metres; change at 7 months 106 (67) metres). However, 12 of their subjects completed the 20 minute test at baseline and therefore had no room for improvement.

The six minute walk test (6MWT) is a more widely reported measure of exercise capacity and is important to consider those studies that have employed this test. The 6MWT was not chosen for this study as it is not routinely used in PR at Glenfield Hospital. Of these studies that have used the 6MWT as an outcome measure for a home based programme Ghanem et al. (2010), Gùell et al. (2008) and, Mendes et al. (2010) all found a significant improvement in distance covered. These studies ranged from an 8 to 12 week home based intervention. However, all these studies had less than 35 patients in their home based groups so are very likely to be underpowered. Interestingly, both Maltais et al. (2008) and Monninkhof et al. (2003a), whose studies were adequately powered, did not find any improvement in 6MWT distance measured, respectively, at 3 months and 6 months, post intervention.

The SPACE for COPD intervention involved no supervised exercise sessions apart from the initial introductory meeting where patients had their walking programme explained and demonstrated to show them the speed to which they were prescribed to walk. The Maltais and Monninkhof studies both had high levels of taught education sessions and supervised exercise, including

being provided with exercise equipment and home visits. It is therefore surprising that neither of these studies found an improvement in exercise capacity. One explanation of why the Monninkhof study may not have seen improvements in exercise capacity could be due to the exercise intensity not being adequate enough to elicit a training effect. The training intensity was not standardised and negotiated between the therapist and participant and therefore potentially sub therapeutic. The SPACE programme, although, unsupervised prescribes walking at 85% of maximal walking capacity and therefore, theoretically high enough to induce a training effect in as little as seven weeks. Maltais et al (2008) who reported no improvements in 6MWT distance at 12 weeks prescribed cycling exercise at 60% of the maximal work rate for 40 minutes 3 times a week. The exercise intensity for the home based group was lower than the usual care group due to safety reasons, but their target time was greater to compensate. It is highly likely that no improvements were detected in the 6MWT as cycling was prescribed as the mode of training which may not be specific enough to impact on walking. The mode of training chosen did impact on the cycle endurance test completed as significant improvements were seen at 12 weeks in cycling endurance time.

These findings above highlight the difference between exercise testing protocols. The 6MWT has been shown not to be the most responsive test to show the effects of PR (Laviolette et al. 2008), however, it is commonly reported, and may be more appropriate at discriminating between the severity of disease (Troosters et al. 2002). Improvements in the 6MWT are reliant on the patient improving their walking speed which may be more difficult to

achieve and does not reflect changes in endurance time. This lack of responsiveness in the test protocol may be the reason why minimal effects were detected in Maltais's study. Maltais et al. (2008) also used a constant work rate (CWR) test, which measured cycle endurance time at 80% VO_2peak. CWR is considered to be more responsive at detecting long term improvement in functional performance after PR (Ong et al. 2004). It reflects endurance capacity which is the focus of most PR programmes, whereby programmes prescribe increasing time rather than intensity to instigate progression and health benefits. This current study demonstrated a significant improvement in the ESWT in both the PR and SPACE for COPD groups. The ESWT test is a CWR test and therefore is perhaps more responsive to the effects of exercise training than the ISWT. The ISWT progressively increases the walking speed throughout the duration of the test and are appropriate at indicating peak exercise capacity and has been used to prescribe the intensity of the ESWT. However, it may not be the best protocol to assess changes in PR which are not based on increasing exercise intensity.

The SPACE for COPD programme significantly and clinically enhanced endurance capacity as demonstrated by the improvements detected in the ESWT (figure 5.9). However, limited improvements were reported in ISWT distance. It is not clear as to why this is the case, but it could be due to the nature of the protocol or those being recruited on to the study having higher than normally reported ISWT distance at baseline and therefore, limited room for improvement. However, it could most likely be explained by participant not completing their walking at a high enough intensity. This could explain why

the PR group showed a statistically significant change, but the mean change did not meet the MCID. A possible explanation for why the PR group did not improve their ISWT distance as anticipated could be due to them not completing the home component of the programme at the appropriate intensity. Analysis of change in scores from baseline to seven weeks supports this theory in that those with lower baseline scores improve the most. However, Evans et al. (2009) reported that baseline ISWT level did not predict change in ISWT distance after PR.

A summary of how the SPACE for COPD programme compares to other home based and SM studies based on the ISWT outcome is presented in Figure 5.14.

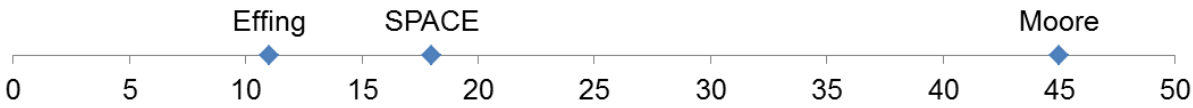


Figure 5.14 Mean change in ISWT distance (m) reported in studies from baseline to post intervention

Reasons for this inconsistency in finding in HRQoL, HADs and exercise performance is in need of further consideration and highlights the difficulty in predicting successful outcomes of rehabilitation programmes. Engagement in the SPACE for COPD may be a key component. The premise for the intervention is to offer an alternative to PR and therefore reach patients that would not normally take part in PR. However, a number of patients may have

been willing to agree to the programme as they have been advised to do PR by a healthcare professional and seen the limited supervision provided by the programme as an easy way not to adhere to the exercise programme. Although progress was assessed during the telephone calls, adherence to the exercise component of the SPACE for COPD study was not fully monitored. It is also possible that the SPACE for COPD programme was too 'light touch' for some participants that require supervision to motivate adherence to the programme. Out of those asked to comment on their preferred treatment, 51% wanted the SPACE for COPD and only 25% want PR. This meant that 29% in the PR and only 5% in the SPACE for COPD received a treatment that wasn't their preference. Although patients were aware that they would be randomly assigned a group, not getting the treatment they preferred may have affected their motivation and engagement in the programme. It is out of the scope of this thesis but it would be of use determine the characteristics of those who did and didn't respond to the SPACE for COPD programme. Future work may also want to evaluate the SPACE for COPD programme offered earlier at the time of referral and not at a point when patients are already expecting supervised outpatient PR.

No statistically significant difference was detected with change in scores at seven weeks in any outcome measure between baseline MRC dyspnoea grades. The exception was the fatigue domain of the CRQ-SR in the PR group. This may be due to it being underpowered, or potentially indicates all MRC grades improve to broadly the same level. However, correlation analysis did detect a relationship between baseline score and change in score in both

groups for the CRQ-SR dyspnoea (figure 5.3 and 5.4), and for the ISWT in the SPACE for COPD group (figure 5.8). This means that those with lower or poorer scores improved the most. It would be interesting to determine the characteristics of those who respond to the intervention programme, however, is out of the scope of this thesis.

5.8 Limitations

A number of limitations have been discussed where relevant to the specific outcome measure. However, a number of methodological limitations need further consideration.

A key limitation is that this study was only single blinded and not double blinded and individual preference to treatment modality could have significantly affected motivation to take part. The premise of SPACE for COPD is to offer an alternative to hospital based PR and not to replace it. However, due to study design and rigor it was not considered appropriate to allow patients to choose which group they were assigned to. As the two interventions are clearly distinct it is highly likely that patients had a preference as to which group they would have preferred to be randomised to. Hence, if they were randomised to a group they didn't want this could have resulted in non-compliance to either the SPACE for COPD programme or to the home exercise aspect of PR. There was a large dropout rate seen in this study which is higher than normally seen in PR. 46 participants were classified as 'lost to follow up', these were the patients that did not complete PR or did not attend the 7 week assessment. It could therefore be argued that

for a proportion of participants the intervention they were allocated to did not meet their expectations.

Another limitation of the study procedure was that adherence to the SPACE for COPD programme was not recorded and no pre-specified definition of compliance was determined at the start of the programme. It would have been useful to record this as it could be expected that those who complied with the programme achieved more enhanced outcomes. It has also resulted in the inability for per protocol analysis to be completed. In addition, as the SPACE for COPD programme is unsupervised it may have been difficult for some patients to consistently meet the prescribed walking speed without it being reviews as in PR, so it may be that a number of patients have either walked at a pace too slow to elicit training benefits or a pace too fast so they fatigue early and de-motivate themselves by not seeing any improvement.

In future it would be useful to determine which component of PR and the SPACE for COPD programme is effective. Those in the PR had weekly contact with a healthcare professional and met with a group of patients undergoing the same experiences and the same treatment. It could be this contact rather than the exercise training and education that have affected a number of the outcome measures. Likewise how effective were the telephone calls received by those in the SPACE for COPD group.

5.9 Conclusion

The aim of this chapter was to determine if the SPACE programme is a noninferior alternative to usual care PR. The results of this study show that SPACE for COPD significantly improve subjective experiences of dyspnoea to a similar level to PR, however, it is inconclusive as to its noninferiority. SPACE also enhances endurance capacity which is noninferior to PR. Overall, SPACE does elicit some key health benefits over a seven week period.

The SPACE for COPD programme did not produce significant improvements in anxiety and depression, however, mean values were low. A sub-group analysis of those with at least a possible presence of anxiety and depression demonstrated a significant improvement. The individual need of each patient needs to be assessed when determining the most appropriate form of support for exercise training.

This is the first noninferiority trials conducted in the UK that has shown that a home based self-managed support model of care elicits significant benefits over a short intervention period. The gains in the SPACE for COPD group did not fully match those achieved in the PR, but as they were statistically and clinically significant warrant consideration for patients who would not otherwise take up the offer of PR.

Chapter 6 - The effectiveness of the SPACE for COPD programme in comparison to Pulmonary Rehabilitation six months post intervention

6.1 Introduction

The effectiveness of SPACE for COPD has been reported over the short term (discussed in chapter 5). However the challenge for successful intervention programmes is how to maintain these improvements over the long term. Although a significant decline is seen from completing PR to follow up assessment (most commonly reported as six or twelve months post intervention), a number of studies (Foglio et al. 1999, Griffiths et al. 2000, Maltais et al. 2008, Singh et al. 1998) have reported exercise capacity significantly higher than baseline levels. Internationally, formal maintenance programmes vary and consist of anything from weekly telephone calls and monthly reinforcement sessions (Ries et al. 2003) to extended PR programmes (Berry et al. 2003). Spencer (2010) investigated a maintenance programme of weekly supervised exercise incorporating a home exercise programme and found that 6 MWD and quality of life were maintained at 12 months. Spencer and others highlights the impact of a maintenance programme. However, it is not clear as to which aspect of the programme that has contributed to maintaining these scores. Was it the home programme or the weekly contact by a healthcare professional.

The potential of SPACE for COPD is in the development of self-management techniques and skills which have a lasting effect and result in long term behaviour change which will have a positive impact of health status. It is possible that the SPACE for COPD programme could result in longer term benefits as it promotes lifestyle changes rather than a short term one off treatment. Also, as home exercise is the focus this may support behaviour change as there is no transition period from an outpatient environment to home.

This chapter will describe the long term (six months) changes of the randomised control trial. Patients that had completed a seven week assessment were contacted six months later and asked to return for a follow up assessment. No other contact was made during this period. This chapter will focus on the following:

- Between group differences from seven weeks to six months
- Within group changes from seven weeks to six months

6.2 Aim

The aim was to determine if the SPACE for COPD programme is noninferior (as good as) to usual care PR in the treatment and management of COPD, six months following the intervention.

6.3 Methods

A full description of the methods of this study can be found in chapter 3. This chapter describes the follow up period of the trial.

All participants who had not withdrawn from the study were invited to attend the hospital to be reassessed six months after completing the intervention. Patients did not have any contact with the research team during this period and therefore assessments were kept blinded. Patients in both intervention groups were encouraged to continue with their walking programme at their seven week assessment, but no other support was given.

6.4 Outcome measures

A full description of the outcome measures used in this study are described in Chapter 3.6. The key outcome measures explored in this chapter are

- Chronic respiratory questionnaire – Self reported (CRQ-SR)
    - Dyspnoea, fatigue, emotion and mastery
- Hospital Anxiety and Depression Scale (HADS)
- Incremental shuttle walk test (ISWT)
- Endurance shuttle walk test (ESWT)
- Pulmonary Rehabilitation Adapted Index of Self Efficacy (PRAISE)

6.5 Statistical analysis

Statistical analyses were completed using the statistical package IBM SPSS statistics version 20. An independent t-test was completed on the baseline

characteristics between those that completed the study and those who withdrew. Repeated measures ANOVA were conducted on all outcome measures to determine any between group differences. For outcome measures with a statistically significant level of sphericity the Greenhouse-Geisser correction was used, and for outcome measures with no statistical significance the test of assumed sphericity was used. A significance level of p=<0.05 was applied.

6.6 Results

287 patients with COPD were recruited to the study. 142 were randomised to the PR intervention and 145 to the SPACE for COPD intervention. Of these patients 84 from the PR group and 95 from the SPACE for COPD group completed the seven week assessment. At the time of the six month assessment a further 14 (17%) withdrew from the PR group and 20 (21%) from the SPACE for COPD group. Therefore 70 from the PR group and 75 from the SPACE for COPD group completed the six month assessment. Reasons for non-completion of the six month assessment are highlighted in figure 6.1. An independent t-test was completed on the continuous data and chi squared on the categorical data to determine if there was any differences in the baseline profile of those that completed the study and those that did not. Although higher mean scores were observed in both the exercise performance tests they were not statistically significant, nor were any other baseline characteristic (table 6.1).

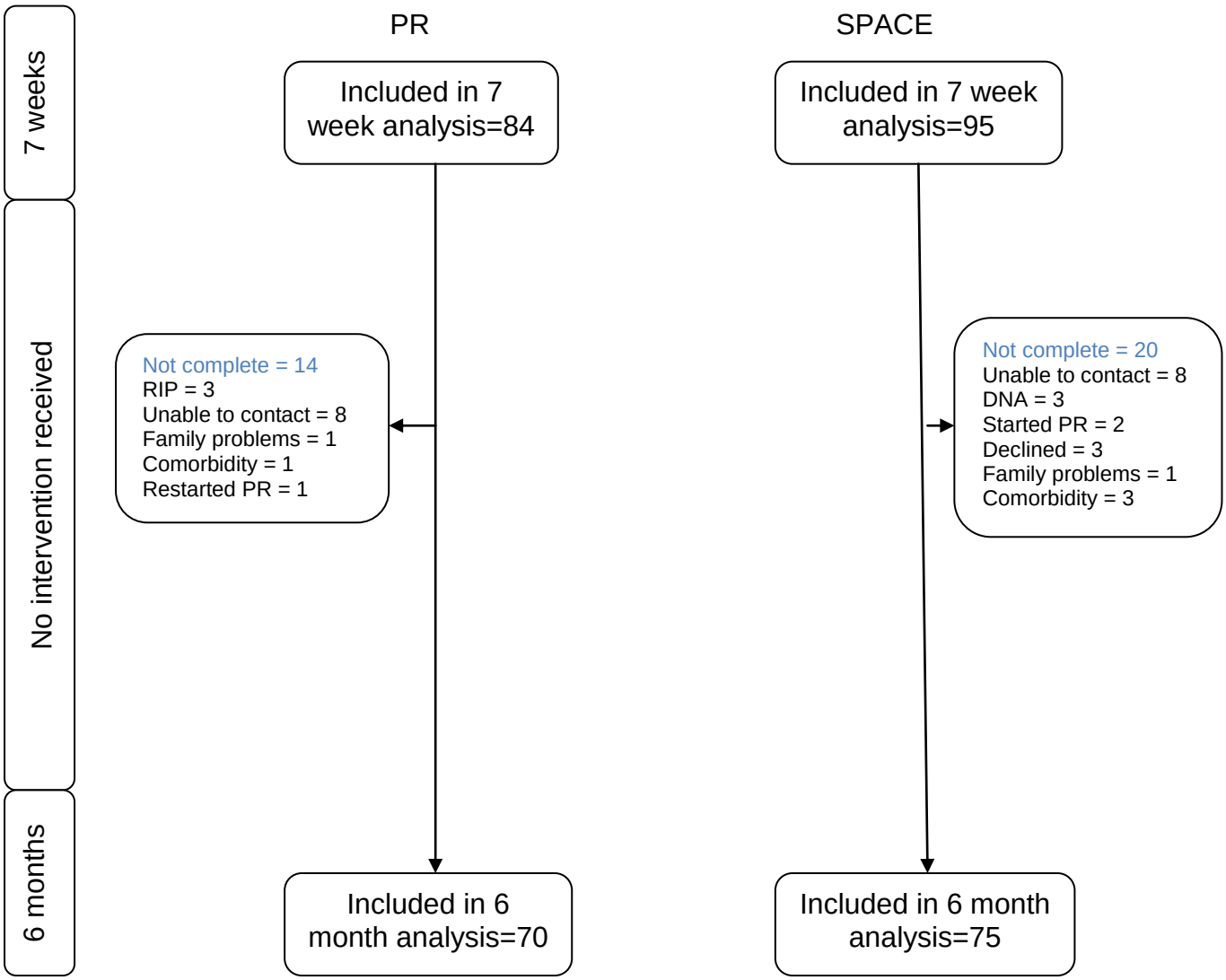


Figure 6.1 flow diagram of study from seven weeks to six months with reasons for withdrawal.

Table 6.1 Baseline characteristics of those that completed and did not complete the six month study. Mean (SD) unless otherwise stated.

	Completers n=143	*Non-completers n=145*	*p value*
Age (yrs)	67.52 (8.63	65.46 (9.10)	0.958
Male:Female (n;%)	95(66%):48(34%)	93(64%):52(36%)	0.682
BMI (m/kg^2)	27.06 (6.16)	28.20 (2.22)	0.126
FEV_1 (litres)	1.23 (0.55)	1.29 (0.55)	0.365
FVC (litres)	2.72 (0.92)	2.69 (0.82)	0.776
MRC (n:%)			0.568
2	28 (19.58%)	21 (14.48%)	
3	57 (39.86%)	52 (35.86%)	
4	40 (27.97%)	47 (32.42%)	
5	19 (13.29%)	25 (17.24%)	
SpO_2 rest %	90.04 (5.42)	90.36 (5.78)	0.630
Smoking status (n:%)			0.568
Current smoker	32 (22.4%)	38 (34.09%)	
Never smoked	9 (6.3%)	6 (4.14%)	
Ex smoker	102 (71.3%)	101 (69.66%)	
Pack years	45.13 (30.44)	47.32 (32.56)	0.566
CRQ-SR			
Dyspnoea	2.48 (0.83)	2.54 (1.03)	0.575
Fatigue	3.48 (1.12)	3.29 (1.26)	0.217
Emotion	4.41 (1.23)	4.39 (1.25)	0.940
Mastery	4.40 (1.35)	4.51 (1.36)	0.543
HADS			
Anxiety	7.68 (3.84)	7.52 (4.16)	0.753
Depression	6.15 (3.20)	6.60 (3.71)	0.293
PRAISE	44.59 (7.24)	44.24 (7.74)	0.710
ISWT (distance)	270.10 (150.68)	237.45 (147.17)	0.066
ESWT (sec)	220.63 (190.21)	188.37 (129.35)	0.097

Health related quality of life (HRQoL)

Chronic Respiratory Questionnaire – Self Report

For the primary outcome of CRQ-SR dyspnoea the repeated measures ANOVA showed Machly's test of sphericity to be not significant (p=0.78), therefore, no correction was needed and assumed sphericity was used. Table 6.2 shows the within subject effects of the time and time and intervention, and between group effects of the CRQ-SR dyspnoea score.

Table 6.2 Significance values for within and between group effects for CRQ-SR Dyspnoea at six months

	Within subject effects		*Between group effects*
	Time	Time*Intervention	
CRQ-SR Dyspnoea	<0.0001	0.063	0.38

The mean (SD) CRQ-SR dyspnoea score for each time point is presented in table 6.4 and figure 6.2

Table 6.3 shows the percent of patients meeting the MCID for CRQ-SR dyspnoea in the PR and SPACE for COPD groups.

Table 6.3 Percent of patients meeting the MCID for CRQ-SR Dyspnoea in both intervention groups

	Change <0.5 %	*Change ≥ 0.5 %*	*Range (-7 to 7)*
Pulmonary Rehab	54	46	-1.53 to 4.40
SPACE	55	45	-4.00 to 2.8

Table 6.4 Mean (SD) baseline, seven week and six month scores and change in scores from baseline to six months in CRQ-SR Dyspnoea for PR and SPACE

CRQ-SR dyspnoea score	*PR mean (SD; n=70)*	*SPACE mean (SD; n=75)*	**Between-group difference mean (95%CI)**
Baseline	2.42 (0.91)	2.58 (0.93)	0.16 (-0.05 to 0.41)
7 weeks	3.38 (1.18)	3.11 (1.23)	-0.27 (-0.62 to 0.15)
6 months	3.08 (1.25)	2.80 (1.13)	-0.28 (-0.69 to 0.13)
Mean change (baseline to 6 months)	0.66 (1.20)	0.22 (1.24)	-0.44 (-0.87 to -0.03)

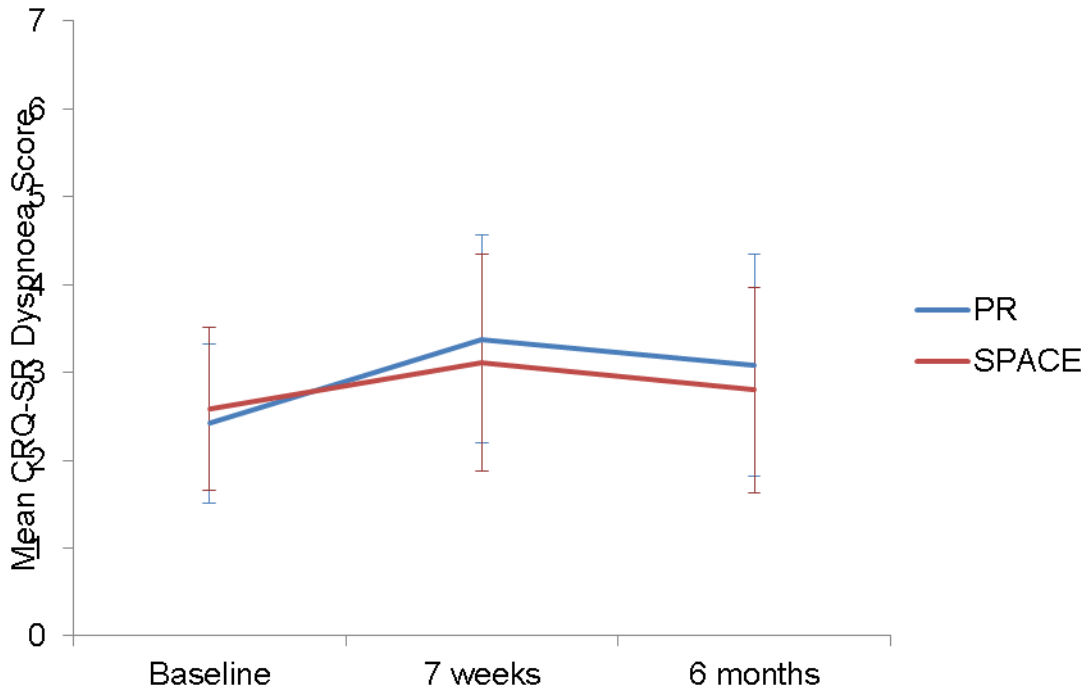


Figure 6.2 Mean (SD) CRQ-SR dyspnoea scores for PR and SPACE over the three assessment points

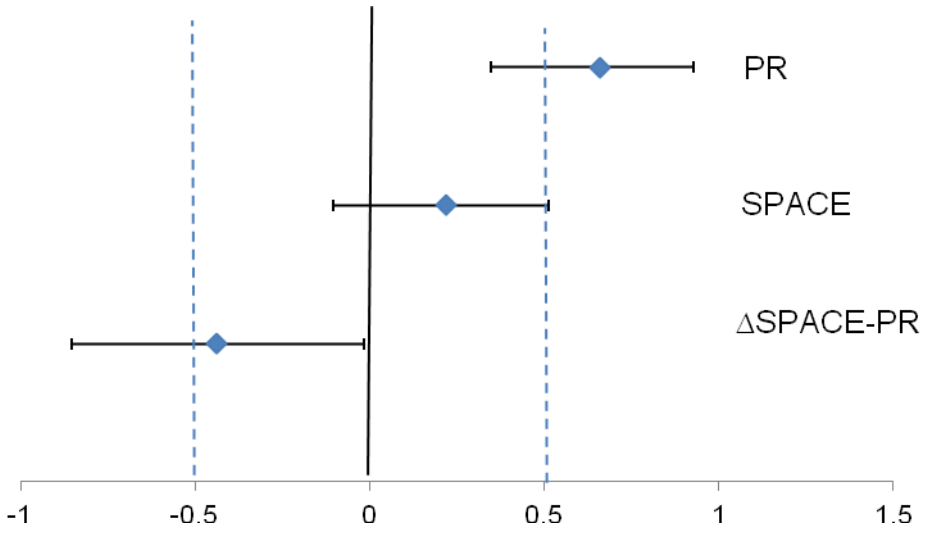


Figure 6.3 Change in CRQ-SR Dyspnoea from baseline to six months

Figure 6.3 plots the change and 95% CI in the CRQ-SR dyspnoea score from baseline to six months. Overall the results show that for CRQ-Dyspnoea there was no difference (p=0.38) between groups at six months (table 6.2). However, the noninferiority margin of 0.5 units (MCID for CRQ-SR) is breached by the 95% CI of the ΔSPACE-PR therefore, this still leads to some uncertainty as to the effectiveness of SPACE for COPD at 6 months (figure 6.3).

Secondary outcomes

The other domains that make up the CRQ-SR of fatigue, emotion and mastery were analysed. Mauchly's test of sphericity was not significant in all three domains (fatigue p=0.580; emotion p=0.819; mastery p=0.171). Repeated measures ANOVA findings are presented in table 6.4.

Table 6.5 Significance values for within and between group effects for CRQ-SR Fatigue, Emotion and Mastery

CRQ Domain	*Within subject effects*		*Between group effects (p=)*
	Time (p=)	Time*Intervention (p=)	
Fatigue	<0.0001	0.210	0.744
Emotion	<0.0001	0.031	0.620
Mastery	0.001	0.083	0.779

The mean (SD) values for the CRQ-SR domains at baseline, seven weeks, six months and mean change from baseline to six months are presented in table 6.6 and figures 6.4, 6.5 and 6.6. The findings suggest that after an initial increase in scores at seven weeks (although not significant for the SPACE for COPD group), they have returned to baseline levels at six months. However, this is apparent in both intervention groups as there is no significant difference in intervention groups at six months (Table 6.5)

Table 6.6 Mean (SD) Baseline, seven week and six month CRQ-SR scores and change in scores from baseline to six months for PR and SPACE

CRQ-SR Domain		*PR mean (SD; n=70)*	*SPACE mean (SD; n=75)*	Between-group difference mean (95%CI)
fatigue score	Baseline	3.36 (1.20)	3.42 (1.19)	0.06 (-0.24 to 0.35)
	7 weeks	4.09 (1.49)	3.71 (1.22)	-0.38 (-0.83 to 0.01)
	6 months	3.47 (1.31)	3.44 (1.40)	-0.03 (-0.53 to 0.39)
	Change	**0.11 (1.27)**	**0.02 (1.28)**	**-0.09 (-0.68 to 0.19)**
emotion score	Baseline	4.37 (1.24)	4.41 (1.24)	0.04 (-0.30 to 0.32)
	7 weeks	4.92 (1.03)	4.56 (1.20)	-0.36 (-0.71 to -0.01)
	6 months	4.51 (1.23)	4.28 (1.32)	-0.23 (-0.59 to 0.28)
	Change	**0.14 (1.02)**	**-0.13 (0.23)**	**-0.27 (-0.71 to 0.15)**
mastery score	Baseline	4.36 (1.30)	4.50 (1.31)	0.14 (-0.22 to 0.46)
	7 weeks	4.94 (1.19)	4.78 (1.31)	-0.16 (-0.58 to 0.20)
	6 months	4.61 (1.27)	4.54 (1.33)	-0.07 (-0.55 to 0.44)
	Change	**0.25 (1.18)**	**0.04 (1.34)**	**-0.21 (-0.86 to 0.03)**

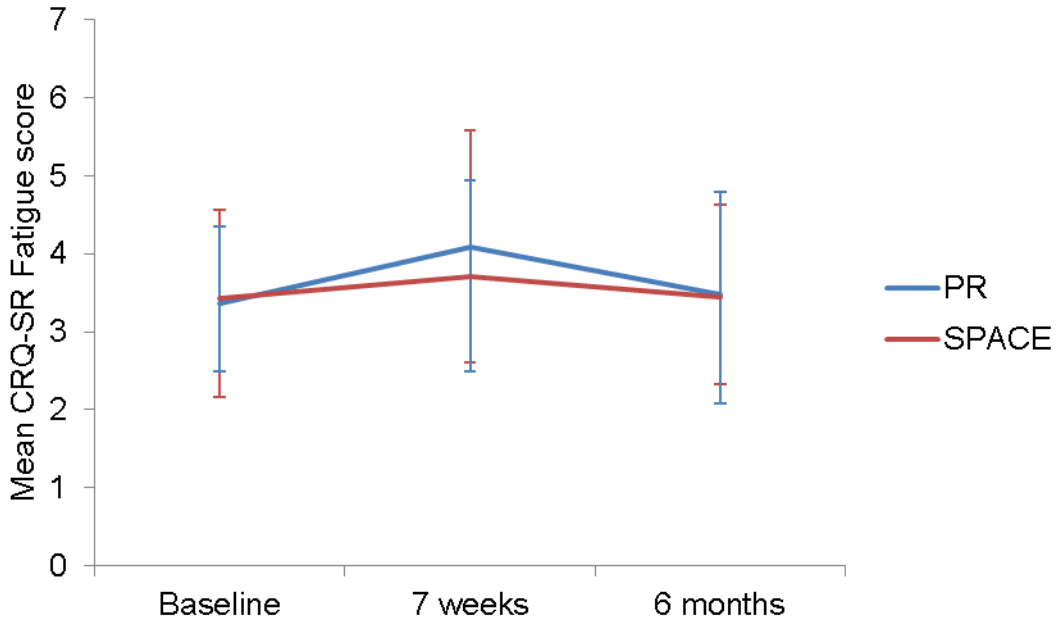


Figure 6.4 Change in mean CRQ-SR Fatigue at baseline, seven week and six months

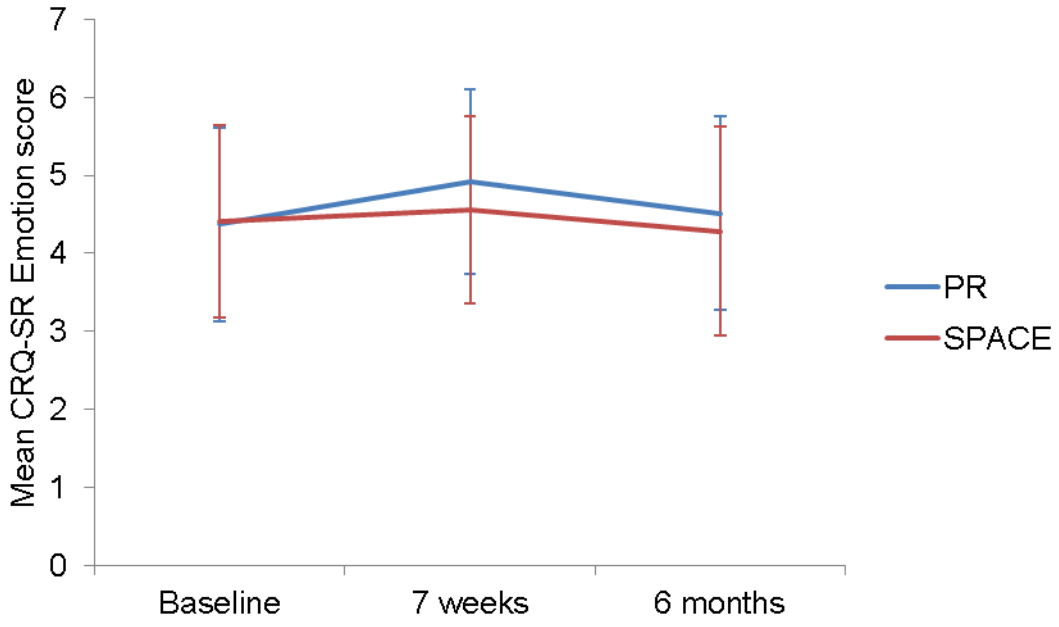


Figure 6.5 Change in mean CRQ-SR Emotion at baseline, seven weeks and six months

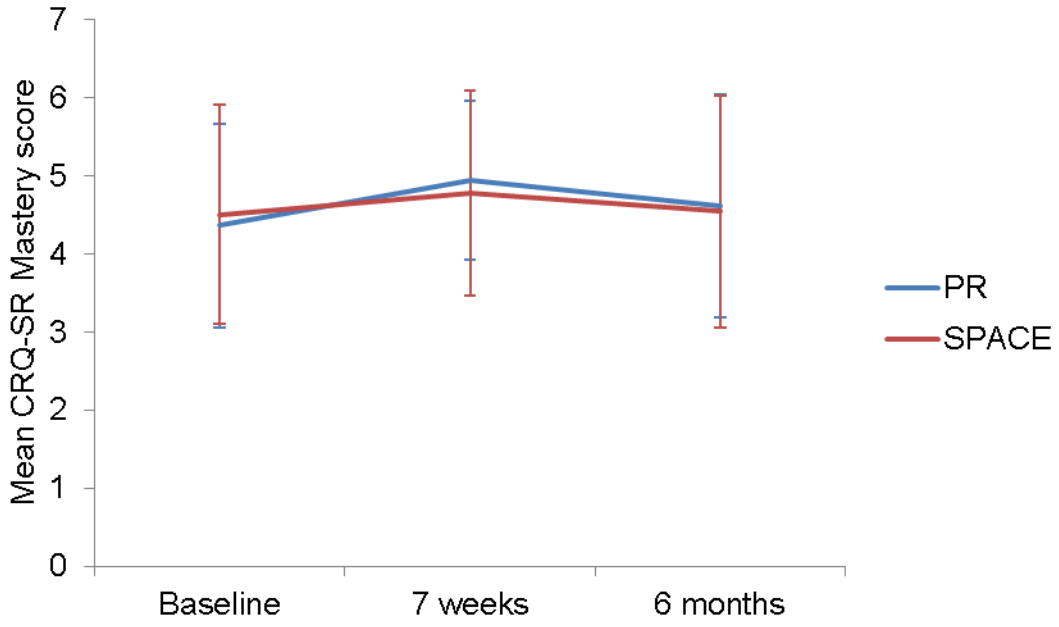


Figure 6.6 Change in mean CRQ-SR Mastery at baseline, seven weeks and six months

Anxiety and Depression

Anxiety and depression were measured using the HADS questionnaire. Mauchly's test of sphericity was not significant for anxiety (p=0.649), therefore spericity assumed was used, but for Depression scores it was significant (p=0.042), therefore, Greenhouse-Geisser was used to correct for this. Results of the repeated measure ANOVA can be found in table 6.7.

Table 6.7 Significance values for within and between group effects for Anxiety and Depression scores at six months

HADS Domain	*Within subject effects*		*Between group effects (p=)*
	Time (p=)	Time*Intervention (p=)	
Anxiety	0.003	0.251	0.599
Depression	0.007	0.158	0.989

Mean baseline, seven weeks, six months and changes from baseline to six months for anxiety and depression scores are presented in Table 6.7 and figures 6.7 and 6.8. Lower scores indicate lower levels of anxiety or depression. The data shows that there is a significant effect of time for both anxiety and depression and that there is no difference between the interventions at six months. However, as the MCID of 1.5 units is not achieved during any time point for either group there is no clinically significant change seen in anxiety or depression.

Table 6.8 Mean (SD) Baseline, seven week and six month HADS and change in scores from baseline to six months for PR and SPACE

HADS Domain		*PR mean (SD; n=70)*	*SPACE mean (SD; n=75)*	Between-group difference mean (95%CI)
Anxiety score	Baseline	7.91 (3.97)	7.39 (4.00)	-0.52 (-1.40 to 0.54)
	7 weeks	6.80 (3.64)	7.14 (4.07)	0.34 (-0.79 to 1.60)
	6 months	7.96 (4.13)	7.31 (4.31)	-0.65 (-2.06 to 0.76)
	Change	**0.05 (3.18)**	**-0.08 (3.31)**	**-0.13 (-0.77 to 1.43)**
Depression score	Baseline	6.67 (3.32)	6.11 (3.59)	-0.56 (-1.36 to 0.31)
	7 weeks	5.55 (3.13)	5.96 (3.57)	0.41 (-0.46 to 1.63)
	6 months	6.52 (3.58)	6.26 (3.64)	-0.26 (-1.45 to 0.94)
	Change	**-0.15 (3.06)**	**0.15 (3.12)**	**0.30 (-0.79 to 1.31)**

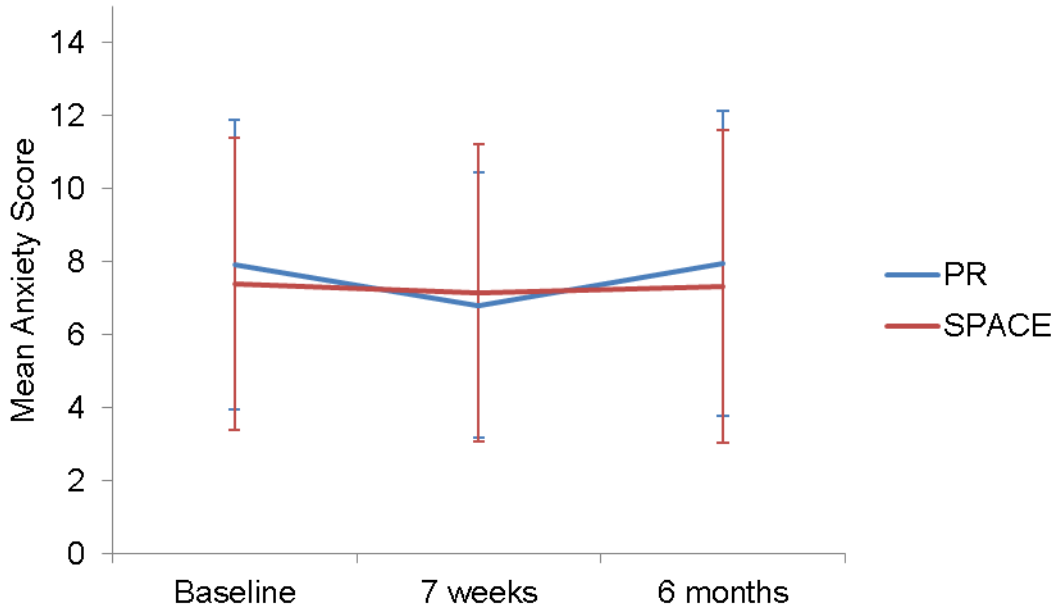


Figure 6.7 Change in mean HADS Anxiety at baseline, seven weeks and six months

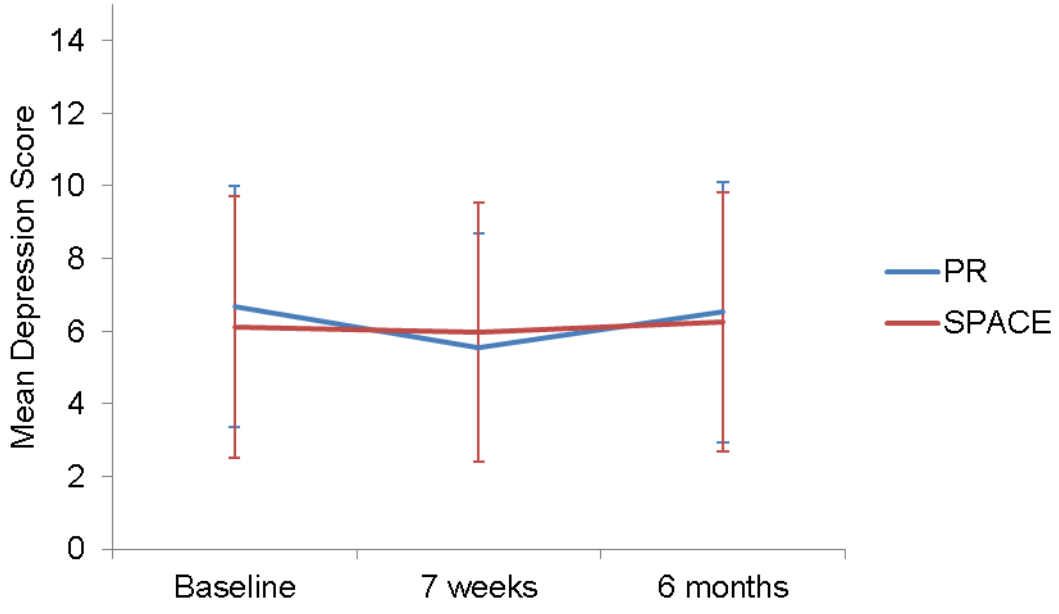


Figure 6.8 Change in mean HADS Depression scores at baseline, seven weeks and six months

The threshold for someone to be considered to have a possible presence anxiety or depression is a score of 8 or above in either domain on the HADS. Therefore, as the mean anxiety and depression scores were below this level a sub group of those with baseline score above or equal to 8 in anxiety and depression are presented in table 6.9 and figures 6.9 and 6.10

Table 6.9 Mean (SD) Baseline, seven week and six month HADS and change in scores from baseline to six months for PR and SPACE for those with baseline score ≥8

HADS Domain		*PR mean (SD)*	*SPACE mean (SD)*	Between-group difference mean (95%CI)
Anxiety score (PR n=39, SPACE n=27)	Baseline	10.75 (2.65)	11.10 (2.68)	0.35 (-0.59 to 1.29)
	7 weeks	8.63 (3.55)	9.38 (4.03)	0.75 (-0.97 to 2.48)
	6 months	9.58 (3.81)	10.00 (3.88)	0.43 (-1.44 to 2.29)
	Change	**-1.17 (2.95)**	**-1.1 (3.67)**	**0.08 (-1.53 to 1.65)**
Depression score (PR n=19, SPACE n=16)	Baseline	10.62 (2.59)	10.54 (2.51)	-0.08 (-1.23 to 1.07)
	7 weeks	9.33 (2.01)	9.48 (2.94)	0.14 (-1.40 to 1.69)
	6 months	10.11 (2.13)	10.13 (2.70)	0.02 (-1.64 to 1.68)
	Change	**-0.51 (3.44)**	**-0.41 (3.42)**	**0.10 (-2.77 to 1.96)**

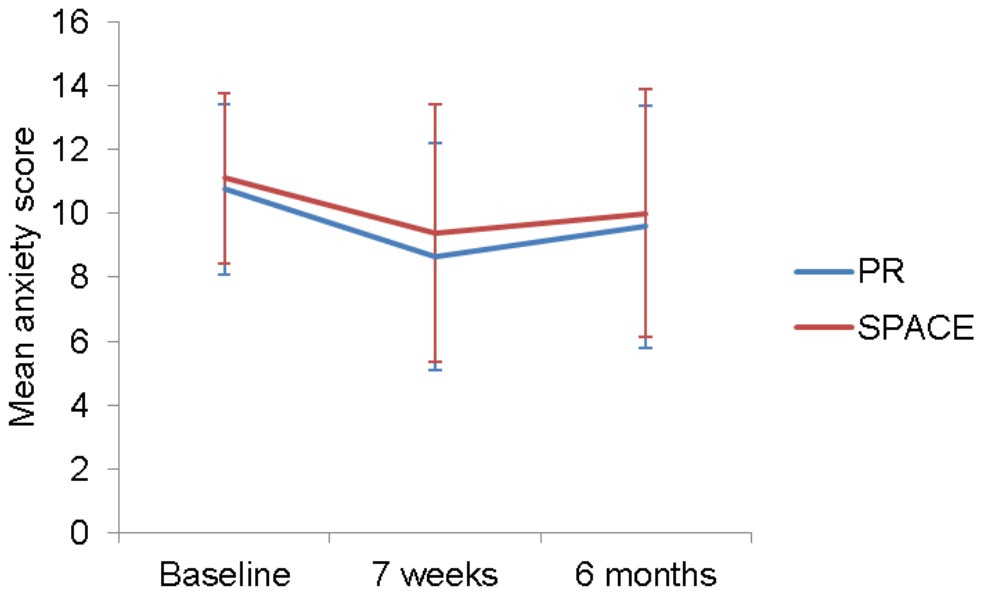


Figure 6.9 Change in mean HADS Anxiety at baseline, seven weeks and six months

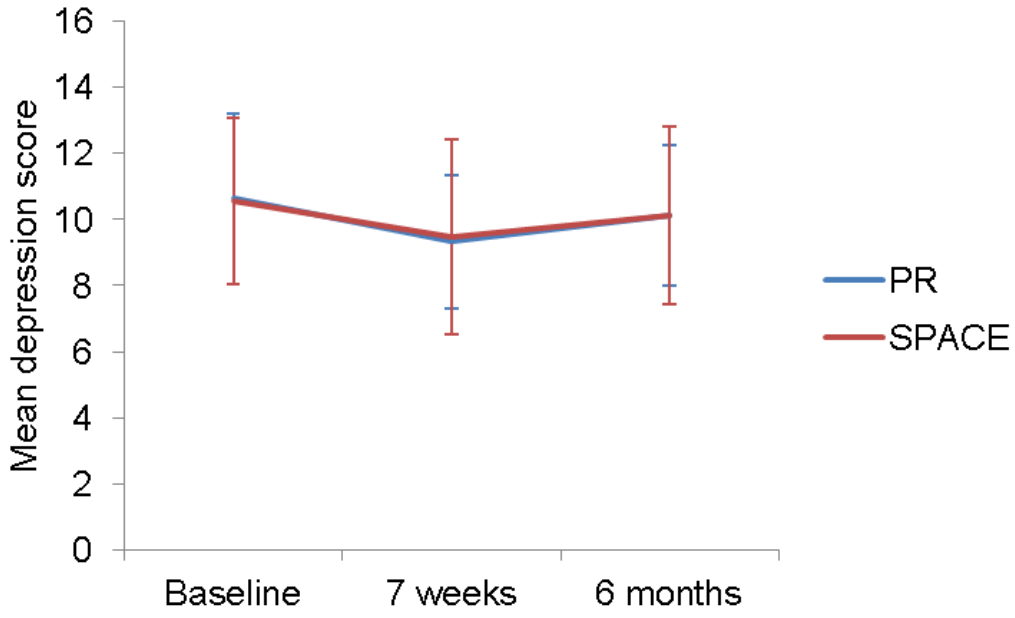


Figure 6.10 Change in mean HADS Depression scores at baseline, seven weeks and six months

Self-Efficacy

Self-efficacy was measured using the PRAISE questionnaire. Mauchly's sphericity was not significant (p=0.194), therefore, sphericity was assumed. Within and between group effects are presented in table 6.10. Mean (SD) scores are presented in table 6.11 and figure 6.11. Results suggest that although small, but significant (p=0.001) changes in self efficacy occurred over time these changes were in a negative direction meaning self-efficacy was lower at six months than at baseline in both intervention groups.

Table 6.10 Significance values for within and between group effects for PRAISE scores

	Within subject effects		*Between group effects (p=)*
	Time (p=)	Time*Intervention (p=)	
PRAISE score	0.001	0.148	0.271

Table 6.11 Mean (SD) Baseline, seven week and six month PRAISE scores and change in scores from baseline to six months for PR and SPACE

Self-Efficacy PRAISE	*PR mean (SD; n=70)*	*SPACE mean (SD; n=75)*	Between-group difference mean (95%CI)
Baseline	44.81 (7.00)	44.83 (7.44)	0.02 (-1.77 to 1.95)
7 weeks	47.24 (8.09)	44.69 (8.66)	-2.55 (-4.86 to 0.13)
6 months	44.11 (9.06)	43.21 (8.79)	-0.9 (-3.86 to 2.05)
Change	**-0.7 (9.73)**	**-1.62 (8.14)**	**-0.92 (-4.35 to 1.82)**

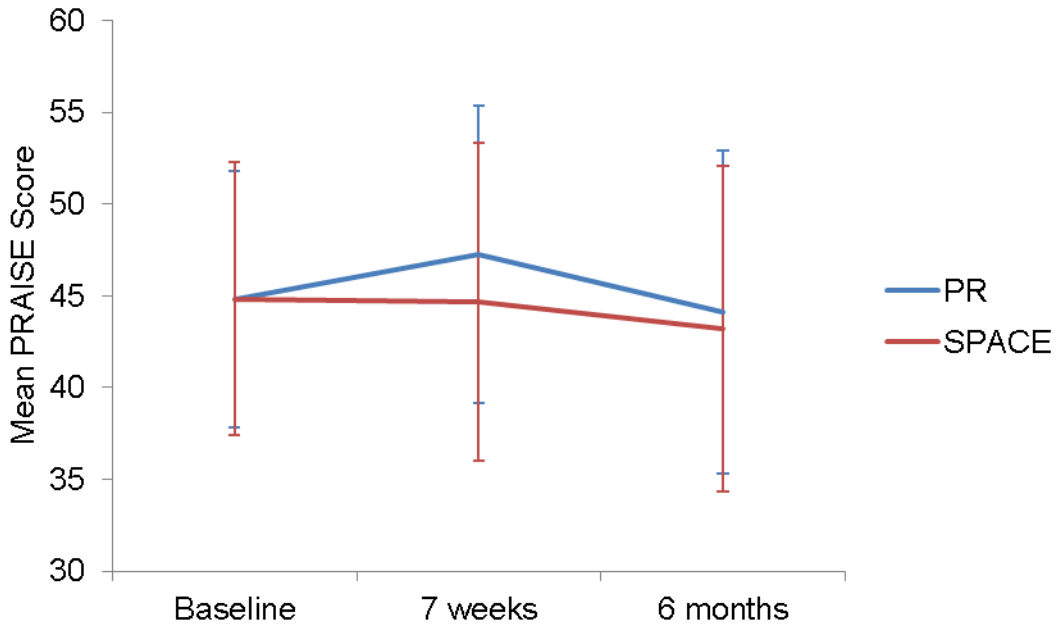


Figure 6.11 Change in mean PRAISE scores at baseline, six weeks and six months

Exercise Performance

There was a number of participants in the PR (n=4) and SPACE for COPD (n=16) groups that were unable to complete the walking tests at the six month assessment period. However, did complete the questionnaires, therefore the exercise performance data presented is based on 125 participants. Exercise performance was measured using the ISWT and the ESWT. Mauchly's test of sphericity was significant for the ISWT (p=0.029) and the ESWT (p=0.001), therefore Greenhouse-Geisser was used. Results from the repeated measures ANOVA are presented in table 6.12. Results suggest that there was a significant effect of time (ISWT and ESWT both p=<0.0001), and there were no difference between interventions in the ISWT (p=0.463) and the ESWT (p=0.912).

Table 6.12 Significance values for within and between group effects for ISWT and ESWT scores (n=125)

	Within subject effects		*Between group effects (p=)*
	Time (p=)	Time*Intervention (p=)	
ISWT	<0.0001	0.344	0.463
ESWT	<0.0001	0.261	0.912

The mean baseline, seven week, six months and change in scores from baseline to six months for the ISWT and the ESWT are presented in table 6.13 and plotted in figures 6.10 and 6.11. The ISWT suggests a significant

effect of time, but six month scores have returned to near baseline levels. The ESWT also significantly changes over time, with the PR group exceeding the MCID of 186 seconds through to the six month assessment (mean change 255.56 seconds). The SPACE for COPD group has a mean score close to the MCID (176.85 seconds) and there are no significant differences between groups at 6 months.

Table 6.13 Mean (SD) Baseline, seven week and six month ISWT and ESWT scores and change in scores from baseline to six months for PR and SPACE

		PR mean (SD; n=66)	*SPACE mean (SD; n=59)*	Between-group difference mean (95%CI)
ISWT (m)	Baseline	268.61 (149.89)	260.24 (147.91)	-8.37 (-37.99 to 32.03)
	7 weeks	310.13 (156.46)	277.86 (145.59)	-32.27 (-74.45 to 17.75)
	6 months	270.00 (150.94)	248.14 (151.86)	-21.86 (-183.90 to 111.04)
	Change	**1.39 (86.47)**	**-12.1 (70.30)**	**-16.49 (-31.26 to 24.96)**
ESWT (sec)	Baseline	189.14 (96.25)	231.42 (231.00)	42.28 (-26.26 to 50.36)
	7 weeks	534.85 (395.38)	444.33 (393.09)	-90.52 (-226.20 to 18.34)
	6 months	444.70 (414.89)	408.27 (420.09)	-36.43 (-183.90 to 111.19)
	Change	**255.56 (386.88)**	**176.85 (400.91)**	**-78.71 (-214.83 to 63.27)**

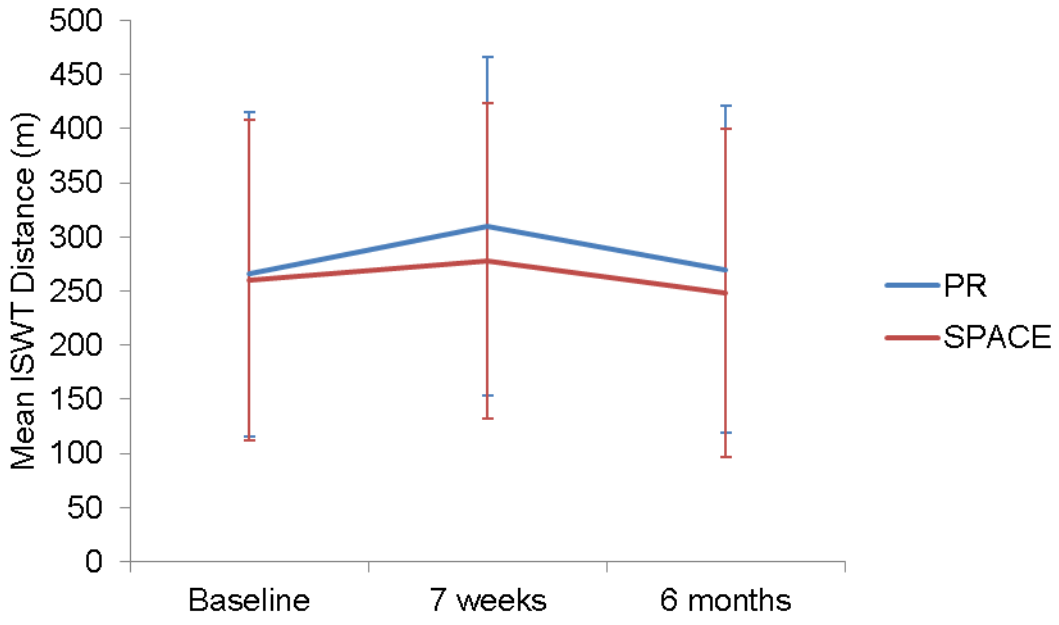


Figure 6.12 Change in mean ISWT distance (m) at baseline, seven weeks and six months

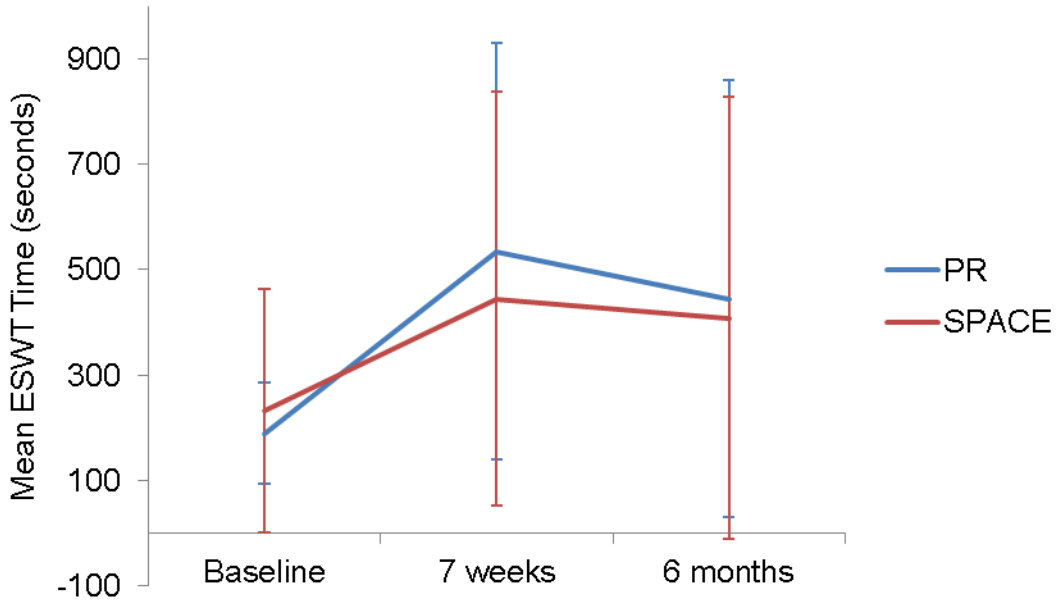


Figure 6.13 Change in mean ESWT time (seconds) at baseline, seven weeks and six months

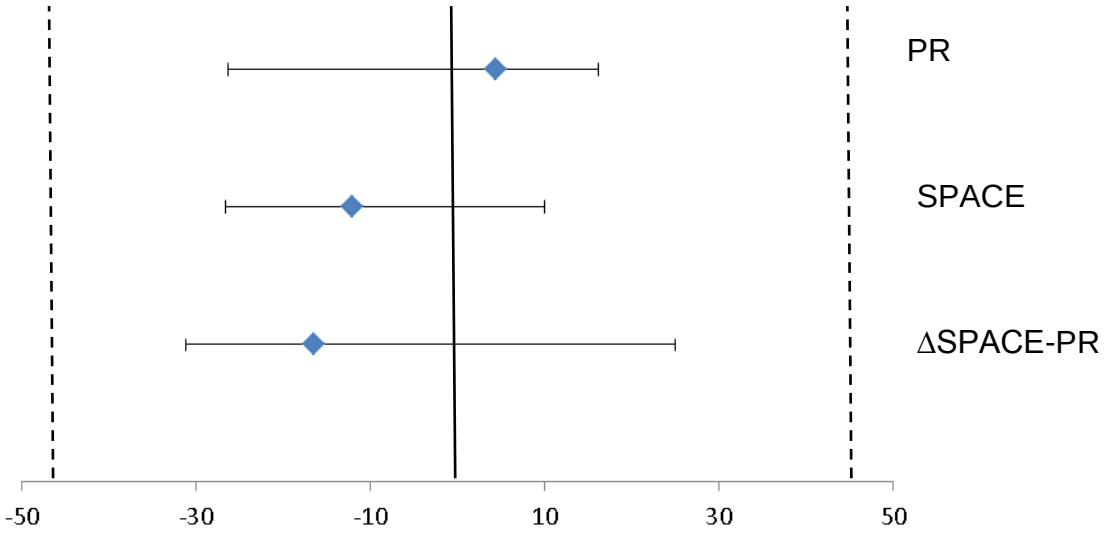


Figure 6.14 Change in ISWT distance (m) from baseline to six months

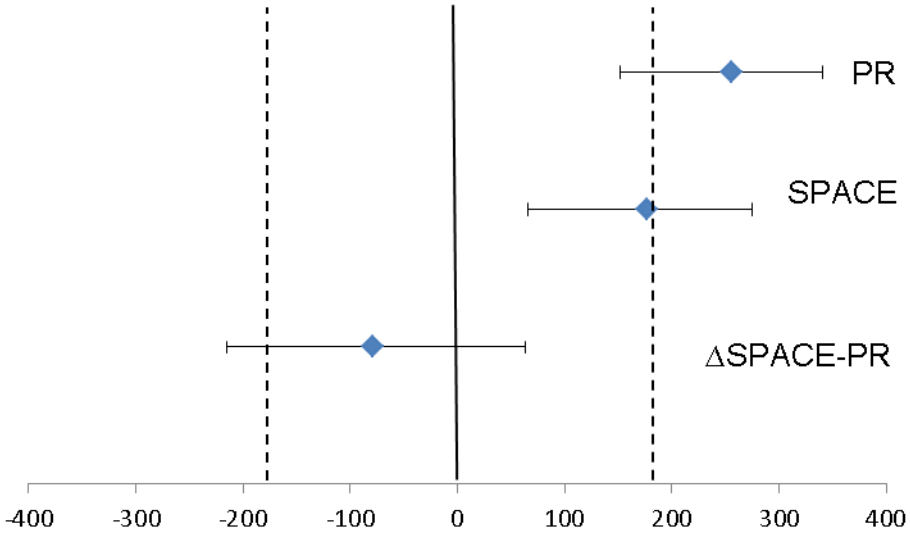


Figure 6.15 Change in ESWT time (seconds) from baseline to six months

Figures 6.12 and 6.13 plot the change and 95% CI in the ISWT and ESWT score from baseline to six months. Overall the results show that for the ISWT and the ESWT there was no difference between groups at six months (table

6.11). Results from the ISWT would suggest that SPACE in noninferior and neither the ∆SPACE-PR or it's 95%CI breach the noninferiority margin. However the mean change in score do not met the MCID of 50m, there is some uncertaininty of the effectiveness of PR on this measure. The results from the ESWT show that the 95% CI of the ∆SPACE-PR changes breach the noninferiority margin and therefore leave some uncertainty as to the noninferiority of SPACE for COPD over PR.

6.7 Discussion

Chapter 5 presented the findings of the SPACE for COPD trial at 7 weeks. This chapter aimed to address the six month follow up results of the SPACE for COPD trial in comparison to conventional PR. The overall trial was designed to detect changes in CRQ-SR dyspnoea at seven weeks and required a minimal sample size of 77 in each group, this was achieved at seven weeks. By six months 70 patients completed the six month assessment in the PR group and 75 in the SPACE for COPD group. A consequence of not achieving enough patients to meet statistical power is the increased risk of a type II error, where the null hypothesis is not rejected when it is in fact false. Statistical power was met at seven weeks, but the six month data did not, therefore, must be interpreted with caution. This section will discuss the findings of the six month follow up trial in relation to other research studies, evaluate the limitations and draw conclusions.

Fifty per cent of those recruited at baseline did not complete the six month assessment. No statistically significant difference was seen between those

that completed and those that did not. Reasons for withdrawal between the seven week assessment and the six month assessment are reported in figure 6.1. As previously highlighted in Chapter 5 baseline characteristics did not concur with what has frequently been reported in clinical practice in this centre for a number of measures. MRC scores are towards the less severe end of the scale compared to the expected profile of patients in PR (Evans et al. 2009), however, no difference was seen in change in scores at seven weeks in the different MRC group scores, this supports Evans et al. (2009) who reported that all MRC grades show comparable improvements in ISWT distance.

PR is effective at improving health outcomes of patients with COPD. Griffith (2000) demonstrated that a 6 week PR programme enhanced walking performance and HRQoL, however, once the programme ceased these improvements progressively diminished at 12 months. Interestingly, the control group that received no intervention declined at six weeks and 12 months from baseline. Due to the initial increase in health outcomes during PR, but despite the subsequent decline, clinical and statistical differences were detected between the groups at 12 months (Griffith et al. 2000).

Although initial improvement were seen in both the PR and SPACE for COPD groups maintaining these improvements is crucial. Various strategies for maintaining these improvements include repeat PR, home based and community based programmes and telephone calls (Berry et al. 2003, Bestall et al. 2003, Brooks et al. 2002, Cockram, Cecins and Jenkins 2006, Güell et al. 2000, Moullec et al. 2008, Ries et al. 2003, Spencer, Alison and McKeough

2010), although non are conclusive (Bolton et al. 2013, Spruit et al. 2013). This section will discuss the outcome measures and then aim to put the SPACE for COPD programme in context to other types of programmes and maintenance strategies.

Health Related Quality of Life (HRQoL) CRQ – SR Dyspnoea, Fatigue, Mastery and Emotion

The primary outcome was the CRQ-SR dyspnoea. The repeated measures ANOVA suggests there is no statistical difference between the PR and SPACE for COPD groups six months after the end of the interventions (p=0.38, Table 6.2). The results also show there is a significant effect of time regardless to which group patients were randomised to (p=<0.0001, table 6.2), meaning both groups significantly improved over time. The mean (SD) changes from baseline to six months were 0.66 (1.20) for the PR group and 0.22 (1.24) in the SPACE for COPD group. The mean score only met the MCID of 0.5 units in the PR group. However there was little difference between groups when looking at the number of people meeting this threshold. 46% in the PR group met this MCID compared to 45% in the SPACE for COPD group. The range of scores were much larger in the SPACE for COPD group which could account why there was a lower mean change, but similar numbers met the MCID in comparison to the PR group. Figure 6.3 shows the changes in CRQ-SR dyspnoea score from baseline to six months. Despite the mean difference in the change scores between SPACE for COPD and PR not being more than the noninferiority margin of 0.5 units the 95% CI do breach

this level meaning there is still some uncertainty as to the noninferority of the SPACE for COPD programme over PR.

There is an inconsistency of outcome and duration of treatment but the most relevant papers to consider are the Maltais et al. (2008) and Effing et al. (2011) studies. The home based Maltais et al. (2008) study used the CRQ-SR dyspnoea as the primary outcome measure for their noninferiority trial of home based self-managed rehabilitation in comparison to usual outpatient care. This study found that both their interventions led to improvements and that the home programme was not inferior to the outpatient programme at three months and one year. However, they did not report any findings at four weeks to determine the effect of their front loaded education programme. This study reported mean differences (95% CI) in CRQ-SR dyspnoea score from baseline to three months of 0.82 (0.64 to 1.01) and from baseline to one year of 0.62 (0.43 to 0.80) in the home group. These figures show a similar increase in dyspnoea score to the SPACE for COPD programme in the short term, but the one year change in score in the Maltais et al. (2008) study is greater than the six month change in the SPACE for COPD group (mean change 0.22 SD 1.24). The difference in the programmes could be explained by the more comprehensive packaged offered by the Maltais study. This study comprised of eight educational sessions over four weeks followed by three times a week for eight weeks exercise based programme. Cycle ergometers were loaned to the participants and an exercise specialist initiated the programme in the patient's home. Intensity on a cycle ergometer is easier to regulate than walking speed and as previously speculated the exercise

training may be the driving force behind changes in dyspnoea. During this eight week programme patients were also telephoned weekly to reinforce the importance of exercise and to detect any problems. This study also had a maintenance element to their programme where each patient was given personalised exercise training recommendations and were contacted every two months to reinforce intended behaviours. Patients were also able to call their case manager for advice throughout the one year trial. In contrast patients in the SPACE for COPD intervention, although were advised to continue with their walking programme and to use the SPACE for COPD manual had no contact with the research team between their seven week and six month assessments.

Effing et al. (2011) studied patients with mild to moderate COPD in a community based programme and also reported CRQ-SR dyspnoea scores. This study reported significant mean (SE) changes of 0.37 (0.13) at seven months and 0.30 (0.13) at 12 months. SPACE for COPD shows an initial mean (SD) change at seven weeks of 0.66 (1.20), which is above the MCID and at six months 0.22 (1.24), which is broadly a similar magnitude to Effing et al. (2011) findings. Effings study is comparable with Maltais (2008) study in that patients received treatment between each assessment point whereas no contact was made between the seven week and six month assessments in the SPACE for COPD trial. It is therefore possible that more support and interaction from healthcare professionals is required to maintain these benefits achieved. This is a potential issue for both the PR and SPACE for COPD groups.

Fatigue, emotion and mastery were also reported as part of the CRQ-SR. All domains showed no significant between group effects at six months (table 6.4). Within group effects do suggest a significant effect of time, however, the improvements shown at seven weeks in the SPACE for COPD group do not meet the MCID of 0.5, so are clinically not significant, and have returned to baseline levels at six months. The PR group do increase their score above the MCID at seven weeks but they have also declined at 6 months, falling back to baseline levels (Table 6.5). Therefore, SPACE for COPD can maintain baseline health related quality of life measures, although a clinically significant difference was not detected in the SPACE for COPD programme at six months, results were maintained around baseline levels, wheras the PR produced an initial increase which then declined. Maintaining these baseline levels may be clinically important.

Maltais et al. (2008) found small, but statistically significant improvements (mean; 95%CI) at one year in fatigue (0.25; 0.66 to 0.44), emotion (0.28; 0.14 to 0.43) and mastery (0.39; 0.23 to 0.57) in home based group. Effing et al. (2011) demonstrated no statistically significant improvement in these domains reporting treatment effects (95% CI) at one year in fatigue of 0.09 (-0.34 to 0.52), emotion 0.10 (-0.22 to 0.42) and mastery 0.11 (-0.21 to 0.43). However, for both these studies (Effing et al. 2011, Maltais et al. 2008) the changes in scores are small and clinically insignificant. A possible reason why Effing et al. (2011) did not show any changes at one year could be that the study included milder patients (FEV_1 % predicted 50%) with higher baseline HRQoL scores, this study was also not powered to detect changes in CRQ-SR.

As previously discussed both the Maltais et al. (2008) and Effing et al. (2011) studies were comprehensive programmes involving interventions up to the one year assessments, whereas the SPACE for COPD intervention has also shown beneficial findings with a programme that is less demanding on resources.

Other SM studies have used the SGRQ as the outcome measure (Khdour et al. (2009), Bourbeau et al. (2003) and Bucknall 2012). Khdour et al. (2009) reported a significant treatment effect in the symptoms, impact and total score domains at six months, but by one year this effect had been reduced and was only significant in the symptoms ($p=0.04$) and impact ($p=0.03$) domains. Likewise, Bourbeau et al. (2003) detected an initial significant treatment effect in the impact and total score after the intervention and by the one year follow up assessment a significant difference was only seen in the total score. Bucknall (2012) only found a significant effect on the impact score at one year. These studies reflect this current study in that after initial gains from their respective interventions, decline follows. By the follow up assessment some of the initial gains are evident however, the issue of how best to maintain the benefits seen as a result of the intervention remains.

Overall, the SPACE for COPD programme reflects other studies, in that home based self-managed interventions do have an impact on HRQoL which declines post intervention. Evidence shows an initial increase as a result of the intervention but these improvements are not maintained and begin to

decline once the programme has finished. The challenge to healthcare providers is to devise an appropriate model to sustain these benefits. Possible maintenance strategies will be discussed in chapter 9

Hospital Anxiety and Depression Scale – (HADS)

Results presented in figure 6.6 suggest that there was no between group difference at six months in anxiety (p=0.599) and depression (p=0.989) and that there was a significant effect of time in both domains. Figures 6.7 and 6.8 show a small reduction in anxiety and depression at seven weeks which return to baseline levels at six months. These changes in both interventions are clinically insignificant. Scores of ≥ 8 are considered to be at least a possible presence of anxiety or depression on the HADS scale. As the mean score for both these measure were below this level a subgroup of those with baseline score ≥ 8 were preseneted in table 6.9 and figures 6.9 and 6.10 These figures show a greater decline at seven weeks and six months in comparison to the group as a whole. The mean (SD) change in anxiety at six months was -1.17 (2.95) in the PR and 1.10 (3.67) units in the SPACE for COPD group. Therefore, analysis would suggest that those with higher baseline scores for anxiety have the greatest improovement. Change in score for those with baseline score of ≥ 8 for depression show a slightly greater improvement in comparison to the group as a whole, but the impact is less than the anxiety domain.

Only a limited number of home based SM studies have reported an impact on anxiety and depression. Effing et al. (2011) found no effect on anxiety or depression at 12 months, however, had low baseline levels with group means of less than the threshold of 8 for both domains. In contrast Bucknall et al. (2012) did report a change (mean;95% CI) in anxiety at 12 months (treatment effect -1.06; -2.08 to -0.03, p=0.044). Bucknall et al. (2012) participants had baseline scores which did breach this threshold for possible presence of anxiety (mean; SD, 9.7 (4.6)). The subgroup analysis from this study supports the premise that self managed programme can have an effect on those with higher baseline levels of anxiety. However, in contrast to this study Bucknall et al. (2012) patients had been admitted to hospital with an exaserbation of COPD so are likely to have different causes of anxiety in comparison to this study of stable COPD patients. This study also involved supervised education with home visits.

Self-Efficacy

Self-efficacy was measured by the PRAISE questionnaire. Lower scores mean lower self-efficacy. There was a significant effect of time (p=0.001) and no difference between groups (p=0.271) at six months. However, scores at six months were lower than baseline, meaning self efficacy had reduced in both groups. As described in chapter 5 there is some uncertainty as to the appropriatness of the PRAISE tool used to measure self efficacy as it may have been too specific to PR. Although only a small reduction is reported an explanation for the reduction in self-efficacy could be absence of support after the intervention had finished.

Percieved self-efficacy reflects an individuals ability to carry out a specific task and has been shown influence intension to exercise and maintainance of exercise. As a fundamental aim of PR is to increase exercise capacity, self efficacy must also be enhance to faciliate this behaviour change. Self-efficacy will be discussed in chapter 8 in regards to PA levels. Self-efficacy also influences patients ability to self manage (Davis et al. 2006) and is an essential component to engagement of self management programmes (Bourbeau and Nault 2007). Therefore, patients may already have had a good level of self efficacy at baseline as those with lower self-efficacy may not have had the confidence in their ability to take part in the study and therefore not consented to the trial. As the PRAISE tool has not been widely used it is diffucult to summise if the baseline score for self efficacy are high or low.

Exercise performance

The ISWT was used to determine maximal exercise capacity. Results at 6 months show there was a significant impact of time (p=<0.0001) and no between group differences (p=0.463). The distance achieved at six months has returned to approximately baseline levels in both groups with mean (SD) changes of 1.39m (86.47) in the PR group and -12.10m (70.30) in the SPACE for COPD group. The ESWT is used to determine sub maximal exercise endurance. This demonstrated a significant effect of time (p=<0.0001) and no between group differences (p=0.912) at six months. Interestingly scores showed only a small decline from seven weeks to six months. Mean (SD) change from baseline to six months was 255.56 sec (386.88) in the PR group and 176.85 sec (400.91) in the SPACE for COPD group. Therefore at six

months the mean change in the PR group exceeds the MCID of 186 seconds (Pepin et al. 2011) and SPACE for COPD is only marginly below that threshold. This would indicate that participants have continued with their PA after the end of the programme however, at a lower than prescribed speed.

Despite ISWT performance not reflecting what is normally seen in PR (score not meeting the MCID) at Glenfield hospital, there may be potential explanations in the baseline characteristics of the study population as described in chapter 5. There is also the fact that the exercise programme does not involve increasing the training load. Walking speed is prescribed at 85% of the maximal speed derived from the baseline ISWT and is not recalebrated at any time throughout the programme to enable progression.

Although no significant between group differences were seen at 6 months for the ISWT the SPACE for COPD group had lower mean scores in comparison to PR and had reduced performance compared to baseline. Patients in the SPACE for COPD group completed the baseline ESWT at this pace and were demonstrated the prescribed speed during their one hour introduction at home, but did not have the regular supervision to reinforce them of their prescribed speed as did those in the PR group. It is highly likely that those in the SPACE for COPD did not walk at the prescribe speed/intensity which has been reflected in ISWT performance at seven weeks and six months.

Endurance capacity as measured by the ESWT remained elevated six months after both interventions. It is, perhaps, not suprising that patients in both

groups did better on the ESWT compared to the ISWT as their walking programme prescribed gradual increases in time and not speed. Time is also an easier variable for patients to monitor and record so they may have focused on this to the detriment of the speed of walking. Patients may have chosen to walk slower so that they could increase the distance and time they walked for, however, this is unknown. It's important to maintain training load (speed) to induce health and fitness benefits and therefore, speed to walking needs to be reinforced with patients completing the SPACE for COPD programme.

There are a number of self management programmes that have reported no effect on exercise performance using the 6MWT after the intervention (Bourbeau et al. 2003, Maltais et al. 2008, Monninkhof et al. 2003a). Despite the Bourbeau et al. (2003) self management intervention consisting of a comprehensive two month programme which was administered by a health professional in the patients own home and Maltais et al. (2008) intervention involving loaning exercise equipment for patients to use in their own home, neither demonstrated an improvement in the 6MWT (mean (95%CI) within group changes at 3 months 8 (-1 to 18) metres and 0 (-13 to 12) metres at twelve months; Maltais et al. 2008). However, Maltais's home based study focussed on cycling exercise and it is therefore not suprising that there has been minimal crossover of training effect to walking performance. Monninkhof et al. (2003a) self management programme consisted of a two year programme of education and one to two weekly exercise sessions in small groups delivered by a physiotherapist. Despite this extensive intervention the

mean (SD) distance walked reduced by 13 (7) metres in the self management and 2 (5) metres in the usual care group from baseline levels. Even though these programmes provided considerable support no improvements in walking performance were found. It is therefore highly relevant that the SPACE for COPD programme has found improvements in exercise performance (ESWT) which has been maintained at six months despite it offering minimal contact with healthcare professionals. However, the trajectory of change after the intervention from the SPACE for COPD study is not clear and if followed up at 12 months could have reduced to near baseline levels. A possible reason for the elevated ESWT score could be due to the large intial increase at seven weeks.

Boxall et al. (2005), Fernandez et al. (2009), Mendes et al. (2010) and Ghanem et al. (2010) all reported significant increases in 6 MWT distance after home-based programmes. Both Boxall et al. (2005) and Fernandez et al (2009) included regular home visits by a physiotherapist and Mendes et al (2010) made regular phone calls and provided patients with heart rate monitors to ensure prescribed exercise intensity. Ghanem et al. (2010) also demonstrated significant improvements in 6 MWT distance but involved patients recovering from acute exacerbation who's baseline profile was quite different to stable COPD patients.

Casanova et al. (2007) observed a progressive decline in the 6 MWD over 5 years in a cohort of mild to moderate COPD patients who were not part of any form of PR programme. The mean decline in 6MWD was 12.5 $m.yr^{-1}$ and up to

25 $m.yr^{-1}$ in those that died within the final 2 years of the follow up measures. Spruit et al. (2012) examined the annual decline in the 6MWD according to GOLD stage and reported a mean decline of 1.6 m in GOLD stage II, 9.8 m in GOLD stage III and 8.5 m in GOLD stage IV. Maltais et al. (2008) reported a mean (95% CI) change of 0 (-13 to 12) metres, Monninkhof et al. (2003) a mean (SD) increase of 13 (7) metres and Ninot et al. (2011) a median (25^{th} to 75^{th} percentile) increase of 30 (5 to 80) metres all at 12 months. Therefore although these differences are small and do not met the MCID for this measure, in comparison to the normal decline reported by Casanova et al. (2007) clinically relevant. The natural decline in the ISWT and ESWT has not been reported. A mean (SD) decline (from baseline) was detected in the SM group at six months of 12 (70) metres and a increase of 1 (86) metres in the PR group. However, in the ESWT both intervention groups had increased mean scores (from baseline), which in the PR still breached the MCID from the baseline measure (PR 256 (387) sec; SPACE 177 (401) sec). It would be of interest to follow up these patients at 12 months to determine the rate and trajectory of change, however this was out of the scope of this thesis. However, it would appear at six months endurance capacity has been enhanced by the SPACE for COPD programme beyond baseline levels and given the natural decline in exercise performance reported (Casanova et al. 2007) may be clincally significant.

The follow up findings seen in the SPACE for COPD programme were in contrast to Strijbos et al. (1996), who is the only other study that has clearly reported follow up data from a 12 months home-base versus PR programme.

After a 12 week programme those in the PR and home based group continued to improve to six months following the intervention. However, by 18 months only those in the home group had continued to improve maximal cycle work rate and four minute walk time. They concluded that the home programme had made the participants more independent and self sufficient as diary cards reveild they were completing more exercise than the PR group. However, it may have been the requirement to complete PA diary cards that had motivated them to continue with the programme.

Although these studies have shown home based and supported self management programmes can improve exercise performance they consistantly rely on health professional input and additional resources. These models of care are not possible in the UK. It may also be difficult to justify these comprehensive programmes as there is inconsistancy as to their effectiveness.

The SPACE for COPD programme has demonstrated that exercise performance can be improved after a seven week programme and that some of the initial gain, such as the ESWT, is still apparent six months later. Other outcome measures declined to baseline levels but so do those in the PR group. The challenge is how to maintain these broader improvements and to stop the decline often reported as a normal course of the disease. The SPACE for COPD programme may be an effective tool to help reduce this decline which is a feasible option to healthcare providers in the UK.

6.8 Limitations

The results of the six month follow up of the PR and SPACE for COPD interventions need to be interpreted in light of a number of limitations. In addition to those discussed in chapter 5 it is worth exploring the fact that the PR group did not respond as expected. This may be due to the baseline profile of the patients and to the motivations of patients taking part in the study.

Patients recruited to the study were not as severe on the MRC scale as normally seen in PR. Those with more severe COPD may have preferred to have had the comfort of knowing they would be in a supervised group so did not want to participate. This may be reflected in the higher CRQ-SR dyspnoea scores seen. There were also a higher percentage of current smokers and higher baseline CRQ-SR scores. It is possible that those who are current smokers are less likely to change their PA health behaviour as they have previous advice and intervention have not been adhered to, or it may be that current smokers were more motivated to do the study as they knew they had a chance of being in a group where they would have limited health professional contact and therefore their smoking habits not challenged.

Another limitation is due to the multiple testing of numerous outcomes and comparisons over three time points. This increases the potential for a type I error where the null hypothesis is rejected when it is actually true.

6.9 Conclusion

This chapter presented and discussed the finding of the six month follow up of the SPACE for COPD programme compared to conventional PR. Findings show that improvements gained at 7 weeks are not maintained but fall back to broadly baseline levels or above for a number of HRQoL variables and peak exercise performance. Future consideration should be given to maintenance strategies in both interventions. The exception was exercise endurance. The results from the ESWT showed that some of the initial improvement gain was apparent at 6 months. However, this was also mirrored in the PR group.

The outcome of the SPACE for COPD programme should not be underestimated. The natural course of the disease is a progressive decline in exercise tolerance and HRQoL (Griffiths et al. 2000). SPACE for COPD has shown that key outcome measures have been maintained at levels similar to baseline, six months after the intervention period.

Chapter 7 – Physical activity levels of patients with COPD

7.1 Introduction

As described in chapter 2 (section 2.3) there is now overwhelming evidence that regular physical activity (PA) has significant health benefits and that inactivity is a major public health problem. National (Department of Health 2011) and international (Nelson et al. 2007) guidelines recommend adults participate in moderate PA for at least 150 minutes per week to improve and maintain health. It is important that this PA is accumulated in bouts of at least 10 consecutive minutes to lead to these gains.

There is substantial evidence that exercise capacity and PA are reduced in patients with COPD (Pitta et al. 2005a, Sandland et al. 2005). PA is an increasingly important clinical outcome as low PA levels have been shown to negatively impact hospital admissions (Garcia-Aymerich et al. 2006), mortality (Waschki et al. 2011, Watz et al. 2008), dyspnoea (Watz et al. 2009), exercise performance and muscle weakness (Pitta et al. 2005a). PA levels have been shown to decline with increasing disease severity (Watz et al. 2009). With the new GOLD grouping classification (described in chapter 2, section 2.1.7 and summarised in Figure 7.1 below) it is of interest to describe PA according to this new system. The MRC dyspnoea grade is a nominal scale of disease impact from one to five. Patients with MRC one were excluded from the study. The MRC scale is commonly used in the UK to categories patients and

therefore, it is of interest to look at PA levels across the different systems of categorising patients.

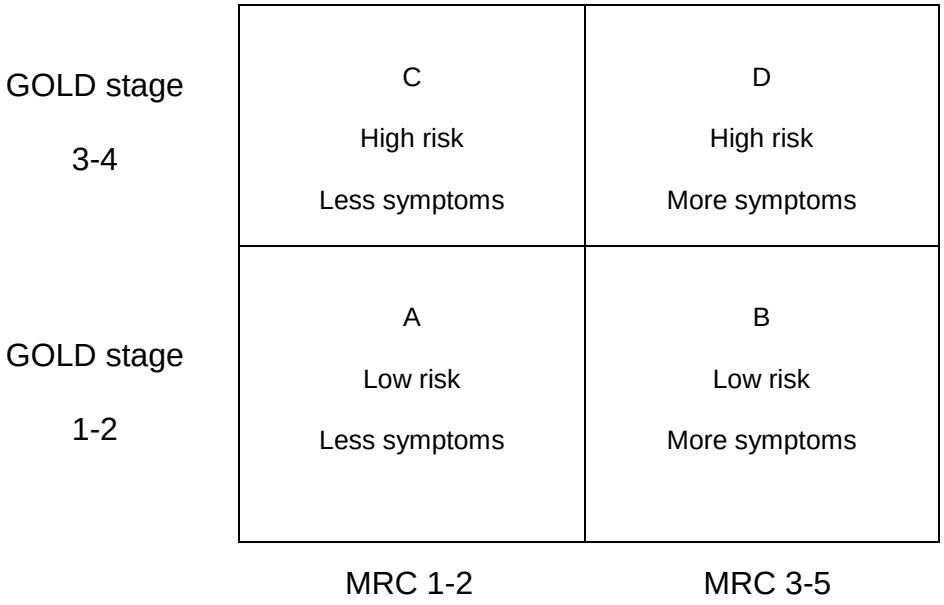


Figure 7.1 GOLD groupings

Severe physical inactivity as defined as a PAL <1.40 has been reported to be the best predictor of all-cause 48 month mortality in patients with COPD (Waschki et al. 2011). PAL is not often reported as a clinical outcome due to its requirement for more sophisticated monitoring, but could become an important diagnostic and prognostic tool (Garcia-Rio et al. 2012).

Both the PR and SPACE for COPD interventions used in this trial have a PA and exercise training component and it is therefore of interest to examine its impact. Thus, it is initially important to understand how best to describe PA and exercise data. There is currently inconsistency in how PA is reported in

this population and a lack of reporting PA in relation to the national and international guidelines. Baseline PA data is presented in this chapter to understand how the different thresholds of recommended PA affect the interpretation of the data. PA was collected from a number of participants recruited to the main trial.

This chapter will describe the baseline levels of PA in a sub-group of the study population and compare them with national guidelines as recommended by the ACSM and the Department of Health (Department of Health 2011, Nelson et al. 2007).

7.2 Aim

There are three main aims for this study:

1. To describe the baseline PA levels of a group of patients recruited to the study and to determine any differences between GOLD groupings and MRC dyspnoea grades.
2. To determine whether patients with COPD are meeting national and international guidelines for exercise.
3. To understand the impact of using differing criteria on determining whether patients achieved national and international guidelines.

7.3 Methods

A detailed description of the study protocol is presented in chapter 3. This chapter details the baseline PA as a measure of the SPACE for COPD trial. Seven week and six month data will be presented and discussed in chapter 8.

A subgroup (n=181) of patients were invited to take part in PA monitoring at baseline, seven weeks and six months. Inclusion to this arm of the trial was determined by activity monitor availability at baseline. Initially we only had access to a small number of activity monitors (nine). Therefore, participants in this sub-group were not randomly selected.

7.4 Measures

This chapter focuses of the baseline measure of PA as part of the trial. PA was measured using the Sensewear® Pro2 Armband (SWM). The SWM's reproducibility, sensitivity and validity are discussed in chapter 4. The patients wore the monitor for five days, including three weekdays and two weekend days (Friday, Saturday, Sunday, Monday and Tuesday). They were advised to wear the SWM during all waking hours and only to remove it during washing, showering, bathing and swimming.

Physical activity variables

A number of variables were taken from the accompanying InnerView™ software and included;

- Total time SWM worn
- Total daily step counts

- Total time <2 METs (sedentary)
- Total time 2-3 METs (light physical activity: LPA)
- Total time 3-6 METs (moderate to vigorous physical activity: MVPA)
- Total time 6+ METs (vigorous activity)
- Total energy expenditure above 3 METs

An example of the output from the SWM is shown in Figure 7.2 (healthy subject)

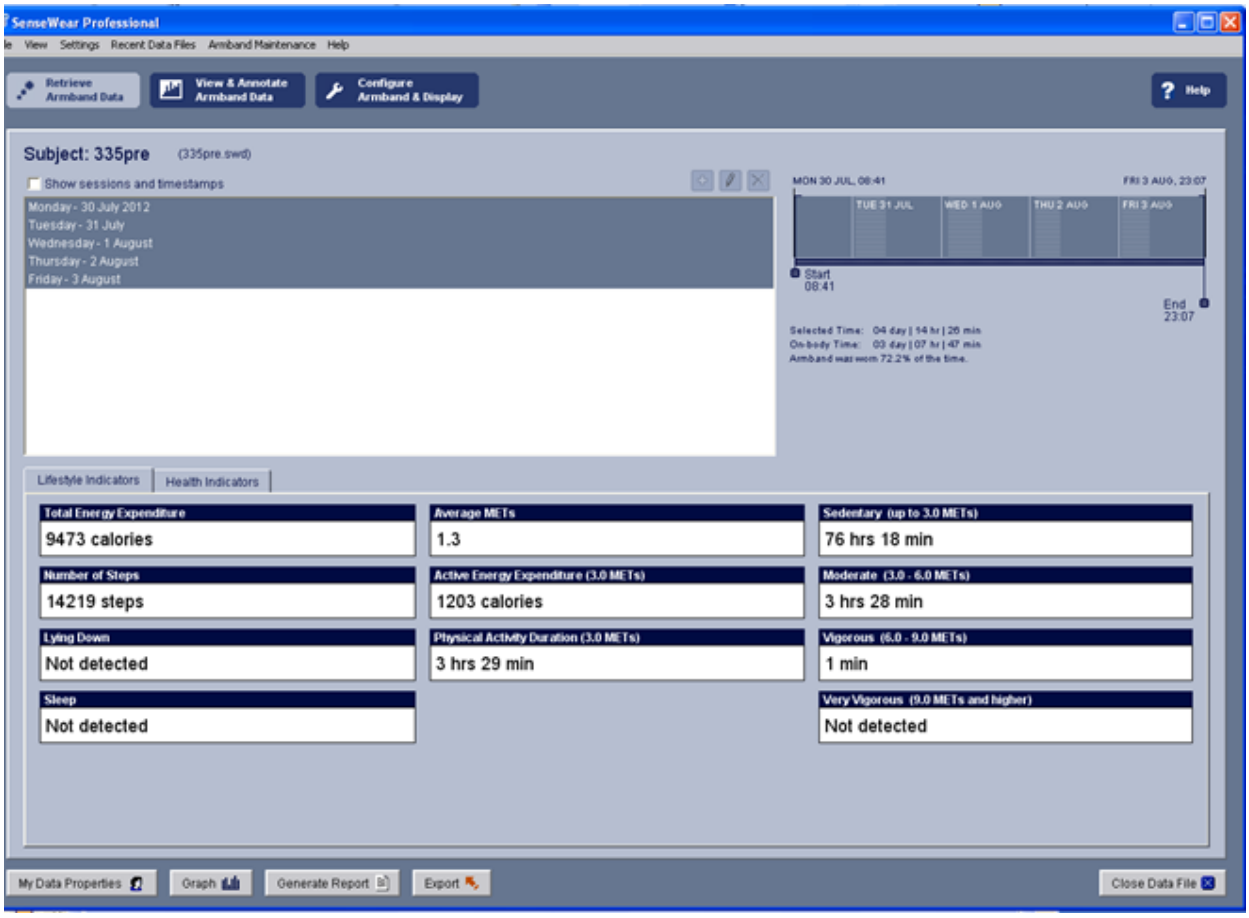


Figure 7.2 InnerView™ software output

Time in moderate physical activity in ≥ 10 minute bouts

Data was exported from the InnerView™ software to Excel to enable the calculation of bouts of exercise. Exported data gives the minute by minute values and therefore length of bouts of PA could be calculated. An Excel equation was used to determine total time in at least 10 minute bouts and total number of bouts of at least 10 minutes. This was completed for each day worn.

Physical Activity Level (PAL)

The physical activity level (PAL) has become a recognised method of expressing total daily energy expenditure (TEE) in multiples of resting metabolic rate (RMR). PAL is calculated via the following equation:

$$PAL = \frac{TEE}{RMR}$$

An individualised PAL can give an indication of how physically active they have been during the 24 hour period. Table 7.1 show the classifications of PAL (Food and Agriculture Organization of the United Nations, 2004).

Table 7.1 Classification of PALs

Activity Level	*PAL*
Extremely Sedentary / Inactive	<1.40
Sedentary	1.40-1.69
Moderately active	1.70-1.99
Vigorously active	2.00-2.40
Extremely active	>2.4

The PAL was calculated by using the total daily energy expenditure estimated by the SWM and by using the Harris-Benedict equation to estimate basal metabolic rate (Harris and Benedict 1918).

Criteria for excluding data

Data was excluded from analysis if it fell under the following conditions:

- An error massage occurred when downloading the SWM data
- Days where there was fewer than 12 hours of data
- If the monitor was worn for fewer than three days

7.5 Statistical analysis

Baseline characteristics are presented in table 7.2. Differences in characteristics between those that did take part in the activity monitor study and those that did not were analysed using independent t-tests or chi square.

To get an overall picture of individual PA, mean data was calculated across the number of days worn. A minimum of three days wear time was chosen as this has been reported to be the minimum number of days needed to gain an

accurate picture of an older adults PA and sedentary level (Hart et al. 2011). A repeated measures ANOVA was completed on each PA variable to determine if there were any differences in PA level between week days and weekend days.

A Shapiro Wilks test of normality was completed on the data and data was determined to be normally distributed. ANOVA's, with a Tukey post hoc test, were completed to determine if there was a difference in steps, total time above 3 METs, total time above 3 METs in at least 10 minute bouts and PAL between GOLD grouping and MRC grades.

7.6 Results

181 patients (63% of those recruited to the main study) took part in the PA monitoring at baseline. Six patients were excluded due to error messages on the SWM and 21 due to not wearing the SWM for the required length of time. This resulted in 154 patients being eligible for analysis. Table 7.2 presents the baseline characteristics for these patients in comparison to those that were not included in the PA trial. No differences were detected in baseline variables between these groups.

Table 7.2 Baseline characteristics of those included and not included in the PA analysis

	Included (n=154)	*Not included (n=134)*	*p value*
Age (yrs)	68 (8.33)	67 (9.46)	0.90
Male:Female (n)	106:47	81:53	0.11
BMI (m/kg^2)	27.41 (5.88)	27.88 (6.54)	0.53
FEV_1 (litres)	1.29 (0.58)	1.22 (0.52)	0.35
FEV_1 %predicted	49 (18)	47 (18)	0.29
FVC (litres)	2.74 (0.92)	2.66 (0.81)	0.47
MRC (n:%)			
2	32 (21%)	18 (13%)	0.32
3	57 (36%)	51 (38%)	
4	44 (29%)	42 (32%)	
5	21 (14%)	23 (17%)	
GOLD (n:%)			
A	20 (13%)	14 (10%)	0.29
B	56 (36%)	49 (37%)	
C	15 (10%)	9 (7%)	
D	63 (41%)	62 (46%)	
SpO_2 rest %	94.20 (2.39)	94.27 (3.71)	0.85
Smoking status (n:%)			
Current smoker	34 (22%)	36 (27%)	0.58
Never smoked	9 (6%)	6 (4%)	
Ex-smoker	111 (72%)	92 (69%)	
Pack years	45.99 (31.97)	46.48 (30.98)	0.90
CRQ-SR			
Dyspnoea	2.59 (0.95)	2.40 (0.87)	0.11
Fatigue	3.46 (1.19)	3.30 (1.18)	0.28
Emotion	4.42 (1.26)	4.38 (1.20)	0.83
Mastery	4.49 (1.39)	4.38 (1.30)	0.50
HADS			
Anxiety	7.57 (4.18)	7.70 (3.75)	0.73
Depression	6.13 (3.32)	6.65 (3.60)	0.30
PRAISE	44.32 (7.76)	44.55 (7.13)	0.81
ISWT (distance)	268.69 (146.16)	236.56 (152.21)	0.07
ESWT (sec)	203.40 (165.66)	206.17 (161.51)	0.89

The analysis of between day differences revealed a difference in step count between Fridays (the first day the monitor was worn; mean (SD) steps; 4390 (3279)) and Sundays (3348 (2502) steps). There were no other statistical different between days for any other PA variable. As this was the only difference that was detected it was assumed fair to mean the data across the number of days worn.

Physical activity by disease severity

Baseline levels of physical activity across disease severity, using both GOLD categories and MRC dyspnoea scales are presented.

GOLD groups

GOLD (Vestbo et al. 2013) recommends classifying patients into four groups: A (low risk, less symptoms), B (Low risk, more symptoms), C (high risk, less symptoms), D (high risk, more symptoms), and are summarised in table 7.1. Mean (SD) values for steps, PAL, total time in light physical activity (LPA: 2-3 METs), total time in moderate to vigorous physical activity (MVPA: 3-6 METs), total time in vigorous physical activity (>6 METs) and energy expenditure over 3 METs for each GOLD category are shown in Table 7.3. ANOVA analysis revealed differences between groups. A Tukey post-hoc test was completed on results that were statistically significant and box plots presented to highlight where these differences lie (figures 7.3 and 7.4).

There is a significant difference between GOLD groups for step counts and time in LPA with GOLD group A accumulating the highest step count and

GOLD group D the lowest (table 7.3). GOLD group D also had significantly lower time in LPA. Although differences were not significant, GOLD group D, those most at risk and with more symptoms, spent most time sedentary and the least time in LPA. GOLD group C spend the most time in PA over 3 METs and GOLD group A spend the least time in PA over 3 METs, however, this was not significant (table 7.3).

Table 7.3 Baseline physical activity variable in different GOLD groups (mean (SD)

	GOLD group				*p*
	A n = 20	B n = 56	C n= 15	D n = 63	
Steps	5731 (3285)	4530 (2437)	5647 (2783)	2661 (1742)	<0.0001
PAL	1.42 (0.24)	1.36 (0.25)	1.43 (0.35)	1.35 (0.25)	0.613
Sedentary (minutes)	651 (124)	657 (105)	650 (137)	688 (162)	0.539
LPA (minutes)	131 (66)	118 (66)	156 (66)	101 (65)	0.038
MVPA (minutes)	65 (56)	65 (58)	83 (80)	60 (61)	0.677
Vigorous (Minutes)	0.5 (1)	2 (7)	3 (7)	11 (48)	0.387
EE over 3 METs (Kcals)	398.74 (443.05)	364.10 (340.43)	428.24 (399.92)	398.22 (651.15)	0.974

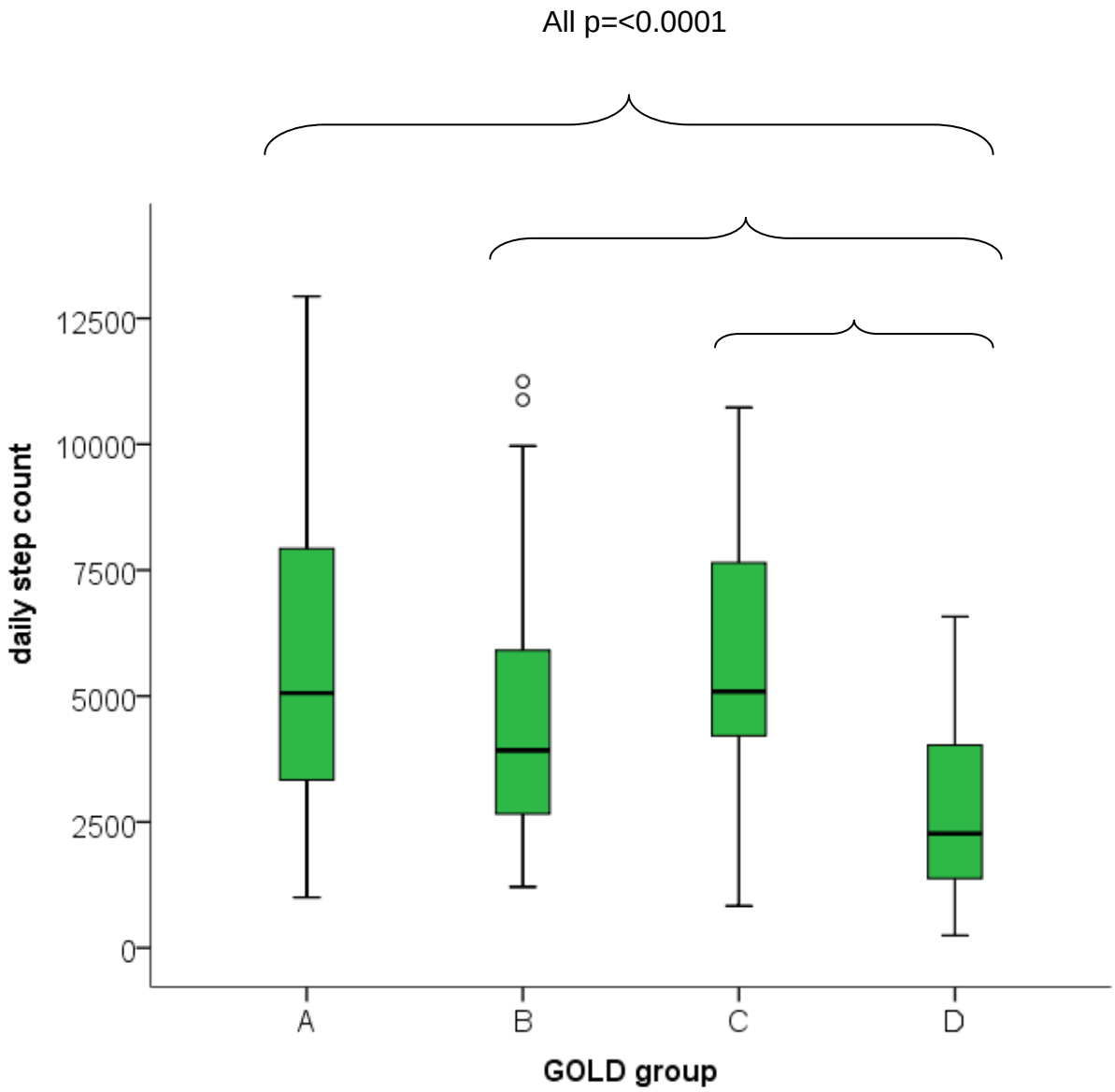


Figure 7.3 A box plot of daily step count by GOLD grouping. Boxes present the median, interquartile ranges and highlight the highest and lowest values. o represents outliers which are more than 1.5 box lengths from the upper quartile.

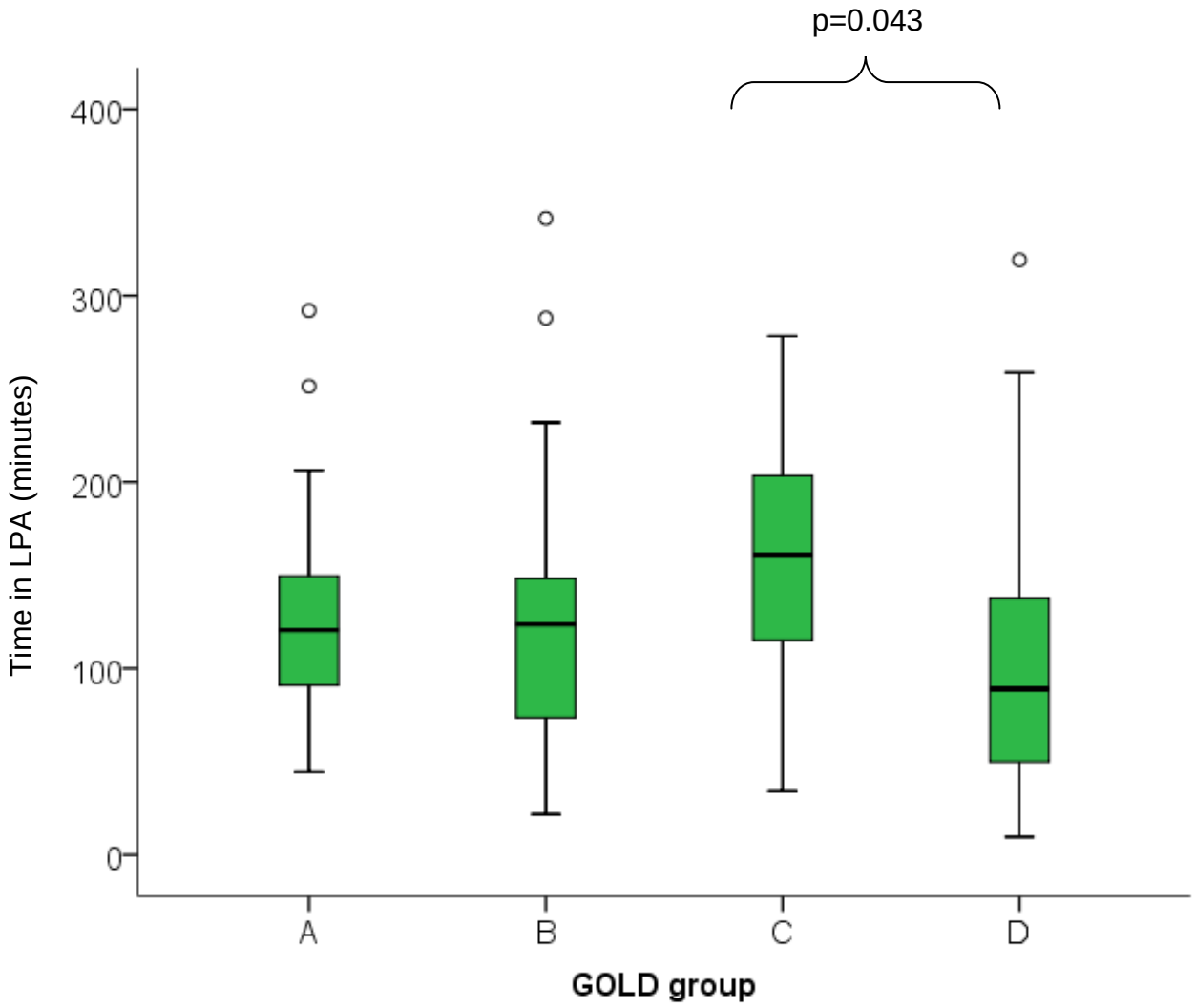


Figure 7.4 A box plot of time in LPA in different GOLD groups. Boxes present the median, interquartile ranges and highlight the highest and lowest values. o represents outliers which are more than1.5 box lengths from the upper quartile.

MRC dyspnoea grade

Mean (SD) values for steps, PAL, total time in light physical activity (LPA: 2-3 METs), total time in moderate to vigorous physical activity (MVPA: 3-6 METs), total time in vigorous physical activity (>6 METs) and energy expenditure over 3 METs for each MRC grade are shown in Table 7.4. ANOVA analysis revealed differences between groups. A Tukey post-hoc test was completed on results that were statistically significant and box plots presents to highlight where these differences lie (figures 7.5 and 7.6).

Table 7.4 Baseline physical activity variable across MRC grades

	MRC Grade				*p*
	2 n = 32	3 n = 57	4 n= 44	5 n = 21	
Steps	5824 (3027)	3908 (2162)	3278 (2351)	2382 (2046)	<0.0001
PAL	1.45 (0.30)	1.37 (0.23)	1.39 (0.32)	1.27 (0.18)	0.111
Sedentary (minutes)	634 (135)	663 (100)	668 (155)	718 (184)	0.188
LPA (minutes)	141 (66)	113 (58)	113 (82)	92 (55)	0.063
MVPA (minutes)	85 (83)	62 (56)	63 (64)	57 (57)	0.340
Vigorous (MINUTES	2 (5)	4 (21)	8 (24)	16 (70)	0.369
EE over 3 METs (Kcals)	451.04 (432.14)	379.91 (455.48)	372.58 (464.62)	375.44 (769.27)	0.903

MRC grade 5 are the most severe patients and spend the most time sedentary and the least time in LPA. They also have the highest time in vigorous activity, although the SD is also high. MRC grade 2 spend the most time in PA above 3 METs and MRC grade 3 the least, although none of these finding were statistically significant. MRC grade 2 have significantly more daily step counts than MRC grades 3 to 5.

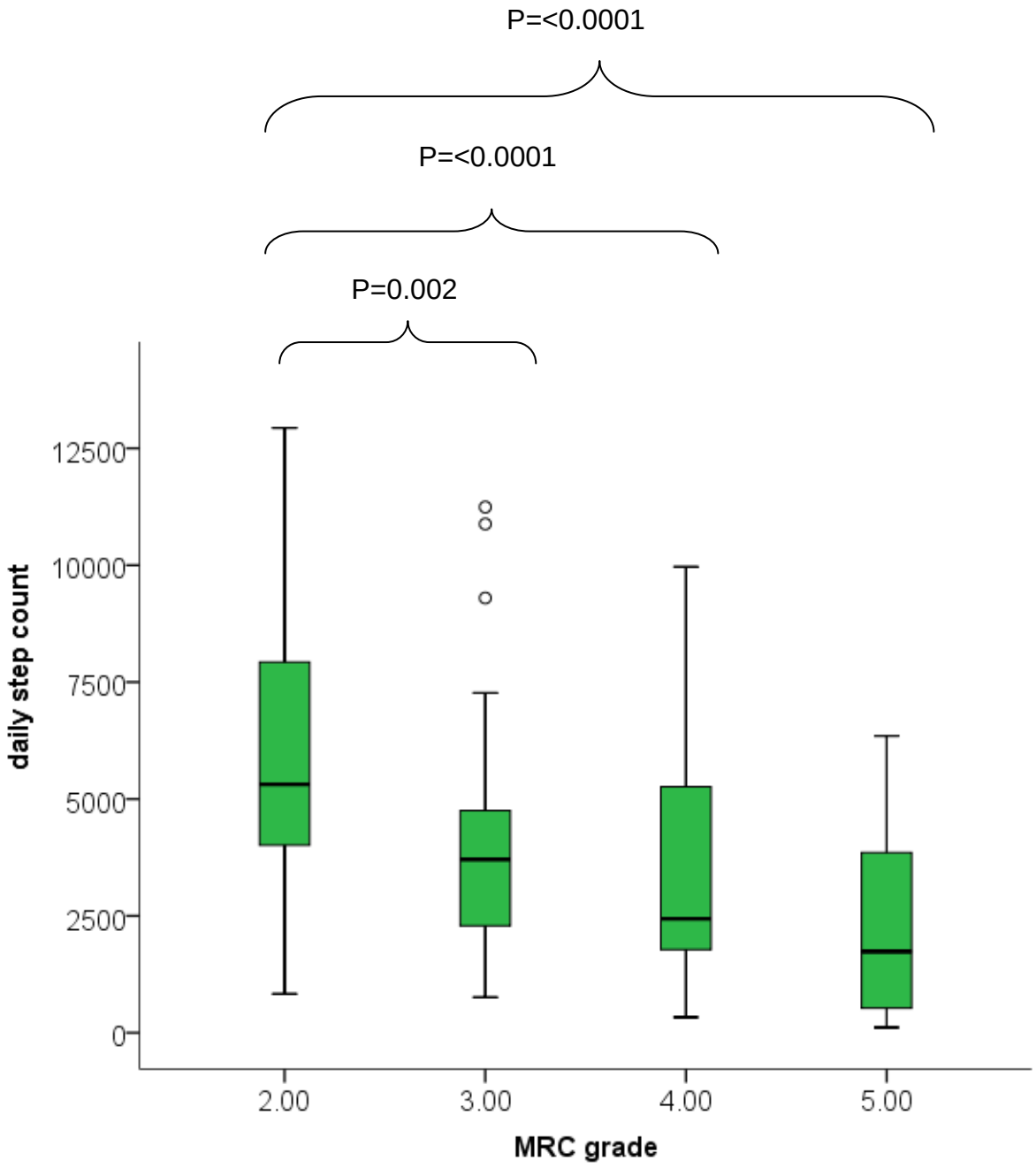


Figure 7.5 Box plot of daily step count in the different MRC grades. Boxes present the median, interquartile ranges and highlight the highest and lowest values. o represents outliers which are more than1.5 box lengths from the upper quartile.

Physical activity level (PAL)

The Mean PAL was 1.38 (0.27), 76% of participant had a PAL of <1.4 classifying them as extremely sedentary. Only 7% of participant had a PAL of between 1.70-1.99 classifying them as moderately active.

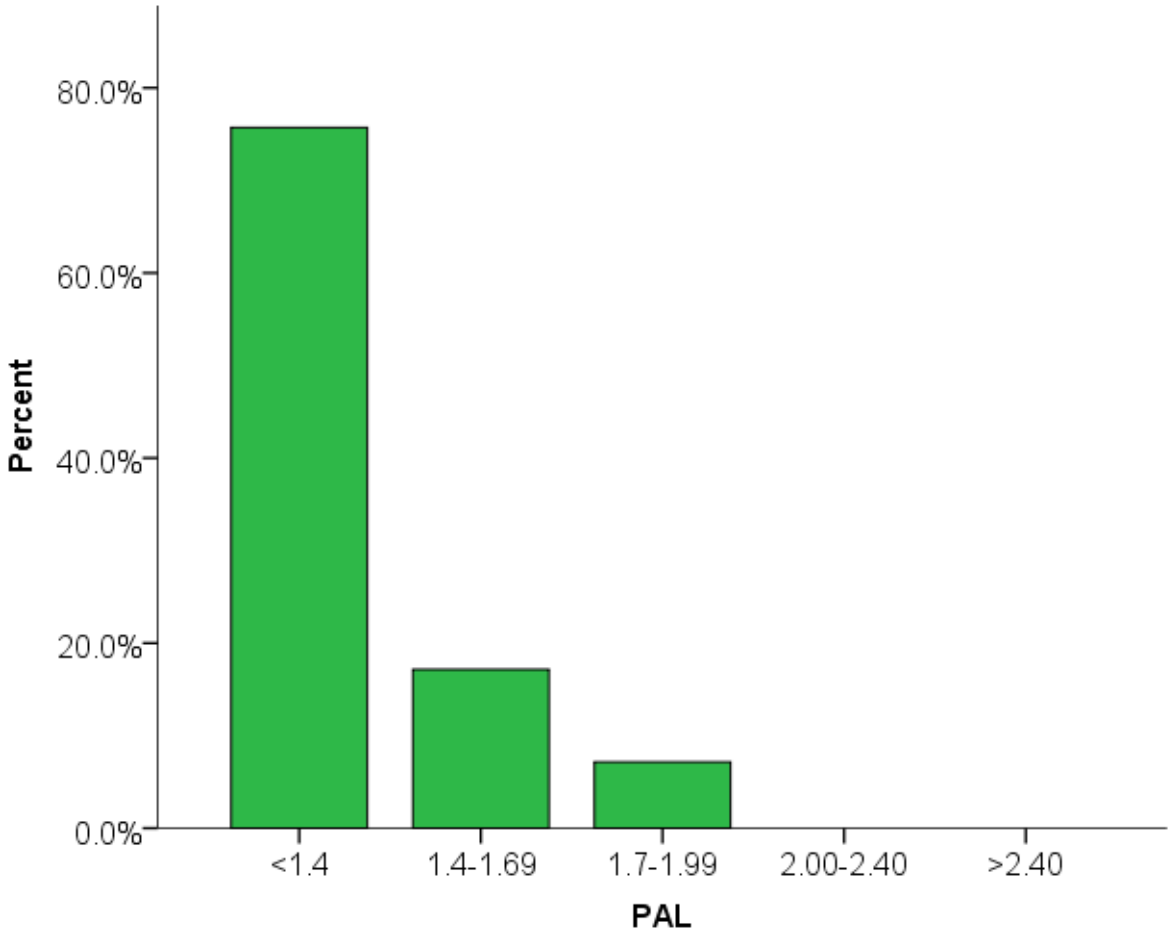


Figure 7.6 Percentage of participants in each of the PAL category

PA guidelines

When analysing PA data according to the different ways recommended values are reported, four target thresholds were identified. Recommended daily targets were stated as being met if the mean daily data had breached either of the thresholds below:

- Accumulation of 30 minutes of moderate PA in total
- Accumulation of 30 minutes of moderate PA in total in at least 10 minutes of consecutive PA
- 10,000 steps
- 7,000 steps

In total (regardless of GOLD grouping, or MRC score) 67% met the mean daily target of at least 30 minutes in non-bouts, which fell to 18% when at least 10 minutes of consecutive bouts of PA were used. A paired t-test revealed that time spent over 3 METs in non-bout activity was significantly higher than time spent over 3 METs in at least 10 minute bouts ($p<0.0001$). Only 4% of patients accumulated 10,000 on an average day, which increased to 8% when using the 7,000 step threshold (data not shown). This data is presented across MRC grade and GOLD category in figure 7.7 and 7.8 which shows that most PA is accumulated in less than 10 minute bouts. With GOLD grouping a significant difference was detected using ANOVA with post hoc test analysis between the number of patients meeting the 7,000 steps between different groups, with GOLD group D reporting a significantly lower number of participants meeting this threshold ($p= >0.0001$; A and D $p=0.004$;

B and D p=0.049; C and D p=0.007). No other statistical difference was detecting between the GOLD groupings for each of the other thresholds.

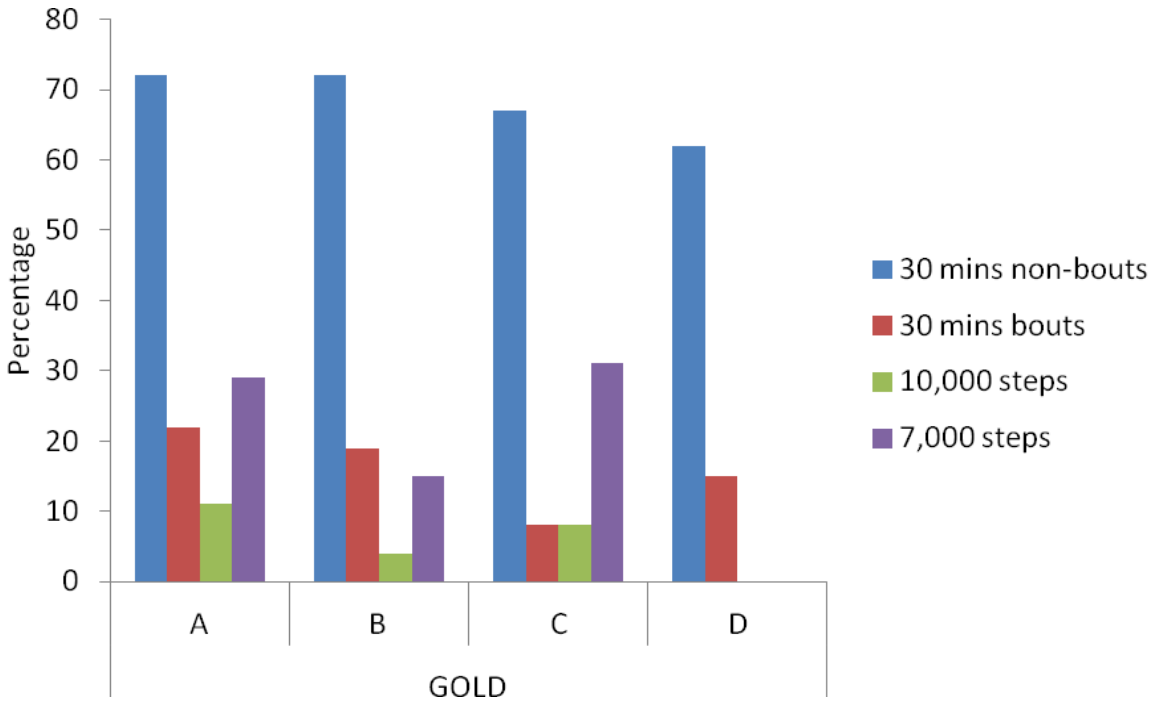


Figure 7.7 Percentage of participant by disease impact (GOLD) meeting different physical activity guidelines

With the MRC scale, using an ANOVA with a post hoc test a difference was also detected using the 7,000 step threshold between the different stages (p=0.001; 2 and 3 p=0.004; 2 and 4 p=0.017; 2 and 5 p=0.003). A significant difference was also identified in 10,000 steps threshold between MRC grades 2 and 4 (p=0.032).

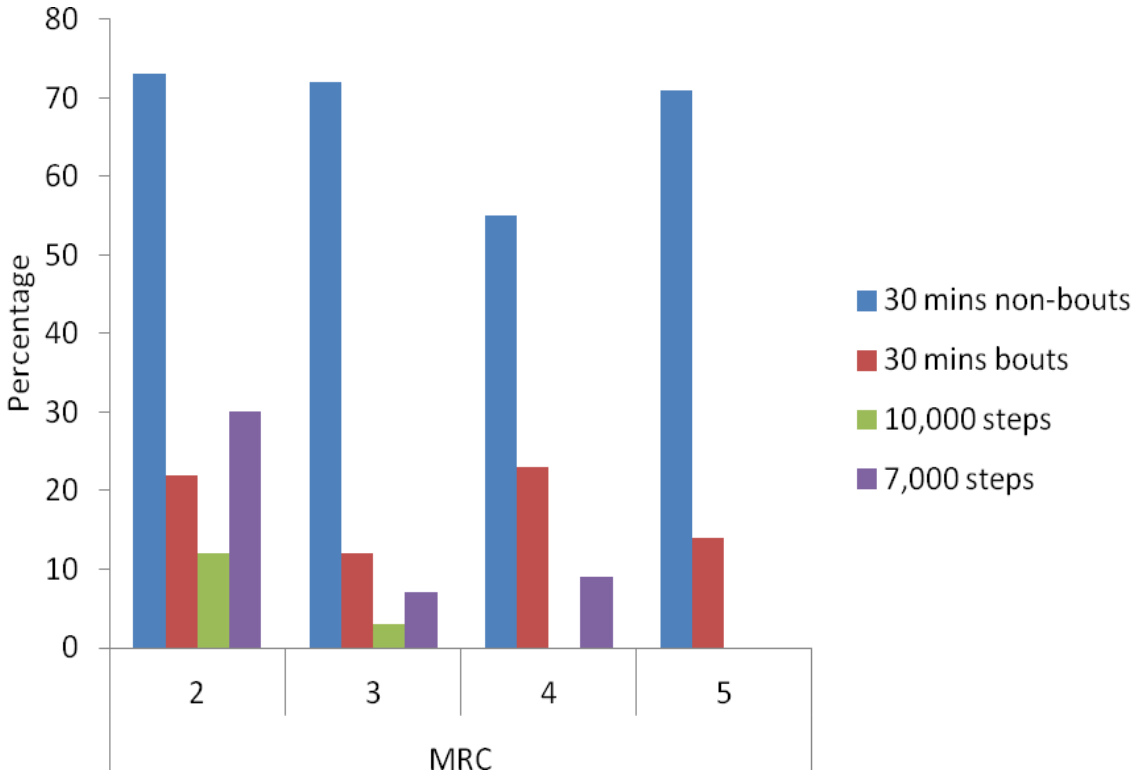


Figure 7.8 Percentage of participant by disease impact (MRC) meeting different physical activity guidelines

7.7 Discussion

The aim of this chapter was to describe PA levels in patients classified using two categories of disease impact, GOLD grouping which has only recently been developed (Vestbo et al. 2013) and MRC dyspnoea grading (Fletcher et al. 1959). This section will first explore the PA findings across these categories and secondly discuss whether patients in this cohort were meeting national and international guidelines for PA and how the different thresholds on achieving these guidelines impact on their interpretation.

PA across classifications of disease impact

GOLD groupings

The general pattern of PA by GOLD groups was broadly as expected. Patients in GOLD group A (less symptoms and less risk) have the higher PA levels and patients in GOLD group D the lowest. Patients in GOLD group D accumulated significantly less mean daily steps than each of the other GOLD group (p=<0.0001, figure 7.4). GOLD group D are those that are high risk and present with more symptoms and therefore are the more severe patients, this finding was therefore anticipated.

GOLD category C spent significantly more time in LPA in comparison to GOLD group D. GOLD group C present with less symptoms and although not significant tend to spend more time in either LPA or MVPA than sedentary time in comparison to the other GOLD groups. Interestingly the variation between the groups in PA levels tends to be in LPA rather than MVPA and therefore it could be the LPA that is impacting on the changes in step counts seen between GOLD categories. It may be anticipated that this difference in LPA is due to activities that participants take part in are lighter in intensity and therefore it is these activities that discriminate between the groups. MVPA is broadly around one hour and does not change greatly between the groups, it therefore may indicate that around one hour is the minimal requirement for activities of daily living, including preparing meals for example. This may be affected by those living alone or with a spouse, however, this was not recorded.

PA across the updated GOLD grouping has yet to be fully described.

Canavan et al. (2013) reported that PA levels are difficult to distinguish between the new GOLD groupings. This is due to the groups not being sequential in disease impact. GOLD group A are those with lower disease severity and lower reported symptoms and GOLD group D those with highest disease severity and more reported symptoms. However GOLD groups C and B may be described as discordant groups with GOLD group C those with higher disease severity and lower reported symptoms and GOLD group B those with lower disease severity and higher reported symptoms. The PA findings in this current study and the Canavan et al. (2013) study reflect the non-sequential nature of the GOLD categories. These guidelines recognise that the impact of the disease is not just based on lung volumes alone. However, the non-linear nature of the grouping system and the complexity of the determinates of PA make the interpretation of these discordant groups difficult. Co-morbidities are common in patients with COPD and could contribute to the reported symptoms in these discordant groups. Comorbidities were recorded as part of the study but unfortunately were not uploaded onto the database to allow further analysis.

MRC dyspnoea grades

Grouping patients according to MRC dyspnoea grade revealed PA activity levels as expected given that MRC reflects functional performance. Those in MRC grade 2 had the highest PA level and MRC grade 5 had the lowest PA level. Findings demonstrated a significant difference between the milder MRC grade 2 patients compared with MRC grades 3, 4, and 5. These finding are in

agreement with Watz et al. (2009), Troosters et al. (2010) and Waschki et al. (2012) who all reported that daily step count decreased as disease impact increased. Watz et al. (2009) reported on the physical activity levels in 170 patients with COPD in Germany. This study reported mean daily step counts of over 6,000 in the milder MMRC 1 (equivalent to MRC 2) group which is higher than this study with mean daily step counts of 5,824 (30277) of those in MRC dyspnoea score 2. Similar levels of daily steps were seen in the more severe patients with Watz et al. (2009) reporting mean daily steps counts of around 2,000 in MMRC group 5 and in this study mean daily step counts were 2,382 (2,046) in MRC dyspnoea grade 5.

Patients in the previous studies worn the activity monitors for 24 hours and the threshold for inclusion was 22 - 22.5 hours per day, in this current study the threshold for inclusion was 12 hours. Although the main difference in wear time would be sleep it is possible that some data in this current study may have been missed and those that would be more likely to have missed data would be the more active milder MRC 2, GOLD group A patients. This study also had fewer patients in the milder groups (GOLD group A). As this group are those with fewer symptoms they may not have initially presented for PR and the milder patients were also excluded from the study (MRC grade 1 were excluded from the trial).

Interestingly, Troosters et al. (2010) and Waschki et al. (2012) also reported the PA of healthy controls. These studies highlighted that healthy adults accumulated around 9,000 to 10,000 steps per day highlighting that in this

current study a drop in step counts has occurred at the very early onset of disease in patients with COPD. This supports the notion that PA interventions may be beneficial for all regardless of disease severity, as all groups need to increase their PA level. It also highlights an important hypothesis as to whether reduced PA is an early feature of COPD or if the progression of COPD causes the reduced PA (Polkey and Rabe 2009). The current data appears to support the former hypothesis as Watz et al. (2009) showed PA levels to decline across GOLD grades and that this decline could be attributed to behaviour change in that patients were choosing to reduce their PA rather than their disease instigating this decline.

In the milder patients (MRC grade 2) with COPD lower PAL levels were observed in this study in comparison to Watz et al. (2009). Their study reported a mean PAL level of 1.63 (0.25) in GOLD stage I (as determined by FEV_1) and this study a mean PAL level of 1.45 (0.30) in MRC grade 2. PAL levels in the most severe disease categories agree with the finding of Watz et al. (2009) with their GOLD stage IV patients having a mean PAL of 1.27 (0.17) and this study the MRC grade 5 patients also had a PAL of 1.27 (0.18). These differences reflect the difference in step count observed as previously discussed.

The variations in PA seen in the milder patients may due to the different classification systems. GOLD stages I to IV is based on spirometry alone and MRC grade is a self-report measure of dyspnoea. Those in GOLD stage I had an FEV_1 % predicted of 90.0% (10.3) and those in this study classified as

MRC had an FEV_1 % predicted of 50.72% (17.69) and therefore it may not be appropriate to compare these groups directly.

Overall PA levels in patients with COPD

PAL has been reported to be the best predictor of 48 month mortality in patients with COPD (Waschki et al. 2011). The mean (SD) PAL for participant in this study was 1.38 (0.27) putting this cohort of patients at increased risk of premature mortality. This figure is lower than that reported by Waschki et al . (2012), van Gestel et al (2012) and Watz et al. (2009) which were 1.45 (0.20), 1.47 (0.23) and 1.53 (0.29) respectively, in broadly similar populations. However, it's similar to Depew, Novotny and Benzo (2012) who reported a mean PAL of 1.39 (0.28) in 165 patients with COPD reflecting the similar step counts in both studies. Intuitively this suggests that daily step count correlates with PAL and would be an effective marker of PA and inactivity.

In this current study the Harris Benedict equation was used to estimate RMR rate for the determination of PAL. This was in contrast to Waschki et al. (2012), van Gestel et al. (2012), Watz et al. (2009) and Depew, Novotny and Benzo (2012) who all had their participants wear the SWM day and night. Therefore, these studies used EE during sleep time as their measure of RMR for calculating PAL. This may be a more precise measure than the Harris Benedict equation which may have influenced PAL. The Harris Benedict equation has been criticised for not accounting for the participant's ratio of lean muscle mass to body weight, which can have a large effect on resting EE and overestimate EE in obese individuals (Douglas et al. 2007). Although the

population in this trial was not classified as obese results may need to be interpreted in light of the method used to determine RMR.

Although PAL is useful prognostically it is more complex to calculate and not easily measured. Some initial finding have been reported on the number of steps that is associated with severe physical inactivity (PAL <1.4). A daily step value of <4580 was the best cut-point for predicting a PAL <1.4 and may be a more useful benchmark to identify severe physical inactivity (Depew, Novotny and Benzo 2012). What is also useful to understand is whether a patients' activity level meets the recommended guidelines for PA.

The data from this cohort of COPD patients demonstrates that those with the greatest disease severity or impact (GOLD group D and MRC grade 5) spend the most time sedentary and the least time in LPA, regardless of the time spent in PA above 3 METs. LPA appears to be what has impacted on step count and is what is attributable to the differences in step counts seen. LPA can be a significant component to 24 hour energy expenditure (EE) and has shown to effect health related outcomes in other chronic disease (Blair et al. 2014). Therefore, it may be of interest to explore the role of LPA levels in patients with COPD further, considering their low level of functional capacity.

PA levels in patients with COPD in relation to national and international guidelines

The ACSM (Nelson et al. 2007) recommend all adults should participate in at least 30 minutes of moderate intensity PA on at least 5 days per week in order to maintain and improve health. This activity can be accumulated in bouts of at least 10 minutes. A number of studies have reported time in moderate exercise in patients with COPD, but many have not used this cut-off point of at least 10 minute bouts (Troosters et al. 2010, Watz et al. 2009). Therefore, the number of people meeting these guidelines will be potentially over estimated. This current data (figure 7.7 and 7.8) highlight this issue as a significant differences was detected between bout and non-bout activity. When looking at the percentage of participant meeting the guidelines is calculated regardless of continuous 10 minute bouts (figure 7.7 and 7.8) 72% meet this threshold from GOLD group A and 73% from MRC grade 2. A decline in those meeting this particular guideline is seen as disease impact increases through the GOLD groupings to 62% of GOLD group D meeting the guideline. However, this pattern is not seen with the MRC grades, with MRC 4 having the lowest percentage (55%) of participants meeting the guidelines. It is unclear as to why this has occurred, but could be due to this study being underpowered and uneven numbers in each grade.

In order for improvements to occur PA needs to in consecutive bouts of at least 10 minutes. When looking at the data and including only those in at least 10 minute bouts the percentage of those meeting the guidelines drops to 22%

in both GOLD group A and MRC 2 to the lowest level in GOLD category C of 8% and MRC grade 3 12%. Interestingly, Troosters et al. (2010) used different MET value cut-off points to define moderate PA. Troosters study set the threshold at 4.5 METs for those under 65 years or at 3.6 METs for subjects over 65 years. These values are for the improvement of cardiorespiratory fitness rather than the maintenance or improvements of health and given the nature and characteristics of those with COPD this may not be appropriate or achievable.

The limited published data on 10 minute bout data is possibly due to a restricted number of activity monitors presenting minute-by-minute data for bout calculation. One study that has reported moderate PA in at least 10 minute bouts is Donaire-Gonzalez et al. (2012). This study reported the PA levels of 177 patients with COPD from across 9 tertiary hospitals in Spain. This study used 2 measures of classifying moderate PA, >2.6 METs that was determined by 50% of maximal oxygen consumption for an incremental exercise test and >3 METs. When using the cut-off of 2.6 METs 61% of participant met the guidelines which reduced to 50% when 3 METs was used. In the current study, 20% of patients completed 30 minutes of moderate PA per day in 10 minute bouts, which is much lower than Donaire-Gonzalez et al. (2012). In the UK self-reported levels of PA suggests that 39% of men and 29% of women meeting the guidelines for PA (British Heart Foundation 2012). Therefore it is surprising how high these levels are in comparison to healthy adults in the UK, let alone patients with COPD. Patients from Donaire-Gonzalez study were of a similar age and percentage of predicted FEV_1 to

this study. PA participation in Spain has also been reported to be at a similar level to the UK (British Heart Foundation 2012) so it is not fully understood why these differences have been observed. It may be speculated that season, temperature and weather variations affect patients with COPD which has been shown to impact on PA levels in the UK (Sewell et al. 2010) and internationally (Pitta et al. 2009).

Van Remoortal et al. (2013) highlighted the limited reporting in the literature of PA in at least 10 minute bouts and proposed a cut-off level of 80 minutes of PA per day in non-bout PA. 80 minutes per day of non-bout PA was associated with 30 minutes of MVPA in 10 minute bouts in 113 patients with COPD (FEV_1 % predicted 65% (27)) and subjects without COPD. This may offer a more accurate picture to determine if guidelines are being met when using monitors that don't display minute-by-minute data. However, it is not clinically useful as individuals still need to be prescribed PA of 30 minutes in 10 minute bouts to ensure guidelines are met.

The data from this current study may not truly reflect whether guidelines have been met as the SWM was not worn for a full week. This study reports the mean daily time >3METs in at least 10 minute bouts and the recommended PA is to complete 30 minutes of moderate PA on at least 5 days, people do not necessarily need to participate in moderate PA every day. Therefore, averaging the time spent in moderate PA over the five days may have missed PA on the days the SWM was not worn. Five days of monitoring was chosen to allow for a certain level of non-compliance in wearing the monitor, as three days of monitoring has shown to be the minimum number of days needed to

predict PA and sedentary behaviour in older adults (Hart et al. 2011). This number of days may give a reliable picture of PA behaviour and PA behaviour change but cannot give an accurate measure of whether weekly guidelines have been met. In future if the aim of PA monitoring is to determine if guidelines have been met then it is recommended that monitors need to be worn for the full seven day week.

Accumulating 10,000 steps per day is a common marker of achieving PA guidelines and improving health (Tudor-Locke and Bassett Jr. 2004). This study has shown that there was a significant difference in step count between disease severity, suggesting there is a progressive decline in PA for those with mild disease to those with severe disease. The mean number of steps in the current study was 3,919 (2624) reflecting the low level of PA in these patients. This is comparable to Depew, Novotny and Benzo (2012) who reported a mean daily step count of 3,827 (3323) in 165 patients with COPD (FEV_1 %predicted 42.8(17.81)%). Few patients met the 10,000 steps threshold with none meeting this guideline in the more severe GOLD group D and MRC grades 4 and 5 (figure 7.6 and 7.7).

Until recently with the development of more sophisticated activity monitors, it has been difficult to determine if 10,000 steps equates to 30 minutes of MVPA given that this figure also needs to incorporate usual daily walking. These guidelines have been revisited and it has been reported that 3,000 steps roughly equates to 30 minutes of MVPA and therefore including free living steps the minimal daily guidance should be 7,000 to 8,000 steps per day

(Tudor-Locke et al. 2011). When using 7,000 steps as the threshold those meting the guidelines increases in the milder patients however it still remains the case that no participants in GOLD group D and MRC grade 5 (figure 7.6 and 7.7) met this guideline. Using this threshold of recommended PA discriminated between both the GOLD groups and MRC grades and therefore, these revised guidelines may be a more appropriate target for older adults and COPD patients with limited functional capacity.

Determining how many steps equates to set times in MVPA is of interest and as described above Tudor-Locke et al. (2011) reported 30 minutes of MVPA corresponds to 3,000 steps. However, this does not concur with the data presented in this current study. GOLD group D participate in an hour of MVPA but had a mean step count of 2661 steps, and MRC grade 5 completed 57 minutes of MVPA and had a mean step count of 2382 steps. The relationship between MVPA and step count was not examined in the SWM, so could not be clearly explained. However, the discrepancy seen with this current study and Tudor-Locke (2011) could be due to the SWM not being sensitive enough to detect step counts in this group, who would typically have low walking speeds.

7.8 limitations

A number of limitations are acknowledged as part of this study and have been considered in the interpretation of the findings.

This study was observational and investigated PA at one time point. Subgroups of those with differing disease severity have been used to highlight the possible progress of PA as the severity of disease progresses. Longitudinal data of PA during the natural course of the disease is lacking due to challenging research design and ethical issues. This was out of the scope of this study, but there is a need to understand the pattern of PA over time against the background of increasing disease severity.

It is highly likely that PA behaviour has increased during the monitoring period. Subjects were aware the study was measuring PA and wearing the PA monitor may have motivated patients to increase their normal PA pattern. However, even if we do consider the data collected to be their 'best' days PA levels reported are still well below recommended levels.

A further limitation is in the assumption of a mean value of 30 minutes in at least 10 minute bouts equate to meeting the guidelines for PA. The guidelines recommend accumulating 150 minutes of MVPA per week and not necessarily 30 minutes per day. At least 3 days of data was used in the analysis as this is the minimum recommended duration in older adults (Hart et al. 2011). In order to obtain a more accurate picture to determine if guidelines are met at least 7 days of monitoring is required.

Differences in PA between studies could be due to monitor wear time and that participants in this study have been told to wear the monitor for waking hours only and may have removed their activity monitor some time before going to

bed and those with milder disease are the ones more likely to continue to with PA and therefore this data may have been missed. A difference in calculation of PAL was also identified in comparison to this one. In this study basal metabolic rate was estimated by the Harris-Benedict equation (Harris and Benedict 1918) and the Waschki (2012) study used energy expenditure during sleep to calculate PAL. Energy expenditure in this current study was estimated by the SWM which was shown not to have good reproducibility and sensitivity. In regards to step count the SWM did not show acceptable reproducibility at the very low speeds (1.73km.hr). 16 patients in the PR group and 12 in the SPACE for COPD group were prescribed their walking programme at this speed and therefore its ability to accurately detect steps and PA in these patients is questionable.

7.9 Conclusion

It is clear that PA levels in patients with COPD are low and those in the greatest impact categories are the lowest. This chapter aimed to describe PA levels using a number of commonly reported variables across disease severity. This highlighted that even those with mild disease (GOLD group A and MRC 2) are limited in their daily PA. This suggests that interventions to improve PA should be offered to all COPD patients regardless of disease severity or impact.

To date most studies have reported total PA as total time in MVPA. The ACSM and the Department of Health recommend that to improve and

maintain health 30 minutes of ≥3METs activity need to be completed on at least 5 days of the week and that time should be accumulated in at least 10 minute bouts. This study reported a significant difference in the time spent above 3 METs when calculated as bouts or non-bouts. This highlights that most of the time reported was accumulated in less than 10 minute bouts which would not necessarily contribute to health improvements. If the 30 minutes of non-bout MVPA threshold was used to determine if an intervention was used, this may not be appropriate and mask the need for PA behaviour change in these patients. It is therefore important to interpret studies in relationship to how they have reported this data and in future studies aiming to improve health should report time in MVPA in at least 10 minute bouts.

The goal for any PA intervention should be to get its participant to meet the PA guidelines. However, these guidelines are directed to healthy adults and it may be that these guidelines are unachievable in those with limited functional capacity and very low baseline levels of PA. There is evidence that LPA can improve health in those with chronic disease (Blair et al. 2014). In this study those with low MVPA also had low LPA levels. It may be of interest for future studies to look at the impact of increasing LPA in patients with low PA levels as this may be a more appropriate and achievable goal.

Chapter 8 – The Effect of the SPACE for COPD programme on physical activity levels in patients with COPD

8.1 Introduction

The previous chapter (chapter 7) discussed that physical inactivity is associated with poorer prognosis in patients with COPD (Casanova et al. 2007, Waschki et al. 2011, Garcia-Rio et al. 2012). As part of the SPACE for COPD study baseline physical activity (PA) was shown to be low with a mean PAL of 1.38 (0.27) which classifies these patients as extremely sedentary. Additionally only 18% completed 30 daily minutes of MVPA in at least 10 minute bouts and only 4% meet the recommended 10,000 steps per day and 8% 7,000 steps per day.

Behaviour modification is needed to increase PA and potentially optimise long term health outcomes. Education and the development of self-management skills (SM) are key to facilitate this change. Both Pulmonary Rehabilitation (PR) and the SPACE for COPD programmes incorporate education and additionally aim to equip patients with skills to problem solve, make informed decisions and enhance confidence to take action. By implementing these skills it is anticipated that positive long term health behaviour will result, such as increased PA levels. Therefore, this chapter will focus on the effect of the SPACE for COPD programme on PA levels at seven weeks (at the end of the intervention), and six months after the intervention has ceased. The SPACE for COPD programme was compared with conventional PR.

8.2 Aim

The aim of this chapter is to evaluate the effect of the SPACE for COPD programme on PA levels in comparison to PR at seven weeks and six months.

8.3 Methods

The main design of the trial is described in detail in chapter 3. Chapter 7 (section 7.3) also gives details of the variables measured and extracted from the Sensewear Armband (SWM). Patients wore the SWM for five days (three weekdays and two weekend days) for all waking hour at baseline, seven weeks and six month assessment time points. For comparison between groups and time points 12 hour data was used. The 12 hours commenced from when the monitor started recording, when the monitor was initially put on by the patient. If a subject had worn the monitor of 24 hours, the 12 hour period commenced in the first minute that lying down was not detected.

Physical activity above prescribed level

The SWM was worn during the Endurance Shuttle Walk Test (ESWT) that was worn during the seven week visit. The timestamp button on the monitor was used to mark the beginning and end of the test. This enabled us to determine the intensity of exercise using METs that corresponded to the prescribed walking speed of 85% of maximal performance on the Incremental Shuttle Walk Test (ISWT; Figure 8.1). This prescribed MET level could then be used to analyse if patients achieved this threshold. ‘Time above prescribed

MET level' and 'Energy expenditure above prescribed MET level' are therefore, described in this chapter.

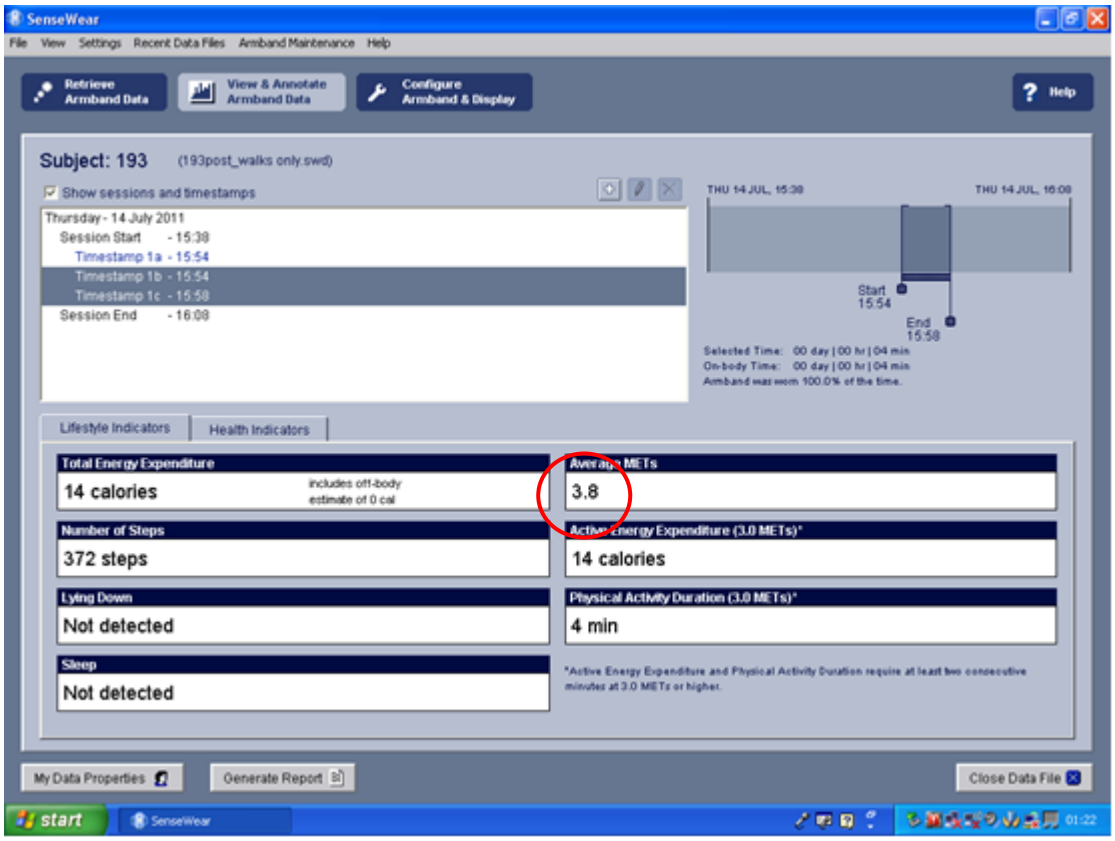


Figure 8.1 InnerView™ Software, highlighting data extraction for prescribed METs (patient example)

8.4 Outcome Measures

- Total daily step counts
- PAL
- Total time <2 METs (sedentary)
- Total time 2-3 METs (light physical activity: LPA)
- Total time 3-6 METs (moderate to vigorous physical activity: MVPA)
- Total time 6+ METs (vigorous activity)
- Total energy expenditure above 3 METs

- Total time above prescribed METs
- Total energy expenditure above prescribed METs
- Total time over 3 METs in at least 10 minute bouts
- Average METs level taken from the ESWT

8.5 Statistical analysis

Data was initially analysed for normality. Within group differences, from baseline to seven weeks, were tested for by a paired t-test and between group differences were tested for by an independent t-test. A significant difference was detected between the treatment groups for FEV_1% predicted. Therefore between group differences over time to six months were analysed using an analysis of covariance (ANCOVA) with FEV_1% predicted as the covariate.

8.6 Results

Of the 154 that took part in the baseline PA monitoring trial, 59 subsequently withdrew. One set of data was discarded due to an error message on the SWM and 43 were discarded as they were not worn for at least 12 hours on at least 3 days. This left 51 subjects with at least 3 days of 12 hour data at each of the time points (baseline, seven weeks and six months) available for analysis (figure 8.2). Baseline characteristics from the 25 subjects in the PR arm of the trial and the 26 in the SPACE for COPD arm are presented in table 8.1. A significant difference in percentage of predicted FEV_1 was detected between the two intervention groups. No other differences were identified (table 8.1)

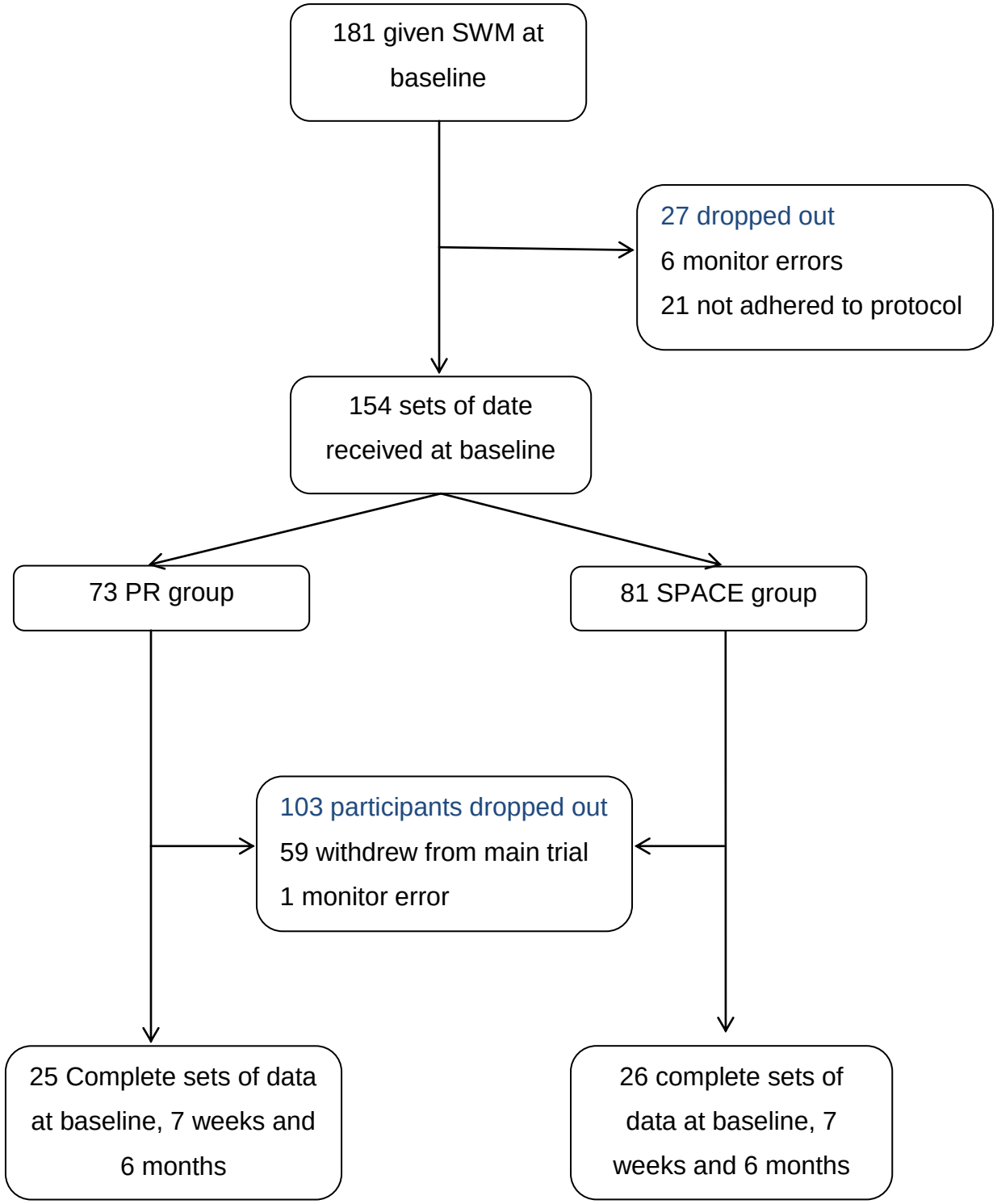


Figure 8.2 CONSORT diagram of patient flow through the study

Table 8.1 Mean (SD) baseline characteristics between PR and SPACE groups who participated in the physical activity monitoring study

	PR (n=25)	*SPACE (n=26)*	*p value*
Age (yrs)	69 (6.24)	68 (6.92)	0.443
Male:Female (n)	18:7	18:8	0.828
BMI (m/kg^2)	27.15 (5.29)	26.65 (5.44)	0.741
FEV_1 (litres)	1.37 (0.51)	1.09 (0.53)	0.060
FEV_1 %predicted	54.83 (20.05)	42.24 (18.81)	0.028
FVC (litres)	2.86 (0.89)	2.60 (0.84)	0.294
MRC (n:%)			
2	5 (20%)	7 (27%)	0.826
3	10 (40%)	10 (38%)	
4	9 (36%)	7 (27%)	
5	1 (4%)	2 (8%)	
GOLD (n:%)			
A	3 (12%)	3 (12%)	0.263
B	12 (48%)	6 (23%)	
C	2 (8%)	3 (12%)	
D	8 (32%)	14 (54%)	
SpO_2 rest %	93.88 (24.80)	94.15 (2.42)	0.684
Smoking status (n:%)			
Current smoker	7 (28%)	4 (15%)	0.091
Never smoked	0 (0%)	4 (15%)	
Ex-smoker	18 (72%)	18 (70%)	
Pack years	51.34 (24.80)	43.25 (37.39)	0.377
CRQ-SR			
Dyspnoea	2.35 (0.80)	2.64 (0.84)	0.217
Fatigue	3.51 (1.13)	3.49 (1.20)	0.952
Emotion	4.45 (1.33)	4.67 (1.22)	0.550
Mastery	4.33 (1.22)	4.59 (1.35)	0.488
HADS			
Anxiety	7.50 (3.83)	7.75 (4.54)	0.838
Depression	6.13 (2.23)	5.83 (3.94)	0.754
PRAISE	42.70 (8.66)	44.27 (8.53)	0.543
ISWT (distance)	267 (128.18)	281 (170.77)	0.742
ESWT (sec)	228 (125.23)	292 (298.90)	0.326

Table 8.2 Comparison of physical activity baseline variables in the PR and SPACE for COPD groups. 12 hour data used. Mean prescribed MET level 3.8

	PR (n=25)	*SPACE (n=26)*	*p*
Steps	3683 (1820)	3902 (2120)	0.694
PAL	1.38 (0.28)	1.40 (0.33)	0.771
Sedentary time (minutes)	549 (103)	540 (119)	0.782
LPA time (minutes)	107 (72)	112 (59)	0.771
MVPA time (minutes)	58 (36)	66 (86)	0.422
Vigorous Time (minutes)	6 (25)	2 (5)	0.346
EE over 3 METs	330 (366)	347 (452)	0.893
Time over prescribed METs	36 (52)	50 (105)	0.570
EE over prescribed METs	199 (356)	323 (519)	0.807
Time over 3 METs in bouts	15 (25)	11 (15)	0.480

Baseline PA levels are presented in table 8.2. No statistical difference was seen between PR and SPACE for COPD groups.

Seven week changes in PA

Seven week changes in PA in the two treatment groups are presented in table 8.3 and between group differences in table 8.4. The mean prescribed MET level was 3.8 METs.

At seven weeks there was no significant change in any PA measure compared to baseline in the PR group. However, a significant improvement was seen in step count, PAL, sedentary time and time over 3 METs in at least 10 minute bouts in the SPACE for COPD group (table 8.3). Differences in the change in score were significantly higher in the SPACE for COPD group than the PR group for steps and time over 3 METs in 10 minute bouts (table 8.4). Change in sedentary time was also significantly less in the SPACE for COPD group than the PR group (table 8.4).

When analysing the data with all the available data from baseline to seven weeks, 83 participants were available for analysis. A similar pattern was seen with this data when comparing pre and post changes in PA. The SPACE for COPD group had a significant improvement in PAL, sedentary time and time over 3 METs in 10 minute bouts, whereas, no significant changes were detected in the PR group (table 8.5). However, the between group differences in the change in scores were not significantly different (table 8.6).

Table 8.3 Mean (SD) Changes in PA from baseline to 7 weeks for PR and SPACE groups. Data presented is from those whom have full data sets at baseline, seven weeks and six months. Data is minutes unless stated.

	Baseline Score (SD)	***7 weeks Score (SD)***	***Change (95% CI)***	**p Value**
PR (n=25)				
Steps (count)	3683 (1820)	3219 (1829)	-464 (-1445 to 517)	0.459
PAL	1.38 (0.28)	1.43 (0.17)	0.05 (-0.08 to 0.17)	0.339
Sedentary	549 (103)	555 (91)	6 (-38 to 45)	0.859
LPA	107 (72)	113 (73)	6 (-23 to 33)	0.720
MVPA	58 (36)	50 (39)	-8 (-28 to 73)	0.299
Vigorous	6 (25)	2 (7)	-4 (-15 to 7)	0.431
EE over 3METs (Kcal)	330 (366)	236 (186)	-94 (-61 to 63)	0.217
Time over prescribed METs	36 (52)	26 (38)	-10 (-32 to26)	0.829
EE over Prescribed METs (kcals)	199 (356)	129 (167)	-70 (-223 to128)	0.878
Time over 3METs in bouts	15 (25)	11 (15)	-4 (-13 to 6)	0.444
SPACE (n=26)				
Steps (count)	3902 (2120)	4976 (3130)	1074 (289 to 1708)	0.008
PAL	1.40 (0.33)	1.56 (0.27)	0.16 (0.04 to 0.29)	0.010
Sedentary	540 (119)	494 (106)	-46 (-86 to -11)	0.013
LPA	112 (59)	136 (73)	24 (-10 to 45)	0.196
MVPA	66 (86)	84 (64)	18 (-5 to 42)	0.114
Vigorous	2 (5)	6 (21)	4 (-4 to 14)	0.275
EE over 3METs (Kcal)	347 (452)	430 (323)	83 (-124 to 288)	0.417
Time over prescribed METs	50 (105)	37 (38)	-13 (-68 to 35)	0.501
EE over Prescribed METs (Kcal)	232 (519)	183 (171)	-49 (-299 to 201)	0.685
Time over 3 METs in bouts	11 (5)	39 (57)	28 (9 to 48)	0.006

Table 8.4 Group differences in the change in PA from baseline to 7 weeks (SPACE minus PR). Data presented is from those whom have full data sets at baseline, seven weeks and six months. Data is minutes unless stated.

n=51	*Between group Difference (95%CI)*	**P Value**
Steps (count)	1463 (280 to 2645)	0.020
PAL	0.12 (-0.050 to 0.29)	0.122
Sedentary	-52 (-106 to 2)	0.039
LPA	13 (-26 to 51)	0.526
MVPA	62 (-56 to 248)	0.242
Vigorous	9 (-5 to 23)	0.179
EE over 3METs (Kcal)	181 (-74 to 436)	0.130
Time over prescribed METs	-14 (-71 to 44)	0.902
EE over Prescribed METs (kcal)	-1.79 (-299 to 295)	0.597
Time over 3 METs bouts	32 (11 to 54)	0.006

The table above (table 8.4) displays the change in PA from baseline to seven weeks in those that had data for all three time points.

Six month changes in PA

Table 8.5 presents the baseline, seven week and six month measures for all PA measures. It also displays the change in score from baseline to six months and the between group differences.

Table 8.5 Mean (SD) baseline, seven week and six month scores and change in scores from baseline to six months in PA for PR and SPACE

		PR	*SPACE*	*Between Group Differences Mean (95% CI)*
Steps	Baseline	3683 (1820)	3902 (2120)	219 (-895 to 1333)
	7 weeks	3219 (1829)	4976 (3130)	1757 (290 to 3224)
	6 months	3408 (2065)	3593 (2160)	185 (-1004 to 1374)
	Change	**-275 (1777)**	**-309 (1872)**	**-34 (-1062 to 994)**
PAL	Baseline	1.38 (0.28)	1.40 (0.33)	0.02 (-0.15 to 0.20)
	7 weeks	1.43 (0.17)	1.56 (0.27)	0.13 (0.01 to 0.27)
	6 months	1.46 (0.27)	1.47 (0.25)	0.01 (-0.13 to 0.16)
	Change	**0.08 (0.37)**	**0.08 (0.25)**	**0 (-181 to 0.18)**
Sedentary	Baseline	549 (103)	540 (119)	-9 (-71 to 54)
	7 weeks	555 (91)	494 (106)	-61 (-116 to -5)
	6 months	556 (95)	543 (96)	-13 (-66 to 41)
	Change	**7 (56)**	**3 (72)**	**-4 (-40 to 32)**
LPA	Baseline	107 (72)	112 (59)	5 (-32 to 42)
	7 weeks	113 (73)	136 (73)	17 (-23 to 59)
	6 months	102 (68)	108 (54)	6 (-29 to 40)
	Change	**-15 (54)**	**-16 (66)**	**-1 (-35 to 33)**
MVPA	Baseline	58 (36)	66 (86)	8 (-209 to 87)
	7 weeks	50 (39)	84 (64)	34 (5 to 65)
	6 months	55 (49)	63 (60)	8 (-22 to 40)
	Change	**-5 (39)**	**-5 (54)**	**0 (-27 to 26)**
Vigorous	Baseline	6 (25)	2 (5)	-4 (-15 to 5.6)
	7 weeks	2 (7)	6 (21)	4 (-5 to 13)
	6 months	7 (22)	6 (17)	-1 (-12 to 10)
	Change	**1 (34)**	**4 (17)**	**3 (-12 to 19)**
EE over 3METs (Kcal)	Baseline	330 (366)	347 (452)	17 (-234 to 268)
	7 weeks	236 (186)	430 (323)	186 (38 to 335)
	6 months	299 (358)	342 (369)	43 (-162 to 247)
	Change	**-53 (452)**	**-48 (213)**	**5 (-213 to 222)**

		PR	*SPACE*	*Between Group Differences Mean (95% CI)*
Time over prescribed METs	Baseline	36 (52)	50 (105)	14 (-37 to 66)
	7 weeks	26 (38)	37 (38)	11 (-22 to 30)
	6 months	38 (55)	45 (74)	7 (-32 to 47)
	Change	**-2 (64)**	**-5 (58)**	**-3 (-42 to 36)**
EE over Prescribed METs	Baseline	199 (356)	232 (519)	33 (-241 to 307)
	7 weeks	129 (167)	183 (171)	54 (-100 to 135)
	6 months	202 (341)	239 (417)	37 (-194 to 267)
	Change	**-3 (483)**	**7 (307)**	**10 (-245 to 281)**
Time over 3 METs in ≥10 min bouts	Baseline	15 (25)	11 (5)	-4 (-15 to 8)
	7 weeks	11 (15)	39 (57)	28 (5 to 52)
	6 months	20 (33)	26 (44)	6 (-16 to 28)
	Change	**5 (33)**	**16 (39)**	**11 (-10 to 31)**

Table 8.6 differences from baseline to six months and differences between PR and SPACE for COPD groups

PA measure	*Within group effects Baseline to six months*		*Between PR v SPACE effects (p=)*
	Time (p=)	*Time*Intervention (p=)*	
Steps	0.162	0.017	0.054
PAL	<0.0001	0.357	0.668
Sedentary	0.043	0.042	0.443
LPA	0.165	0.705	0.382
MVPA	0.344	0.232	0.606
Vigorous	0.730	0.445	0.415
EE over 3METs (Kcal)	0.636	0.196	0.625
Time over prescribed METs	0.783	0.952	0.885
EE over Prescribed METs	<0.0001	0.906	0.851
Time over 3 METs in bouts	0.037	0.008	0.606

Table 8.6 presents the repeated measure analysis for PA over six months. Data suggests that by six months there is no difference between the groups in any PA measure

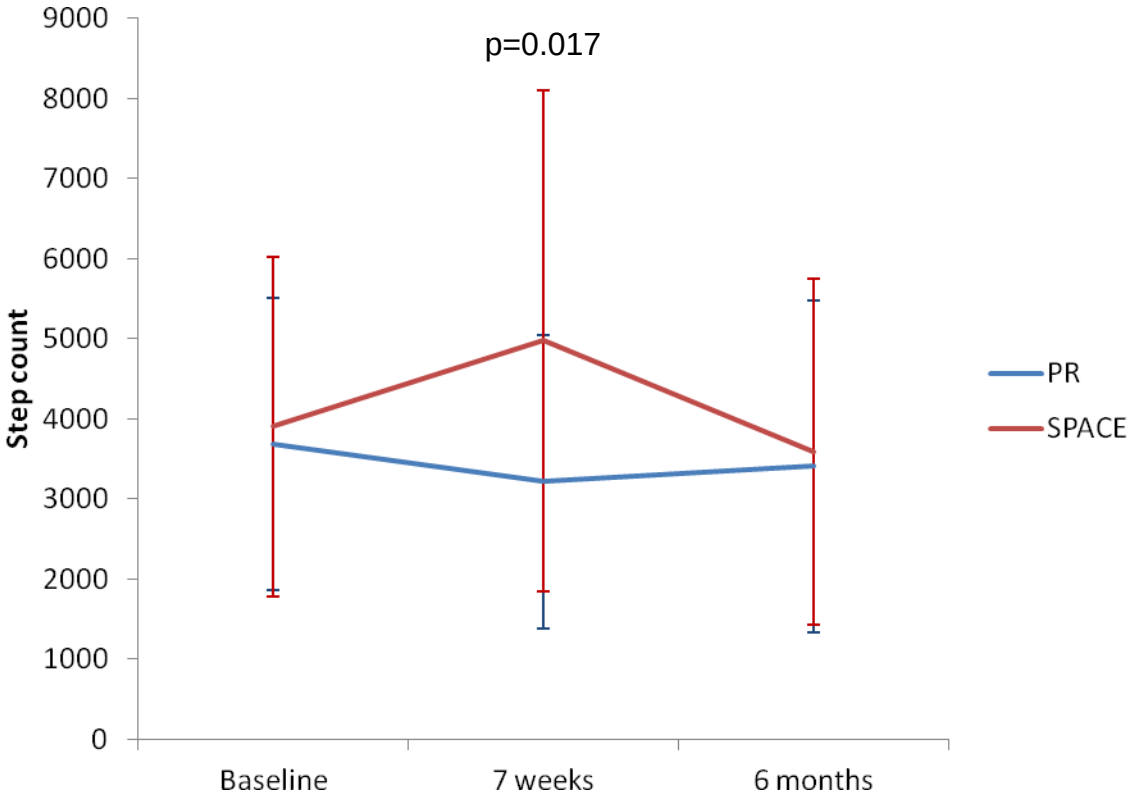


Figure 8.3 Mean (SD) scores of step count at baseline, seven weeks and six months in the PR and SPACE for COPD groups.

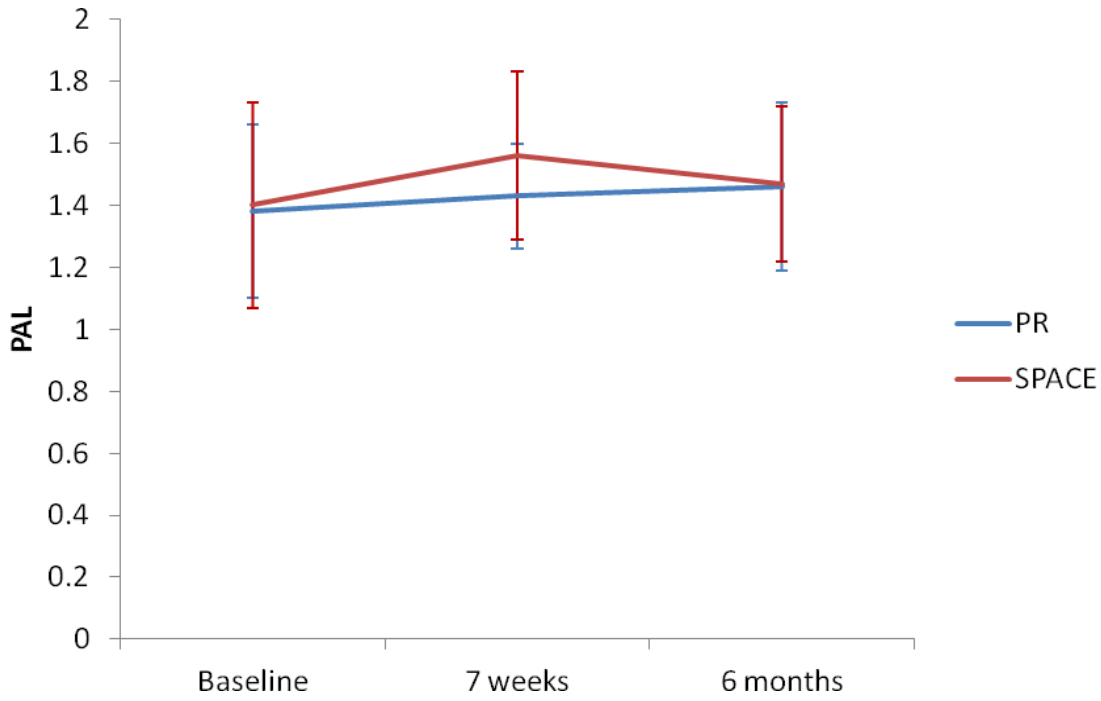


Figure 8.4 Mean (SD) scores of PAL at baseline, seven weeks and six months in the PR and SPACE for COPD groups.

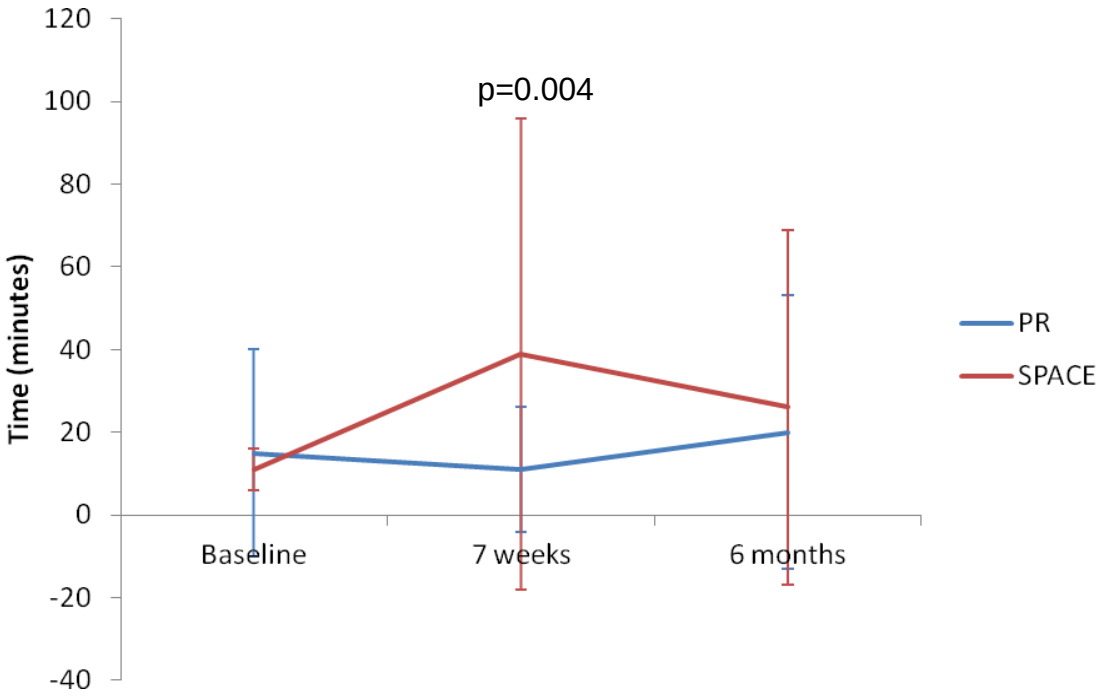


Figure 8.5 Mean (SD) scores of time spent over 3 METs in at least 10 minute bouts at baseline, seven weeks and six months in the PR and SPACE for COPD groups.

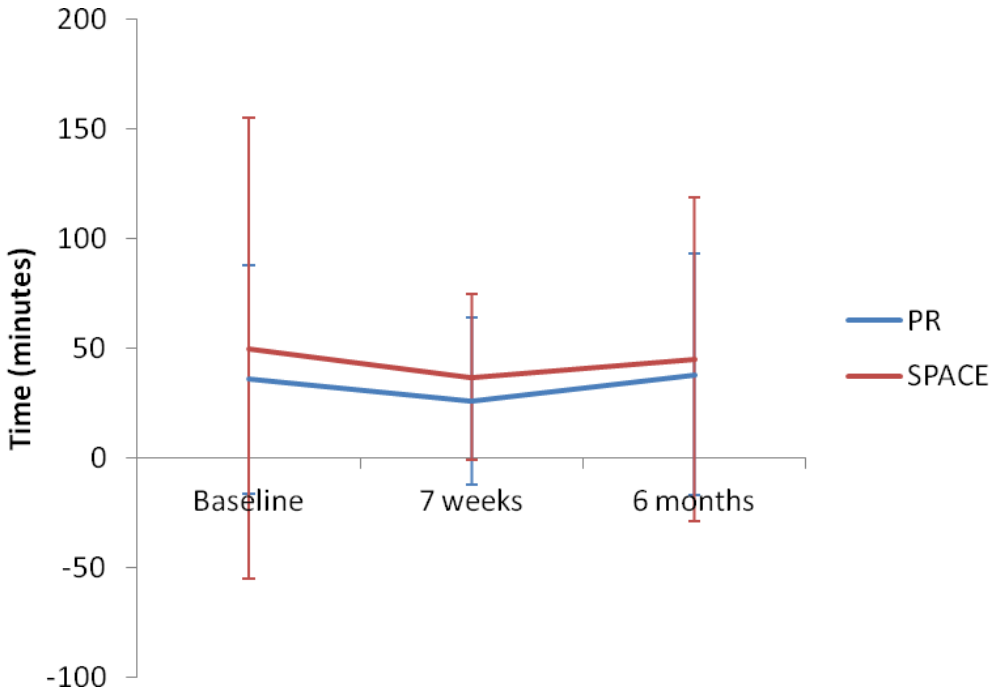


Figure 8.6 Mean (SD) scores of time spent above prescribed METs at baseline, seven weeks and six months in the PR and SPACE for COPD groups.

Figures 8.3 to 8.6 show the change in PA at baseline, seven weeks and six months. Significant between group differences are highlighted at seven weeks. Figures 8.3, 8.4 and 8.5 show an intial increase in PA in the SPACE for COPD group compared to PR. However, by six months scores return to near baseline levels. Figure 8.6 demonstrates the decline in the time spent above the individual presrcibed level of PA, decreasing at seven weeks in both groups and then returning to baseline at six months. The mean individually prescribed MET intensity prescribed was 3.8 METs. Therefore, patients were spending more time in the window between 3 and 3.8 METs, less time between 3.8 METs and 6 METs and more time over 6 METs after the intervention.

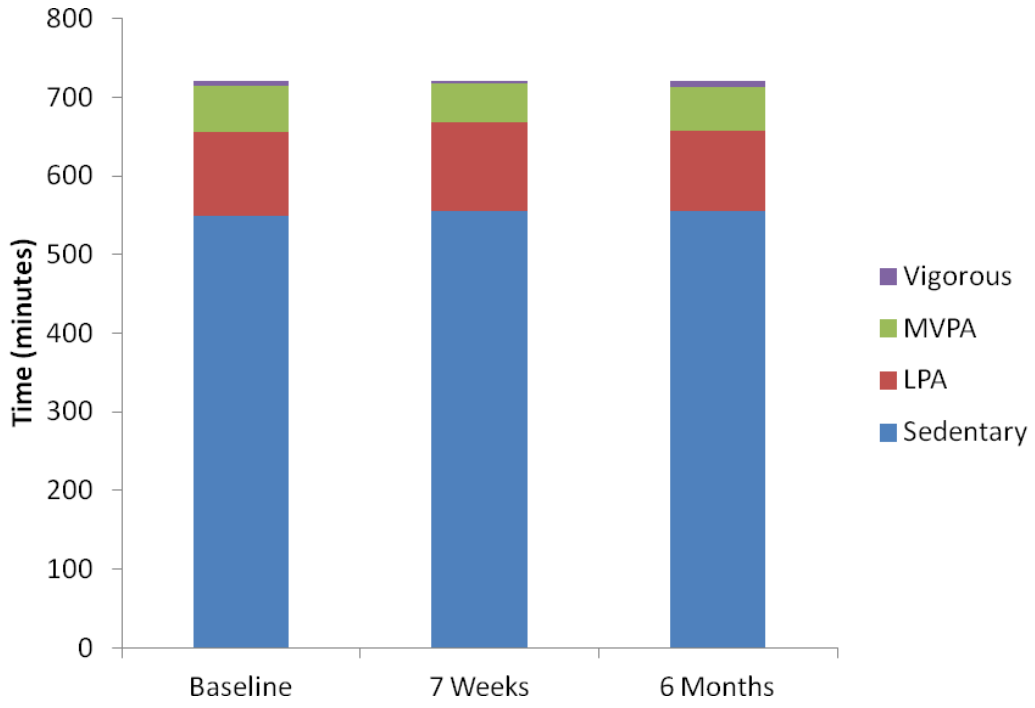


Figure 8.7 Proportion of time spent in sedenary and PA categories at baseline, seven weeks and six months in the PR group

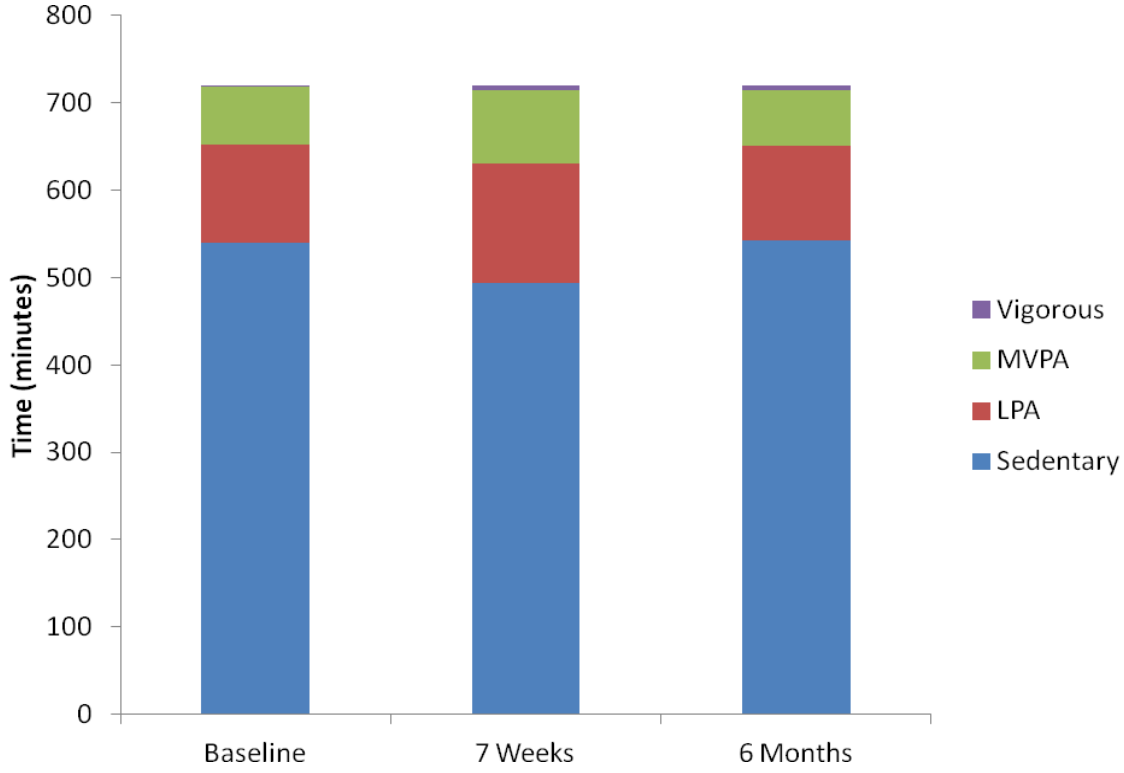


Figure 8.8 Proportion of time spent in sedenary and PA categories at baseline, seven weeks and six months in the SPACE for COPD group

Figure 8.7 and 8.8 show the distribution of the 12 hour (720 minutes) day in PA intensities and sedentary time. The figures demonstrate the increase in MVPA and LPA in the SPACE for COPD group in comparison to PR at seven weeks. Only minimal changes are detected in the PR group.

Figures 8.8 and 8.9 show the change in PAL category from baseline, seven weeks and six months in the PR group (figure 8.9) and SPACE for COPD group (figure 8.10). At baseline both groups have a large percentage of patients in the <1.40 category which is extremely sedentary. At seven weeks this has declined and the 1.40-1.69 category increased, indicating both groups have increased their PA. However, by six months PA has reduced according to PAL category. There were no statistically significant differences between PR and SPACE for COPD in each of the categories at either time point.

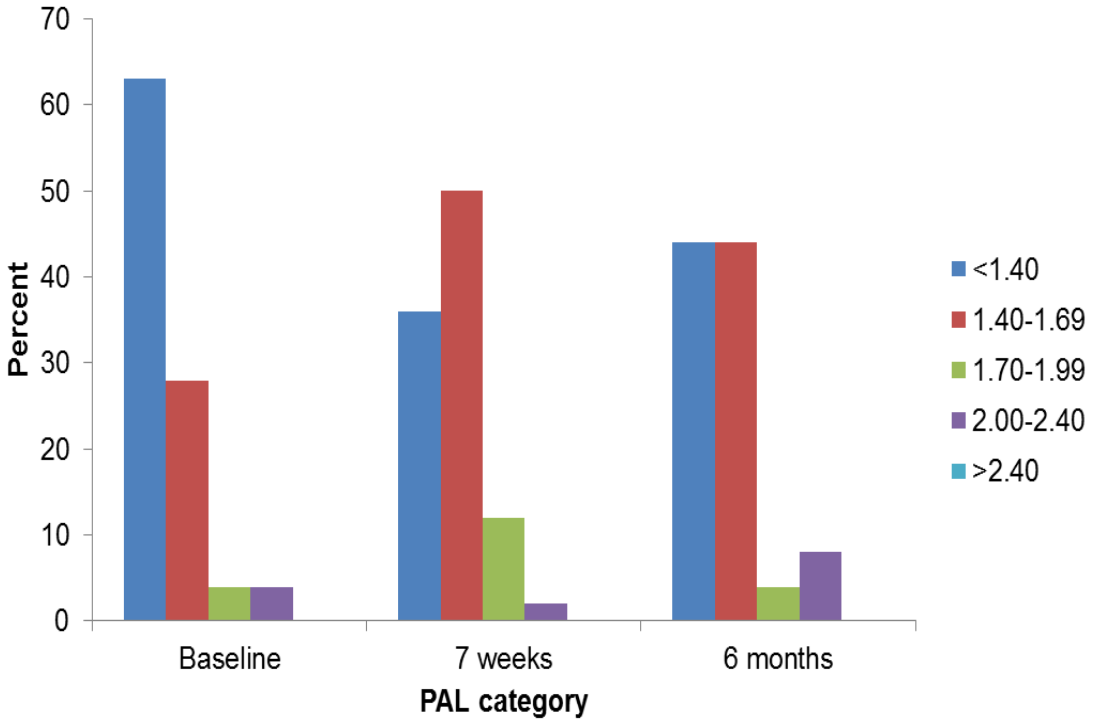


Figure 8.9 Change in PAL category from baseline, seven weeks and six months in the PR group

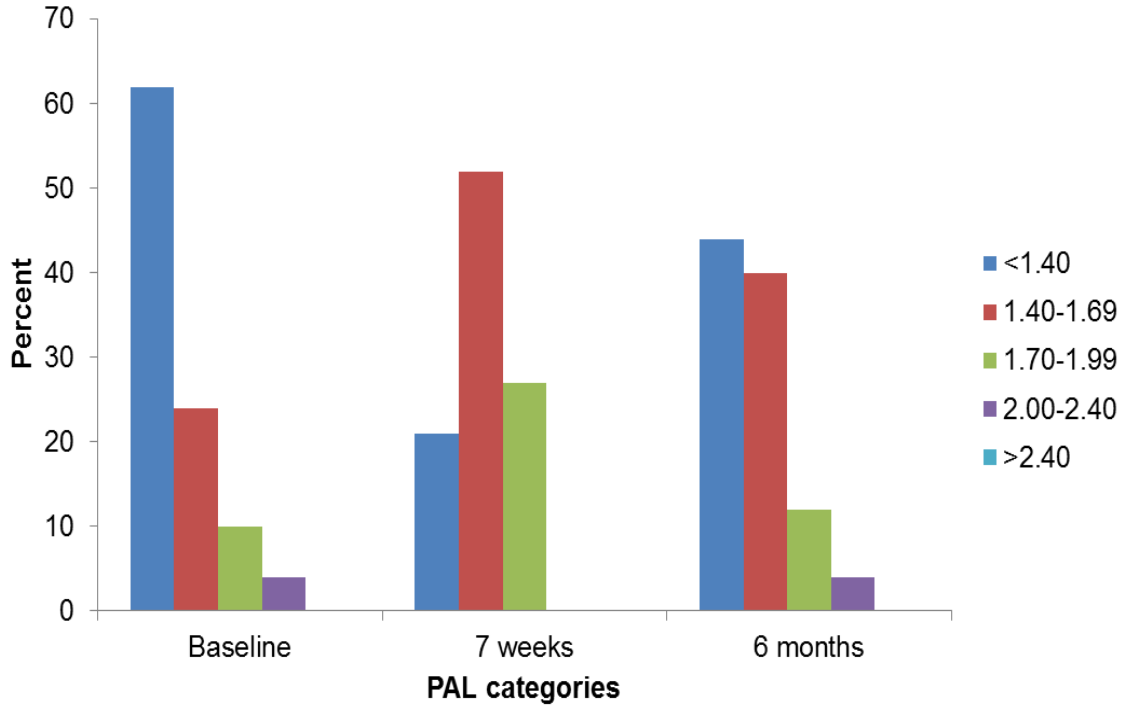


Figure 8.10 Change in PAL category from baseline, seven weeks and six months in the SPACE for COPD group

8.7 Discussion

Describing the level of PA and sedentary behaviour after a home based SM programme is novel. The aim of this chapter was to explore the effect of the SPACE for COPD programme on various measures of PA and sedentary time at seven weeks and six months in comparison to PR. This study was only completed on a subgroup of participants and was subject to a large dropout rate, therefore the interpretations of the findings are discussed in aliment with this limitation.

Patients in the SPACE for COPD group have shown a significant increase in step count, PAL, LPA, MVPA, vigorous activity, EE over 3 METs and time over 3 METs in bouts of at least 10 minutes, and a reduction in sedentary time and time and EE over individually prescribed METs was at seven weeks. This demonstrates that this group increased their PA level and reduced sedentary time, however, this increased activity was not at a level corresponding to their individually prescribed exercise. This reduction in time over prescribed METs is potentially reflected by the change in ISWT seen where no significant improvement was detected (table 5.10). At seven weeks those in the SPACE for COPD had a within group significantly enhanced improvement in daily step count ($p=0.020$; table 8.4), time over 3 METs in 10 minute bouts ($p=0.006$; table 8.4), and reduced sedentary time ($p=0.039$; table 8.4) compared to PR.

Those in the PR group showed no significant improvements in any of the PA variables. This is an unexpected finding as it has been previously reported that the PR programme at Glenfield demonstrated a 29 to 41% increase in

activity monitor counts after seven week (Sewell et al. 2005). Pitta et al. (2008) reported faster walking time after three months of PR. However, they did not observe a significant increase in walking time until after six months of supervised PR and that this increase in walking time was due to small increase in short bouts of PA up to 1 minute in length. It is possible that due to the higher number in the PR not getting the group they preferred they may not have engaged in the programme fully. They attended the supervised outpatient sessions that were enough to increase their exercise performance but not adhere to their home programme. It may also be speculated that those in the PR group abdicated responsibility for their health to the healthcare team and relied purely on their supervise exercise session. This may explain why their ISWT and ESWT increased but was not reflected in PA levels. The emphasis in PR is on exercise and completing bouts of walking. However, no increase in time spent in MVPA in at least 10 minute bouts was observed. This supports the hypothesis that patients in the PR group have completed the course of supervised exercise, but not adhered to the home aspect of the programme.

The discrepancy in the exercise performance measures and PA measures is not fully understood. However, it is possible that the PA monitoring has not fully captured PA levels as only a snap shots of time was recorded. There is the possibility that the PR group have increased their exercise capacity purely on the basis of the supervised outpatient sessions and they have not continued with their walking programme at home. Whereas, the SPACE for COPD group who have shown increases in daily PA but not such large

improvements in exercise capacity (ISWT and ESWT) have increased their time walking but this time has been sub therapeutic. However, due to the much smaller numbers in the PA monitoring part of the trial, it is most likely that statistical power has not been met for this outcome measure. The possible characteristics of those more suited to PR and those more suited to SPACE for COPD warrant closer examination. Due to the small numbers in this trial it has not been possible to analyse the predictors of improved physical activity.

At six months PA and sedentary time had returned to baseline levels and no significant difference was detected between PR and SPACE for COPD. The within subject analysis show a significant effect of time (p=0.03) and time*intervention (p=0.008, table 8.6) for the >3METs in bouts which is reflected in the percentage of participants meeting the threshold of 30 minutes of >3METs in 10 minute bouts in the SPACE for COPD group. Although overall PA levels have returned to baseline it appears that when PA does take place it is more likely to be in longer durations than at baseline. This is an important observation due to its related health behaviour and has not been previously reported. Although patients appear to be spending more time in continuous bouts of exercise at six months the mean time is still below recommended levels. The effect of a PA intervention on adherence to PA guidelines in patients with COPD has not previously been reported. Cindy Ng (2012) completed a systematic review to determine if exercise training impacts daily PA in patients with COPD and concluded that exercise training resulted in only a small effect of daily PA. This highlights the complexity of

factors influencing PA. While PA levels has been associated with poor prognosis (Waschki et al. 2011) it is yet to be fully elucidated if exercise training leads to increased PA and hence improved health outcomes.

Although the reliability of the SWM was reduced at lower walking speeds (1.78 km.hr; Chapter 4) the median prescribed walking speed was 3.6 km.hr and the mean prescribed MET level was 3.8 METs. Therefore we can be confident of the 10 minute bout data.

The only other SM trial that has reported PA as an outcome measure is Effing et al.(2011) . This study used the Yamax DigiWalker SW-200 pedometer to assess the number of steps over seven days at baseline, three months and 12 months. Over the 11 month intervention there was a mean improvement of 1190 steps. This is comparable to the SPACE intervention after seven weeks. A limitation of Effings et al. study was that only step count was measured and that pedometers have been shown to be less reliable to activity monitors at slower speeds of walking (Turner et al. 2012), a characteristic of patients with COPD (Troosters et al. 2010). Step count is a useful measure but does not indicate intensity or patterns of PA and therefore it is not possible to determine if the ACSM guidelines have been met. The PA data from this trial is more descriptive in determining patterns and intensities of PA and therefore provides a more meaningful insight to PA behaviours of patients with COPD. Additionally this current study has provided data 6 months after the completion of the intervention and the Effing et al. (2011) study shows no follow up data.

The continued supervision in the Effing et al. study to the 12 month assessment highlights the possible value of continued support. Although the SPACE for COPD programme was successful at increasing daily activity it was not maintained at six months. The short term interaction with healthcare professionals during the seven week intervention may have provided support and motivation without the need for supervised sessions to increase PA. Maintaining this improvement in PA is the challenge and the best mechanism to deliver this is not fully understood and in need of further investigation.

It has been hypothesised that in order for behaviour change to take place an individual's knowledge, self-efficacy and skills need to be enhanced (Bourbeau, Nault and Dang-Tang, 2004). It is a limitation of this trial that knowledge was not measured. However, the PRAISE questionnaire was used to assess self-efficacy. A significant increase in self-efficacy was detected at seven weeks in the PR but not in the SPACE for COPD group. In light of this chapter findings, this data does not support Bourbeau, Nault and Dang-Tang theory (2004). However, as previously postulated (chapter 5.7) the PRAISE questionnaire may not be an appropriate tool to measure self-efficacy in the SPACE for COPD group or that statistical power was not met. Also the link between knowledge, self-efficacy and behaviour change may not be as simple as implied by their model (figure 2.2.1).

8.8 Limitations

In order to standardise within and between group data the first waking 12 hours of monitoring was chosen. Therefore, monitors worn for longer period's data has not been included. Although it is anticipated that the first 12 hours is most likely be more active it is probable that data has been missed. There are no clear guidelines as to the most appropriate method for the wear of activity monitors and 12 hours was chosen based on previous studies who have used this cut point (Pitta et al. 2008, Pitta et al. 2009). Other studies have reported PA measures as percentage of wear time (Hill et al. 2012) which may offer a more accurate picture. However, a minimum wear time still needs to be stipulated as short wear times may not give a truly representative depiction of PA. The minimum number of hours per day required to gain an accurate representation of an individual's PA is currently unknown and warrants further investigation.

Compliance with wearing the monitor is a limitation in this study. Of those asked to wear the monitor compliance was 54%, which is much lower than that reported by Waschki et al (2012) who had a compliance rate of 94%. A possible explanation for this difference can be seen is in the protocols. Waschki's study required participants to wear the monitors 24 hours a day and only take them off during swimming and personal hygiene activities. This would therefore mean they have had less opportunity to forget to put the monitor back on as it will have not been taken off at night. This study allowed participants to remove their monitors at night. This was done at the time as it was believed that we did not need PA data overnight and thought they may

cause participants less irritation if they did not need to wear monitors overnight. On reflection this may have increase the risk of participants forgetting to put their monitors on in the mornings and hence not having enough data to analyse.

Measuring PA is challenging and activity monitors offer the best predictor of activity levels as opposed to self-report and pedometers. However, the SWM and other accelerometers are unable to give details as to the precise nature of the activity. Perhaps the combination of both accelerometry and questionnaires or activity diaries could offer the best picture of PA behaviour in this population.

8.9 Conclusion

This study is the first to report detailed PA data after a home based SM programme. Although numbers were small, at seven weeks no significant improvement in any PA variable was detected in the PR group. The SPACE for COPD group showed a significant increase in step count, PAL and time over 3 METs in bouts and a decrease in sedentary time. There were significant improvements in step count and time over 3 METs in at least 10 minute bouts in the SPACE for COPD group in comparison to PR at seven weeks. By six months there were no group differences and PA had returned to near baseline levels. As the natural course of COPD would indicate a continued decline in PA (Griffiths et al. 2000) maintaining baseline levels is clinically relevant. The challenge remains to determine who best would respond to PR and SPACE for COPD and how to maintain these changes

seen in the SPACE for COPD beyond seven weeks. In order to confirm this larger studies are needed.

Chapter 9 – General Discussion

This chapter brings together the key findings from this thesis to provide an overview of the effectiveness of the SPACE for COPD programme.

The aim of this thesis was to explore the impact of the SPACE for COPD programme by completing a single blinded noninferior RCT in comparison to conventional PR. The SPACE for COPD programme is a novel approach to delivering rehabilitation in a home based context. It is supported by a manual giving advice and developing skills to enhance SM behaviour.

The hypothesis tested in this thesis was that the SPACE for COPD programme would be noninferior to conventional COPD at seven weeks in regards to self-reported symptoms of dyspnoea. In addition, this thesis also explored the impact of the SPACE for COPD programme on other measures of HRQoL, psychological functioning, self-efficacy, exercise performance and daily PA levels. This thesis commenced with an evaluation of the SWM to ensure it was a valid measure of PA in patients with COPD and sensitive to small changes in walking speed.

This chapter is divided into four main sections. The first section is a summary of the main findings (9.1). An evaluation of the study limitations is presented in the second section (9.2). The third section will explore possible future work

(9.3) and the final section draws together the final conclusions of this thesis (9.4).

9.1 Main findings

A summary of the main findings is presented in Table 9.1. The significance column refers to the primary analysis of whether between group differences were apparent. Due to statistical software limitations, it was not possible to analyse imputed data at 6 months.

Table 9.1 Summary of the primary analysis

	ITT completer		*ITT imputed*	
	Significant	Noninferiority	Significant	Noninferiority
7 weeks follow up				
Primary outcome CRQ – SR dyspnoea	No	Uncertain	No	Uncertain
Secondary outcomes				
CRQ – SR fatigue	Yes	Uncertain	Yes	Uncertain
CRQ – SR Emotion	Yes	Uncertain	Yes	Uncertain
CRQ – SR Mastery	Yes	Uncertain	Yes	Uncertain
HADS anxiety	No	Uncertain	No	Uncertain
HADS depression	No	Uncertain	No	Uncertain
PRAISE	No	Not completed	Yes	Not completed
ISWT	Yes	SPACE noninferior	Yes	SPACE noninferior
ESWT	Yes	uncertain	Yes	Uncertain
6 months follow up				
Primary outcome CRQ – SR dyspnoea	No	Uncertain		
Secondary outcomes				
CRQ – SR fatigue	No	Uncertain		
CRQ – SR Emotion	No	Uncertain		
CRQ – SR Mastery	No	Uncertain		
HADS anxiety	No	SPACE noninferior		
HADS depression	No	SPACE noninferior		
PRAISE	No	Not completed		
ISWT	No	SPACE noninferior		
ESWT	No	Uncertain		

The hypothesis that the SPACE for COPD programme would improve self-reported dyspnoea (CRQ – SR dyspnoea) to a noninferior level in comparison to conventional PR is broadly supported by this trial. No statistically significant difference was detected at seven weeks between SPACE for COPD and PR groups (chapter 5). However, in line with the CONSORT recommendations (Piaggio et al. 2012) for reporting noninferiority trials as the 95% CI of the difference in change between the SPACE for COPD trial and the PR breached the MCID of 0.5 units there still remains some uncertainty as to its level of noninferiority.

At seven weeks improvements in CRQ-SR dyspnoea, walking endurance time, step count and time above 3 METs in at least 10 minute bouts (chapters 5 and 8) were detected which were equivalent or better than PR. This is the first study to describe such changes in a relative short time frame and demonstrate how soon changes can take place from a home based unsupervised SM programme.

The follow up data demonstrated that gains obtained in the short term were lost six months after the formal intervention programme has ceased (chapters 6 and 8) and values were comparable to baseline except for ISWT data in favour of the SPACE for COPD group. This was reflected in both the PR and SPACE for COPD group. Given the observed decline in exercise performance and HRQoL seen in patients with COPD (Casanova et al. 2007, Griffiths et al. 2000) maintenance of baseline levels would possibly indicate that both programmes have had some impact in patients with COPD which may have

helped reduce the rate of this expected decline. This is the first study to follow up UK participants after a home based supported SM intervention has finished to determine any trajectory of change.

Chapter 7 described the PA and sedentary behaviour of patients with COPD. This has not been previously been reported in such detail in a UK based population. It highlights the low levels of PA in this cohort and the impact of interpreting the recommended guidelines for PA and exercise. Chapter 8 provides an insight into the change in PA as a result of the interventions and indicates that although patients in the SPACE for COPD group increase their time in MVPA and step count they did not increase their time at their prescribed intensity of activity. Therefore although PA has increase in the SPACE for COPD group it was not sufficiently high enough to secure gains in maximal exercise capacity (ISWT).

At seven weeks the SPACE for COPD programme has shown to have an effect on self-reported dyspnoea, anxiety (for those with at least a possible presence) and exercise performance. Although benefits have been identified these improvements were not as large as those seen in the PR group. Furthermore, despite PR showing significant improvements these changes were not as great as anticipated in this group. The Mean (95% CI) change for the ISWT was 42 (24 to 59) m which does not met the MCID of 48m for this measure. Previous studies from the same centre demonstrate the mean change for the ISWT after PR met the MCID in each study (Evans et al. 2009, Greening et al. 2012, Harrison et al. 2012, Sewell et al. 2006, Sewell et al.

2005, Vincent et al. 2011). This could be explained by the participant in these previous studies having lower baseline $FEV_{1,}$ larger numbers of participants in MRC 4 and 5 and lower mean ISWT scores. This highlights that this current study has possibly recruited patients that are not wholly representative of the PR population at this centre. A number of authors from this centre have previously reported greater benefits of the PR at Glenfield (Harrison et al. 2012, Sewell et al. 2006) and that all MRC grades can benefit (Evans et al. 2009). A possible explanation for this could be that this study has recruited a subtly different population and overall have fewer symptoms and therefore are less motivated to participate and to adhere to their programme. As patients were told about the study during their referral appointment they may have seen the unsupervised SPACE for COPD programme as the desired or 'easy option' and if randomised to PR not fully engaged in the programme (and therefore not complete their home exercise at a high enough intensity to elicit change in maximal exercise capacity). Although we did not formally measure adherence to the programme either within or outside the supervised sessions attendance rate was recorded. This is a limitation of this study is that patients could not be blinded to the treatment they received and therefore may have had a preference to which group to would like to be in. Although not recorded in all participants the majority of participants wanted the SPACE for COPD treatment and there were 29% in the PR opposed to 5% in the SPACE for COPD who were assigned to the treatment group they did not prefer. It is therefore possible that this may have influenced their commitment to the programme. These numbers were small so analysis was not completed on this data. In future it would be of interest to determine how much preference

influences outcome of the intervention. It is interesting however, that on the surface the SPACE for COPD intervention seemed, in principle, acceptable to a number of patients that had been expecting a formal course of rehabilitation.

Interestingly, the SPACE for COPD group demonstrated significant improvements in step count and time above 3 METs in 10 minute bouts, beyond that seen in PR. Changes in PA was not reflected in changes in exercise performance demonstrating the complexity of the link between PA and exercise capacity. However, a key reason for the minimal improvement seen in the ISWT could be that the home based/unsupervised walking programme did not progress in intensity which is a fundamental component of exercise training stimuli. This is mirrored in the reduction in time above prescribed METs at seven weeks in the SPACE for COPD group. It may be that those in the SPACE for COPD group find behaviour change in PA in their home environment easier to establish, however, as it was not monitored this increased PA level was potentially sub therapeutic. Whereas it is possible that the PR group passed on the responsibility of their behaviour change to the healthcare professional and not completed their home programme sufficiently, but did do enough exercise in their supervised PR sessions to increase peak exercise capacity (ISWT).

Overall, the findings of the SPACE for COPD programme suggest it confers some benefits in regards to HRQoL, exercise performance and PA levels. These are key factors which have all been shown to have a significant impact on the burden to the individual and to the healthcare system (Garcia-Aymerich

et al. 2006, Waschki et al. 2011). A number of these improvements were not as great as PR, however 6 months after treatment the groups were not significantly different from one another and back to baseline levels. PR is the recommended treatment for patients with COPD (Bolton et al. 2013), however demand and drop out is high. The SPACE for COPD programme does result in positive benefits and therefore, could be used as an alternative 'next best' option. What is not clear from this current study is to whom this form of delivery is most suited. It could be argued that those with fewer symptoms (GOLD groups A and C and MRC 1,2 and 3) may be more suited to a home based programme and those with more symptoms (GOLD groups B and D and MRC 4 and 5) more suited to supervised PR, however, this has not been formally reported or fully debated.

There has been several home based and SM programmes reported in the literature and this thesis has aimed to clarify the various interpretations of these. A key difference in the SPACE for COPD study is that it is a shorter intervention than many others reported which have lasted up to 2 years (Monninkhof et al. 2003a). This study is unique in being an adequately powered study demonstrating benefit in such a short period which is match to the UK model of healthcare. These other reported longer studies would not be feasible in the UK.

In addition to the length of programme, supervision and health care professional contact is another key distinguishing factor. In this current study no supervised exercise or education sessions were included and only minimal

contact with a healthcare professional took place. Previous studies although labelled as SM or home based actually provide more supervision and professional contact than PR in the UK (Boxall et al. 2005, Effing et al. 2011, Monninkhof et al. 2003a, Ninot et al. 2011). SPACE for COPD is the first unsupervised home based programme supported by a SM manual in the UK to have an impact on patients with COPD. It is acknowledged that this impact is not as great as PR and this issue of supervision could be the key factor in the differences seen. On the whole this study supports Puente-Maestu et al. (2000) who highlighted that unsupervised programmes can show significant physiological improvements but they are to a lesser degree than supervised programme.

Maintenance of the benefits seen in PR and SPACE for COPD programmes has not been achieved at six months despite both programmes promoting long-term adherence to health-enhancing behaviours. Other studies examining maintenance strategies support this this finding which suggest pre-intervention levels are returned to within 12 months of programme completion (Beauchamp et al. 2013a, Griffiths et al. 2000, Ries et al. 1995) independently of any follow up. This reduction in outcome variables is commonly attributed to lack of adherence to a home maintenance exercise programme (Brooks et al. 2002, Griffiths et al. 2000). Therefore, it is of interest to determine the programme components and individual characteristics which contribute to sustained behaviour change offered in formal maintenance programmes. It remains unclear in the literature as to the best strategy to support patients post rehabilitation (Spruit and Singh 2013). For those attending hospital based

programmes it is possible that they find difficulty in the transition to community based programmes where more responsibility is focussed on the individual. It was anticipated that those completing the SPACE for COPD programme may have done better at the six month point due to the programme being delivered in the patient's own home. However, this was not the findings of this study. Maintenance programmes reported in the literature often involved community based supervised exercise (Beauchamp et al. 2013b, Cockram, Cecins and Jenkins 2006, van Wetering et al. 2010) which involved frequent supervision and may not be feasible or cost effective in the UK. Alternative strategies for supporting maintenance is telephone health monitoring which may be more suitable for the UK model of healthcare and maybe a more effective approach to post rehabilitation (Walters et al. 2012).

The challenge remains as to the best strategy to enhance and maintain positive health related behaviour. This is a complex issue on its own and is further complicated by the disease progression and potential exacerbations of patients with COPD. Individual characteristic which attribute to maintenance needs further exploration. Soicher (2012) monitored PA after PR up to 12 months and found that those with high baseline PA levels which subsequently declined also reported more barriers to exercise and poorer past exercise habits in comparison to those who had maintained high PA levels. Therefore strategies that focus on enhancing self-efficacy and overcoming barriers to exercise are needed to ensure greater success. It may be that the SPACE for COPD programme does not go far enough in addressing the maintenance of behaviour change or that patients are not engaging in the information

incorporated in the manual. For insight into these issues further qualitative investigations are being carried out, but are not within the remit of this thesis.

9.2 Limitations

An important limitation to this study is that due to the nature of research the patients recruited may not have been representative of COPD patients generally seen at this centre reported in the literature. Chapter 5, 6 and 8 have all reported on how baseline characteristics and responses to PR have not necessarily characteristic of this population. A reason why this study has recruited an unrepresentative population is complex but could possibly be due to a portion of participants interpreting the home-based nature of the study as an ‘easy option’. They have been referred to PR which is a comprehensive programme meaning a significant commitment and progress being closely monitored, but by opting for the SPACE programme they could appear to be meeting their health professionals advice but not committing too much. Those that were then subsequently refered to PR therefore may have been less motivated to engage and adhere to the programme and therefore not performed as expected. As patients could not be blinded to the treatment group it is natural to assume many will have had a preference to which group they were assigned to and not getting the group they preferred may have impacted on the results. Preference was only recorded in roughly half of the participants and therefore it was not possible to investigate its impact.

Baseline characteristics also suggested those initially recruited were less severe than normally seen. This could be as those with more advanced symptoms felt like they needed the support of a hospital based setting.

Given the self-directed nature of the SPACE for COPD programme it may be that this programme is more suited to certain personality types and is not suitable for all with COPD. Future work into SPACE for COPD to identify those most likely to benefit from its approach would be valuable. Management of long term conditions should be individualised and matched to those most able to benefit. There is no ‘one size fits all’ treatment, but SPACE for COPD could reasonably offered as a suitable alternative, further investigations needs to identify suitable characteristics which make SPACE for COPD the best option.

A key limitation to the SPACE for COPD trial is that adherence to the exercise programme and engagement in the SPACE for COPD manual was not monitored, although during the phone calls patients were required to comment on their engagement to the programme. It may be those that did respond to the programme were those that adhered to their programme and those that did not respond to the programme did not engage in the exercise or complete any of the tasks aimed at improving self-efficacy. No formal monitoring of SPACE for COPD manual took place in terms of looking at tasks completed and completeness of the walking diary. PA monitors were worn at the 3 measurement time points but this may not truly reflect adherence to the walking programme as wearing the monitor may have changed behaviour. It

may be of use to monitor patients more closely or ask them to complete a PA diary to assess adherence. However, future work into the SPACE for COPD programme is investigating the use of a website as a platform for delivering the intervention and requires patients to input their PA daily. This will enable insight into how well patients engage in the programme. The website also offers an additional mode of delivering rehabilitation which may be more suited to those confident and preferring the use of technology.

The majority of patients with COPD have at least one comorbidity (Divo et al. 2012). Mapel et al. (2000) reported a mean of 3.7 chronic conditions in those with COPD compared with 1.8 chronic conditions in those without. Comorbid conditions significantly impact on health status, hospitalization and mortality in patients with COPD (Divo et al. 2012). Those who are inactive, and hence a target for rehabilitation interventions, are more likely to have more comorbidities (Van Remoortel et al. 2014) and this complex association between conditions explain the clustering of chronic disease seen in patients with COPD. Although this study did record comorbidity it was not put on the database which limits analysis of factors influencing adherence and positive outcomes on the programme. It may be assumed that those with more comorbid conditions and in particular those that affect walking and PA will not have performed as well as those with fewer conditions. It possible that a more overarching view of chronic conditions, and treatment aimed at addressing the individuals more holistically may be more effective at initiating and sustaining health improvements.

Chapter 8 presents the seven week and six month changes in PA in those participating in PR and SPACE for COPD programmes. PA was not the main outcome of the trial, therefore, with its small numbers (n=51) it is highly possible that this study is not sufficiently powered.

9.3 Future Work

Implementation

This thesis presents the first adequately powered home based supported SM RCT of the SPACE for COPD programme. There next step would be to evaluate its effectiveness in clinical practice without the constraints of a research trial. This will therefore address the issue of preference and potentially draw out those to which this approach is more suitable. Training programmes are currently being developed to equip healthcare professionals to deliver and support the SPACE for COPD programme. Future studies should look at the effectiveness of this mode of delivery across a number of centres to determine its feasibility nationwide.

Maintenance

This thesis reported that initial benefits of the SPACE for COPD programme were not maintained at six months. Therefore strategies to support patients after the 2 telephone calls are required. A possible option is to continue with the telephone support as this approach has shown to positively influence patient behaviour (Walters et al. 2012). However, this is not routinely done after PR who also declined after the intervention period, therefore a strategy for both programmes needs investigation. Advances in technology could be

used to facilitate and enhance behaviour change. Text messaging and telehealth monitoring shows promise and has been used in a number of studies (Holland 2013, Tabak, op den Akker and Hermens 2014)

Mode of delivery

As previously mentioned in this chapter a RCT is underway investigating the delivery of the SPACE for COPD programme via the internet. Patients need to engage in sections of the programme before they can progress to the next stage and are required the upload their daily activity. This would therefore allow us insight into how well those that do adhere to the programme do.

Another option is to deliver the introduction to the manual as a group. This allows patients to meet others in the same situations as they would if they completed PR. Support from a peer group could be encouraged by each group developing its own internet blogs or using social media sites. Group dynamics has been shown to be important to successful behaviour change (Bandura 1977) a number of other SM programme have used a group based approach, such as the Expert Patient Programme (Barlow et al. 2009) and the chronic disease self-management programme (Lorig et al. 2001). These programmes have been successful and patients reported that the group nature enhanced motivation and increased confidence and control (Barlow et al. 2005). However, these programmes only report psychological gains and exercise performance has not been measured.

Timing of delivery

In the UK there is a substantial number of patients declining the offer of PR, offering patients a choice of venue may improve uptake. This has been shown to be the case with cardiac rehabilitation with the increase uptake in the service due to the heart manual (Dalal and Evans 2003). Therefore offering the SPACE for COPD programme at the point of referral needs investigating.

Health Economics

There is an assumption that those who successfully self-manage would rely less on healthcare services. One previous study has reported an economic analysis of a home based SM programme in COPD (Koff et al. 2009) and although the mean cost per patient was lower than hospital based PR there was no significant difference between the two groups. Home based cardiac rehabilitation has also been shown to be more costly than centre based due to the increase number of home visits (Jolly et al. 2007). Cost of healthcare is increasing and any savings alongside clinical effectiveness is desirable. Future work on the SPACE for COPD programme needs to do a full economic analysis in comparison to conventional PR. Once the cost of the SPACE for COPD programme has been established the programme is more likely to be commissioned.

9.4 Final conclusions

A hospital approach to PR may not be feasible for all that would benefit. An alternative strategy to deliver rehabilitation in patients with COPD and to increase choice is home based SM rehabilitation. The SPACE for COPD

programme offers a ‘light touch’ approach and was the main focus of this thesis. Findings suggest that the SPACE for COPD programme does achieve benefit in aspects of HRQoL and endurance capacity, but in a number of other outcomes the impact was not as large as that detected in PR.

Although numbers were small the SPACE for COPD programme positively impacted an daily PA levels. Additional studies need to investigate this further. With numerous improvements seen after the SPACE for COPD programme it warrants consideration for those who would not normally take up the opportunity of hospital based PR.

SPACE for COPD could offer great potential and now needs to focus on the impact of the programme in practice to determine if it is a suitable alternative when offered to those who refuse referral to PR. There is also possible for the SPACE for COPD programme to be used after PR to continue with the trajectory of change seen after a course of PR.

Appendix

Appendix A: Literature (PICO) Search Terms

Database Search:

MEDLINE, PubMed, Science Direct

PICO Search Strategy

Population:

"pulmonary disease, chronic obstructive" OR COPD OR "chronic obstructive pulmonary disease"

[Limit to: Publication Year 1990-Current and English Language]

Intervention:

"Home*" OR "home based" OR "home-based" OR "home-care" OR "home care" OR "unsupervised" OR "self-monitored"

educat* OR self-manag* OR "self manag*" OR self-car* OR "self car*" OR train* OR instruct* OR "patient cent*" OR patient-cent* OR patientfocus* OR "patient focus*" OR patient-education OR "patient education" OR "management plan*" OR "management program*"

[Limit to: Publication Year 1990-Current and English Language]

Comparison:

"usual care" OR rehabilitat* OR control

[Limit to: Publication Year 1990-Current and English Language]

Outcome:

exercise OR "health status" OR "quality of life" OR hospital* OR "healthcare utilisation" OR "healthcare utilization" OR knowledge OR activity

[Limit to: Publication Year 1990-Current and English Language]

Appendix B: CONSORT Checklist

CONSORT Statement 2006 - Checklist for Non-inferiority and Equivalence Trials

Items to include when reporting a non-inferiority or equivalence randomized trial

PAPER SECTION **And topic**	Item	**Descriptor**	**Reported on Page #**
TITLE & ABSTRACT	1	How participants were allocated to interventions (*e.g.*, "random allocation", "randomized", or "randomly assigned"), *specifying that the trial is a non-inferiority or equivalence trial.*	vi
INTRODUCTION Background	2	Scientific background and explanation of rationale, *including the rationale for using a non-inferiority or equivalence design.*	7
METHODS Participants	3	Eligibility criteria for participants *(detailing whether participants in the non-inferiority or equivalence trial are similar to those in any trial(s) that established efficacy of the reference treatment)* and the settings and locations where the data were collected.	64
Interventions	4	Precise details of the interventions intended for each group *detailing whether the reference treatment in the non-inferiority or equivalence trial is identical (or very similar) to that in any trial(s) that established efficacy,* and how and when they were actually administered.	67
Objectives	5	Specific objectives and hypotheses, *including the hypothesis concerning non-inferiority or equivalence.*	4
Outcomes	6	Clearly defined primary and secondary outcome measures *detailing whether the outcomes in the non-inferiority or equivalence trial are identical (or very similar) to those in any trial(s) that established efficacy of the reference treatment* and, when applicable, any methods used to enhance the quality of measurements (*e.g.*, multiple observations, training of assessors).	82
Sample size	7	How sample size was determined *detailing whether it was calculated using a non-inferiority or equivalence criterion and specifying the margin of equivalence with the rationale for its choice.* When applicable, explanation of any interim analyses and stopping rules (*and whether related to a non-inferiority or equivalence hypothesis*).	88
Randomization -- Sequence generation	8	Method used to generate the random allocation sequence, including details of any restrictions (*e.g.*, blocking, stratification)	66
Randomization -- Allocation concealment	9	Method used to implement the random allocation sequence (*e.g.*, numbered containers or central telephone), clarifying whether the sequence was concealed until interventions were assigned.	66
Randomization -- Implementation	10	Who generated the allocation sequence, who enrolled participants, and who assigned participants to their groups.	66
Blinding (masking)	11	Whether or not participants, those administering the interventions, and those assessing the outcomes were blinded to group assignment. If done, how the success of blinding was evaluated.	66
Statistical methods	12	Statistical methods used to compare groups for primary outcome(s), *specifying whether a one or two-sided confidence interval approach was used.* Methods for additional analyses, such as subgroup analyses and adjusted analyses.	88
RESULTS Participant flow	13	Flow of participants through each stage (a diagram is strongly recommended). Specifically, for each group report the numbers of participants randomly assigned, receiving intended treatment, completing the study protocol, and analyzed for the primary outcome. Describe protocol deviations from study as planned, together with reasons.	118
Recruitment	14	Dates defining the periods of recruitment and follow-up.	64

Baseline data	15	Baseline demographic and clinical characteristics of each group.	122
Numbers analyzed	16	Number of participants (denominator) in each group included in each analysis and whether the analysis was *"intention-to-treat" and/or alternative analyses were conducted*. State the results in absolute numbers when feasible (*e.g.*, 10/20, not 50%).	Chapters 5, 6, 7, 8
Outcomes and estimation	17	For each primary and secondary outcome, a summary of results for each group, and the estimated effect size and its precision (*e.g.*, 95% confidence interval). *For the outcome(s) for which non-inferiority or equivalence is hypothesized, a figure showing confidence intervals and margins of equivalence may be useful*.	Chapters 5, 6, 7, 8
Ancillary analyses	18	Address multiplicity by reporting any other analyses performed, including subgroup analyses and adjusted analyses, indicating those pre-specified and those exploratory.	Chapters 5, 6, 7, 8
Adverse events	19	All important adverse events or side effects in each intervention group.	None. Those withdrawn 118
DISCUSSION Interpretation	20	Interpretation of the results, taking into account the *non-inferiority or equivalence hypothesis and any other* study hypotheses, sources of potential bias or imprecision and the dangers associated with multiplicity of analyses and outcomes.	Chapter 9
Generalizability	21	Generalizability (external validity) of the trial findings.	Chapter 9
Overall evidence	22	General interpretation of the results in the context of current evidence.	Chapter 9

www.consort-statement.org

Appendix C: Ethical Approval

Leicestershire, Northamptonshire & Rutland Research Ethics Committee 1
1 Standard Court
Park Row
Nottingham
NG1 6GN

Telephone: 01159123344 ext: 49435
Facsimile: 01159123300

15 February 2007

Professor Sally Singh
Head of Pulmonary and Cardiac Rehabilitation
University Hospitals of Leicester
Glenfield Hospital
Groby Road
Leicester, LE3 9QP

Dear Professor Singh,

Full title of study: **A self-management rehabilitation programme for chronic obstructive pulmonary disease (COPD): is it a feasible alternative to conventional pulmonary rehabilitation?**

REC reference number: **07/Q2501/6**

Thank you for your letter of 31 January 2007, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

Ethical review of research sites

The favourable opinion applies to the research sites listed on the attached form.

Conditions of approval

The favourable opinion is given provided that you comply with the conditions set out in the attached document. You are advised to study the conditions carefully.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Application		03 October 2006
Investigator CV - Chief Investigator		10 October 2006
Investigator CV - Student		
Protocol	2	03 February 2007
Peer Review		22 September 2006

Statistician Comments		02 August 2006
Questionnaire: CRQ-SR Follow Up		
Questionnaire: CRQ-SR		
Letter of invitation to participant	1	03 October 2006
GP/Consultant Information Sheets	1	03 October 2006
Participant Information Sheet	2	25 January 2007
Participant Consent Form	1	03 October 2006
Response to Request for Further Information		31 January 2007
Instructions on the use of CRQ-SR		
University Grant Acceptance Form		25 November 2005
Grant Acceptance Form		16 November 2005
Letter of approach to Dr	1	03 October 2006

Research governance approval

The study should not commence at any NHS site until the local Principal Investigator has obtained final research governance approval from the R&D Department for the relevant NHS care organisation.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees (July 2001) and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

07/Q2501/6 Please quote this number on all correspondence

With the Committee's best wishes for the success of this project

Yours sincerely

[redacted]

Dr C Edwards/Ms L Ellis
Chair/Co-ordinator

Email: Linda.ellis@nottinghamshirecounty-tpct.nhs.uk

Enclosures: *Standard approval conditions*
Site approval form

Copy to: R&D Department for NHS care organisation at lead site - University Hospital of Leicester NHS Trust

Appendix D: Patient information sheet

University Hospitals of Leicester NHS
NHS Trust

Glenfield Hospital

Groby Road

Leicester

LE3 9QP

A self-management rehabilitation programme for chronic obstructive pulmonary disease (COPD): is it a feasible alternative to conventional rehabilitation?
(Version 7 26/08/10)

You are being invited to take part in research study being conducted by the pulmonary rehabilitation team in conjunction with Coventry University. The research is also been undertaken as part of an educational study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of the study?

Recent evidence has shown pulmonary rehabilitation for patients with chronic obstructive pulmonary disease (COPD) to be of benefit. However, only 3% of individuals with COPD have access to such a service. It may be more appropriate for patients to have access to a manual which covers issues such as drug and symptom management, exercise and nutrition at home. This would give help and advice concerning managing their own condition without having to travel to the hospital. This study is needed in order to inform the current delivery of the rehabilitation service, optimise patient care and aid in the development of new COPD rehabilitation programmes.

Why have I been chosen?

As an individual with COPD that has been referred to the rehabilitation programme you have been identified as a suitable participant of the study. It is important to us to see how people progress using the manual we have developed in comparison to those doing the

hospital based programme. It will help us develop and improve future services with this knowledge.

1. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason.

2. What will happen to me if I take part?

You will be able to take this patient information sheet home with you and you will be contacted by telephone to discuss participating in the study. If you agreed to take part in the research you will be placed at random into either the self-management or hospital group.

Once you have provisionally agreed to take part in the research you will be contacted to arrange a date and time to discuss the project in more detail. We don't know how effective the self management manual will be. To find out, we need to make comparisons between the different treatments. We put people into groups and give each group a different treatment; the results are compared to see if one is better. To try to make sure the groups are the same to start with, each patient is put into a group by chance (randomly). The results are then compared. There will be a 50/50 chance of being allocated to either group.

Overall your involvement will last for 6 months, although the study will go on for much longer. We routinely monitor participants in the rehabilitation programme at the end of the course. For the purpose of this study we would ask you to attend for one additional visit, this would last about one and a half hours, during which time we would measure your exercise capacity and ask you to fill in some questionnaires. All of these tests are normal procedure for rehabilitation. You may also be asked to take part in a focus group at the 7 week visit. You do not have to do this to be part of this research.

We would, with your permission, inform your General Practitioner that you have agreed to take part in this study

3. What do I have to do?

If you are assigned to the hospital based rehabilitation programme you will complete the normal 7 week (twice weekly) programme of exercise and educational advice. You will be requested to complete the standard assessments of lung function, exercise capacity (walking test) and be asked to complete some questionnaires about your health status and activity patterns. You will be assessed before you commence the hospital programme, 7 weeks later and the 6 months after the hospital programme, as is routine. After your 7 week appointment you may be invited to take part in a focus group. This will involve a small group of other participants who have attended pulmonary rehabilitation classes at the hospital. It is an opportunity for you to feedback what you found useful about rehabilitation and what you would like to be included in a self-managed programme of rehabilitation at home. This should not last longer than an hour and will be recorded with your consent.

If you are assigned to the self-management group you will undergo the same assessments at the same time points as the hospital group, however, you will be given a manual for people with pulmonary disease and invited to a workshop on how to use the manual. Your manual will outline how to manage your condition including information on drug and symptom management, exercise and nutrition. Included will be some home-based exercises you can carry out in your own time. You will receive 2 phone calls to see how you are progressing with the manual. You will not participate in the exercise and educational sessions at the hospital. After your 7 week appointment you may be invited to take part in a focus group. This will involve a small group of other participants who have used the self-management manual. It is an opportunity for you to feedback what you found useful about the manual and if anything could be improved. This should not last longer than an hour and will be recorded with your consent.

You may also be invited to wear an activity monitor which is worn on your arm. This is to be worn for 5 days during waking hours (please do not allow the monitor to get wet, so please remove if going swimming or you are having a bath etc.). You need not change your normal activity pattern while wearing this monitor. Again this will be assessed before you start your programme and also 7 weeks and 6 months after, as is routine.

4. What are the possible disadvantages and risks of taking part?

If you are placed in the self-management group you will not participate in the routine 7 weeks of rehabilitation at the hospital. However, If the self-management manual has proved to be ineffective for you, you will be offered the routine 7 week rehabilitation sessions at the hospital.

5. What are the possible benefits of taking part?

We hope that the research will aid you in your understanding of exercise and rehabilitation and inform both present and future pulmonary rehabilitation programmes therefore benefiting COPD patients.

8. What if something goes wrong?

If you are harmed by taking part in this research project, there are no special compensation arrangement. If you are harmed due to someone's negligence, then you may have grounds for a legal action but you may have to pay for it. Regardless of this, if you wish to complain, or have any concerns about any aspect of the way you have been approached or treated during the course of this study, the normal National Health Service complaints mechanisms would be available to you.

9. Will my taking part in this study be kept confidential?

All information that is collected about you during the course of the research will be kept strictly confidential. Any information about you, which leaves the hospital, will have your name and address removed so that you cannot be recognised from it. Participants will not be identified in any subsequent written material; for example, pseudonyms will be used to refer to participants' names. Results will be reported in such a way that completely preserves confidentiality.

10. What will happen to the results of the research study?

The results of the study will be disseminated in peer and lay journals, professional publications and presentations made at relevant conferences. Results will be reported in

such a way that preserves confidentiality. All participants will also receive a summary of the results.

11. Who is organising and funding the research?

This study is being funded by the Pulmonary Rehabilitation Research Group and the Pulmonary Rehabilitation team will be recruiting participants.

12. Who has reviewed the study?

All research that involves NHS patients or staff, information fro NHS medical records or uses NHS premises or facilities must be approved by an NHS research Ethics Committee before it goes ahead. Approval does not guarantee that you will not come to any harm if you take part. However, approval means that the committee is satisfied that your rights will be respected, that any risks have been reduced to a minimum and balanced against possible benefits and that you have been given sufficient information of which to make an informed decision.

13. Contact for further information

If you have any concerns or other questions about this study or the way it has been carried out, you should contact the principal researcher (Sally Singh Tel: 0116 2502535)

Contact for further information:
Elizabeth Horton

Faculty of Health and Life Sciences
Coventry University
Priory Street
Coventry
CV1 5FB
Tel: 024 7688 8915
Email: apx242@coventry.ac.uk

Thank you for reading this
Yours faithfully

Elizabeth Horton

University Hospitals of Leicester NHS
NHS Trust

Glenfield Hospital

Groby Road

Leicester

LE3 9QP

CONSENT FORM (Version 6, 26/08/2010)

Identification Number for this study:

A self-management rehabilitation programme for chronic obstructive pulmonary disease (COPD): is it a feasible alternative to conventional rehabilitation?

Please initial box

1. I confirm that I have read and understand the information sheet dated 26/08/2010 version 7 for the above study and have had the opportunity to ask questions. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐
3. I understand that sections of any of my medical notes may be looked at by responsible individuals from Coventry University or from regulatory authorities where it is relevant to my taking part in research. I give permission for these individuals to have access to my records. ☐
4. I agree to take part in the above study. ☐
5. I agree for my GP to be informed of my participation. ☐
6. I agree to take part in a tape recorded focus group and for anonymous quotes to be used in the final report ☐
7. I understand that all the information I give will be treated in confidence. Should I disclose any information that highlights a breach of the law, or dangerous practice the interviewer will be duty bound to breach confidentiality. ☐

_____	_____	_____
Name of Patient	Date	Signature
_____	_____	_____
Name of Person taking consent (if different from researcher)	Date	Signature
_____	_____	_____
Researcher	Date	Signature

1 for patient; 1 for researcher; 1 to be kept with hospital note

Appendix F: Telephone schedule

Telephone schedule

Date……..

1. How are you getting on with the manual?
2. What stage are you at currently? **1 2 3 4**
3. The walking programme: where are you now?
   a. **Frequency …… per day**
   b. **Time …… minutes in total**
   c. Provide encouragement to progress to next step
4. How many days a week do you use the manual? **…… average time**
5. How many A&E visits? **Respiratory…… Non-respiratory……**
6. How many hospital vists? **Respiratory…… Non-respiratory……**
7. How many visits to GP practice? **…….. regular check-ups**
   …….. practice nurse
   …….. GP
8. How many courses of: **…….. antibiotics**
   …….. steroids

Length of Call (mins):

Any questions?

Appendix G: Action Plan

Chronic Obstructive Pulmonary Disease (COPD) Action Plan

Your name:	**Best FEV1** **Best FVC**
Date of birth: / /	
Name of your GP:	**Room air O2 saturation:** %
Your GP's phone number:	☐ **CO2 retainer**
Name of your consultant:	
Name of your nurse:	**Oxygen:** **Litres a minute:**
Your nurse's phone number:	

The medication I usually take to help my breathing	Dose	How often I take my medication
1		
2		
3		
4		
5		

If you have antibiotics and steroids at home ('standby medication'), you may need to take them if your symptoms get worse.

- You must always follow the instructions you were given with this medication.
- Look at the sputum colour chart and follow the advice.
- If you are unsure about starting your standby medication then speak to your GP or healthcare professional.

Your standby medication			
Antibiotic	**Dose**	**How often?**	**For how long?**
1			
Steroid	**Dose**	**How often?**	**For how long?**
Extra reliever	**Dose**	**How often?**	**For how long?**
1			
2			
3			

Sputum colour chart
You should start a course of antibiotics only if your sputum (phlegm) is a shade of yellow or green as shown..

If you have a moderate attack (where you feel unwell, but not severely ill), phone your GP or other professional.

A moderate attack can:

- make you more wheezy or breathless;
- make you cough more and produce more sputum;
- change the colour of your sputum;
- put you off your food;
- make you lose sleep; and
- make you take more reliever medication than usual.

You can help yourself by:

- eating small amounts more often instead of having large meals;
- using controlled breathing techniques;
- using chest clearance techniques;
- using anxiety- or stress-management techniques; and
- making sure you drink regularly.

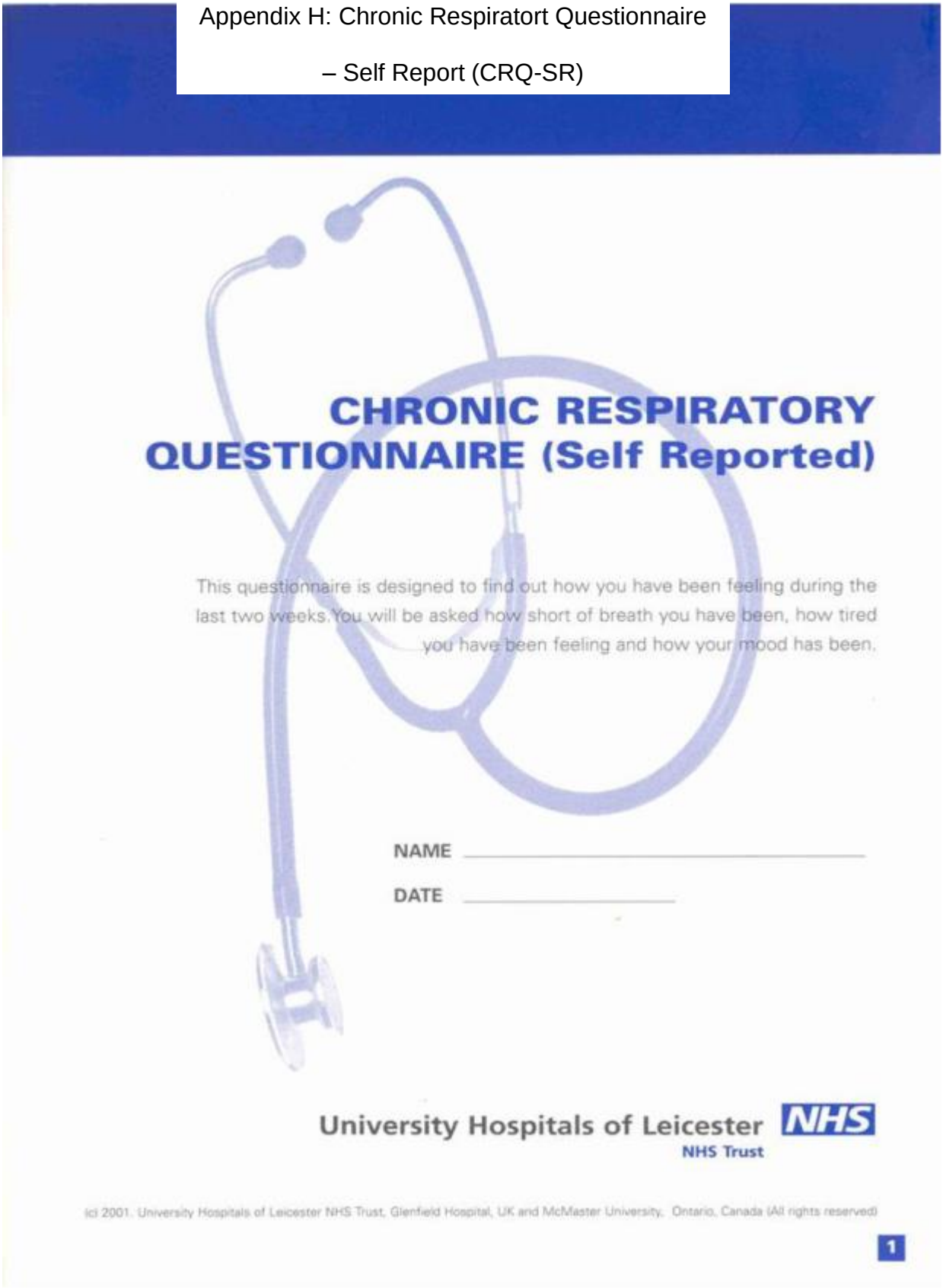
What to do if you have a severe attack

- Phone 999 for an ambulance.
- Show paramedics this plan and say you have severe COPD.

If you have a severe attack, you may:

- not be able to do your usual activities, such as dressing or having a bath or shower;
- suffer from fever and chills;
- have more swelling at your ankles; and
- become very short of breath.

Appendix H: Chronic Respiratort Questionnaire – Self Report (CRQ-SR)



CHRONIC RESPIRATORY QUESTIONNAIRE (Self Reported)

This questionnaire is designed to find out how you have been feeling during the last two weeks. You will be asked how short of breath you have been, how tired you have been feeling and how your mood has been.

NAME _____

DATE _____

University Hospitals of Leicester NHS
NHS Trust

1

CHRONIC RESPIRATORY QUESTIONNAIRE (Self Reported)

We would like you to think of ways in which your shortness of breath limits your life. We are particularly interested in activities which you still do, but which are limited by your shortness of breath.

Listed below are some activities which can make people with lung problems feel short of breath.

If you have felt **short of breath** doing any of the **activities** listed below **during the last two weeks** then please tick each relevant activity. If you have **not** done the activity during the last two weeks or it does **not** make you short of breath then leave it blank.

THE ACTIVITIES ARE:

☐ 1. BEING ANGRY OR UPSET	☐ 14. PLAYING SPORTS
☐ 2. HAVING A BATH OR SHOWER	☐ 15. REACHING OVER YOUR HEAD
☐ 3. BENDING	☐ 16. RUNNING - SUCH AS FOR A BUS
☐ 4. CARRYING - SUCH AS GROCERIES	☐ 17. SHOPPING
☐ 5. DRESSING	☐ 18. WHILE TRYING TO SLEEP
☐ 6. EATING	☐ 19. TALKING
☐ 7. GOING FOR A WALK	☐ 20. VACUUMING
☐ 8. DOING YOUR HOUSEWORK	☐ 21. WALKING AROUND YOUR OWN HOME
☐ 9. HURRYING	☐ 22. WALKING UPHILL
☐ 10. MAKING YOUR BED	☐ 23. WALKING UPSTAIRS
☐ 11. MOPPING OR SCRUBBING A FLOOR	☐ 24. WALKING WITH OTHERS ON LEVEL GROUND
☐ 12. MOVING FURNITURE	☐ 25. PREPARING MEALS
☐ 13. PLAYING WITH CHILDREN/GRANDCHILDREN	

Please list **any other activities** that you have done during the last two weeks which have made you feel short of breath. These should be activities which you do frequently and which are important in your day-to-day life.

We would now like you to identify the **most important activities** in which you have been limited by your **shortness of breath** in the last **two weeks**.

Using the list you have made on the previous page, write down the **five most important activities** that have made you short of breath on the lines below. We would then like you to tell us **how short of breath** you have been while performing each activity by ticking the box which best describes how you feel.

HOW SHORT OF BREATH HAVE YOU BEEN DURING THE LAST TWO WEEKS WHILE PERFORMING THESE ACTIVITIES?

	Extremely short of breath	Very short of breath	Quite short of breath	Moderate shortness of breath	Some shortness of breath	A little shortness of breath	Not at all short of breath
1. _____	☐	☐	☐	☐	☐	☐	☐
2. _____	☐	☐	☐	☐	☐	☐	☐
3. _____	☐	☐	☐	☐	☐	☐	☐
4. _____	☐	☐	☐	☐	☐	☐	☐
5. _____	☐	☐	☐	☐	☐	☐	☐

PLEASE MAKE SURE YOU HAVE COMPLETED THE ABOVE TABLE BEFORE TURNING THE PAGE

Thank you

CHRONIC RESPIRATORY QUESTIONNAIRE (Self Reported)

6. In general, how much of the time during the last 2 weeks have you felt frustrated or impatient?

Please indicate how often during the last 2 weeks you have felt frustrated or impatient by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

7. How often during the past 2 weeks did you have a feeling of fear or panic when you had difficulty getting your breath?

Please indicate how often you had a feeling of fear or panic when you had difficulty getting your breath by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

8. What about fatigue? How tired have you felt over the last 2 weeks?

Please indicate how tired you have felt over the last 2 weeks by ticking one of the following options from the list below.

1. EXTREMELY TIRED ❑
2. VERY TIRED ❑
3. QUITE A BIT OF TIREDNESS ❑
4. MODERATELY TIRED ❑
5. SOMEWHAT TIRED ❑
6. A LITTLE TIRED ❑
7. NOT AT ALL TIRED ❑

9. How often during the last 2 weeks have you felt embarrassed by your coughing or heavy breathing?

Please indicate how much of the time you felt embarrassed by your coughing or heavy breathing by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

10. In the last 2 weeks, how much of the time did you feel very confident and sure that you could deal with your illness?

Please indicate how much of the time you felt very confident and sure that you could deal with your illness by ticking one of the following options from the list below.

1. NONE OF THE TIME ❑
2. A LITTLE OF THE TIME ❑
3. SOME OF THE TIME ❑
4. A GOOD BIT OF THE TIME ❑
5. MOST OF THE TIME ❑
6. ALMOST ALL OF THE TIME ❑
7. ALL OF THE TIME ❑

11. How much energy have you had in the last 2 weeks?

Please indicate how much energy you have had by ticking one of the following options from the list below.

1. NO ENERGY AT ALL ❑
2. A LITTLE ENERGY ❑
3. SOME ENERGY ❑
4. MODERATELY ENERGETIC ❑
5. QUITE A BIT OF ENERGY ❑
6. VERY ENERGETIC ❑
7. FULL OF ENERGY ❑

12. In general, how much of the time did you feel upset, worried or depressed during the past 2 weeks?

Please indicate how much of the time you felt upset, worried or depressed during the past 2 weeks by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

13. How often during the last 2 weeks did you feel you had complete control of your breathing problems?

Please indicate how often you felt you had complete control of your breathing problems by ticking one of the following options from the list below.

1. NONE OF THE TIME ❑
2. A LITTLE OF THE TIME ❑
3. SOME OF THE TIME ❑
4. A GOOD BIT OF THE TIME ❑
5. MOST OF THE TIME ❑
6. ALMOST ALL OF THE TIME ❑
7. ALL OF THE TIME ❑

14. How much of the time during the last 2 weeks did you feel relaxed and free of tension?

Please indicate how much of the time you felt relaxed and free of tension by ticking one of the following options from the list below.

1. NONE OF THE TIME ❑
2. A LITTLE OF THE TIME ❑
3. SOME OF THE TIME ❑
4. A GOOD BIT OF THE TIME ❑
5. MOST OF THE TIME ❑
6. ALMOST ALL OF THE TIME ❑
7. ALL OF THE TIME ❑

15. How often during the last 2 weeks have you felt low in energy?

Please indicate how often during the last 2 weeks you have felt low in energy by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

16. In general, how often during the last 2 weeks have you felt discouraged or down in the dumps?

Please indicate how often during the last 2 weeks you felt discouraged or down in the dumps by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

17. How often during the last 2 weeks have you felt worn out or sluggish?

Please indicate how much of the time you felt worn out or sluggish by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

18. How happy, satisfied or pleased have you been with your personal life during the last 2 weeks?

Please indicate how happy, satisfied or pleased you have been by ticking one of the following options from the list below.

1. VERY DISSATISFIED, UNHAPPY MOST OF THE TIME ❑
2. GENERALLY DISSATISFIED, UNHAPPY ❑
3. SOMEWHAT DISSATISFIED, UNHAPPY ❑
4. GENERALLY SATISFIED, PLEASED ❑
5. HAPPY MOST OF THE TIME ❑
6. VERY HAPPY MOST OF THE TIME ❑
7. EXTREMELY HAPPY, COULD NOT HAVE BEEN MORE SATISFIED OR PLEASED ❑

19. How often during the last 2 weeks did you feel upset or scared when you had difficulty getting your breath?

Please indicate how often during the past 2 weeks you felt upset or scared when you had difficulty getting your breath by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

20. In general how often during the last 2 weeks have you felt restless, tense or uptight?

Please indicate how often you have felt restless, tense or uptight by ticking one of the following options from the list below.

1. ALL OF THE TIME ❑
2. MOST OF THE TIME ❑
3. A GOOD BIT OF THE TIME ❑
4. SOME OF THE TIME ❑
5. A LITTLE OF THE TIME ❑
6. HARDLY ANY OF THE TIME ❑
7. NONE OF THE TIME ❑

Thank you very much for taking the time to complete this questionnaire.

Appendix I: Hospital Anxiety and Depression Scale (HADS)

HOSPITAL ANXIETY and DEPRESSION SCALE (HADS)

Name: _____ **Date:** _____

e aware that emotions play an important part in most illnesses. If your clinician knows about these feelings he able to help you more.

naire is designed to help your clinician to know how you feel. Read each item below and underline the reply closest to how you have been feeling in the past week. Ignore the numbers printed at the edge of the '.

oo long over your replies, your immediate reaction to each item will probably be more accurate than a long esponse.

	A	D
I feel tense or 'wound up'		
Most of the time		
A lot of the time		
From time to time, occasionally		
Not at all		
I still enjoy things I used to enjoy		
Definitely as much		
Not quite as much		
Only a little		
Hardly at all		
I get a sort of frightened feeling as if something awful is about to happen		
Very definitely and quite badly		
Yes, but not too badly		
A little, but it doesn't worry me		
Not at all		
I can laugh and see the funny side of things		
As much as I always could		
Not quite so much now		
Definitely not so much		
Not at all		
Worrying thoughts go through my mind		
A great deal of the time		
A lot of the time		
Not too often		
Very little		
I feel cheerful		
Never		
Not often		
Sometimes		
Most of the time		
I can sit at ease and feel relaxed		
Definitely		
Usually		
Not often		
Not at all		
I feel as if I am slowed down		
Nearly all the time		3
Very often		2
Sometimes		1
Not at all		0
I get a sort of frightened feeling like 'butterflies' in the stomach		
Not at all	0	
Occasionally	1	
Quite often	2	
Very often	3	
I have lost interest in my appearance		
Definitely		3
I don't take as much care as I should		2
I may not take quite as much care		1
I take just as much care as ever		0
I feel restless as if I have to be on the move		
Very much indeed	3	
Quite a lot	2	
Not very much	1	
not at all	0	
I look forward with enjoyment to things		
As much a I ever did		0
Rather less than I used to		1
Definitely less than I used to		2
Hardly at all		3
I get sudden feelings of panic		
Very often indeed	3	
Quite often	2	
Not very often	1	
Not at all	0	
I can enjoy a good book or radio or television programme		
Often		0
Sometimes		1
Not often		2
Very seldom		3

Now check that you have answered all the questions

	A	D
TOTAL		

Appendix J: Pulmonary Rehabilitation Adapted Index of

Self-Efficacy (PRAISE)

General Self-Efficacy Scale.
Adapted for Pulmonary Rehabilitation.

Please circle where you feel you are now.

Statement	**Score**			
I can always manage to solve difficult problems if I try hard enough.	1	2	3	4
If someone opposes me, I can find the means and ways to get what I want.	1	2	3	4
It is easy for me to stick to my aims and accomplish my goals.	1	2	3	4
I am confident that I can walk for a good distance, at my own pace, despite it making me breathless.	1	2	3	4
I am confident that I could deal efficiently with unexpected events.	1	2	3	4
Thanks to my resourcefulness, I know how to handle unforeseen situations.	1	2	3	4
I feel confident that I will be able to perform the exercises asked of me during the course of rehabilitation, even if I find them difficult.	1	2	3	4
I can solve most problems if I invest the necessary effort.	1	2	3	4
I feel that I have an adequate amount of knowledge about my lung disease, despite it being a complex condition.	1	2	3	4
I can remain calm when facing difficulties because I can rely on my coping abilities.	1	2	3	4
When I am confronted with a problem, I can usually find several solutions.	1	2	3	4
I feel positive that I will be able to complete the exercises at home, despite there being no supervision from a health professional.	1	2	3	4
If I am in trouble, I can usually think of a solution.	1	2	3	4
I can handle whatever comes my way.	1	2	3	4
On a day to day basis I feel in control of my lung disease and how that affects my lifestyle, even when my symptoms become distressing.	1	2	3	4

Response Format.

1= Not at all true
2= Hardly true
3= Moderately true
4= Exactly true

Appendix K: Ethical approval to the SWM validation

and reproducibility study

COVENTRY UNIVERSITY ETHICS COMMITTEE (Form 1)

POSTGRADUATE STUDENT & STAFF APPLICATION FOR ETHICAL APPROVAL

Name Elizabeth Wilcock **E-mail** e.wilcock@coventry.ac.uk		
Designation / Subject & Faculty: Faculty of Health and Life Sciences		
Title of Study: The validity and reliability of the SenseWear Pro2 Armband to measure energy expenditure during moderate activity		
1. Summary of proposal We have COREC approval to investigated physical activity levels using accelerometers in chronic obstructive pulmonary disease patients. However, before we can carry this out we must assess the sensitivity and reliability of the accelerometers. It is proposed that we carry out a test-retest reliability study of ten accelerometers so that we can be confident in the measures they are reporting.		
2. Sample of participants One healthy adult subject recruited from the Faculty of Health and Life Sciences		
3. Site/s location James Starley Sport Science Laboratories		
*Tick / Cross. *Where answered 'NO', please give reasons on separate page.*	**Yes**	**No***
4. Scientific background, design, method and conduct of the study. a) Have you given a justification for the research?	X	
b) Have you commented on the appropriateness of the design, the perceived benefits, risks and inconveniences to participants?	X	
5. Recruitment of participants. Have you provided a comprehensive account of the characteristics of the population including the process for obtaining access as well as the inclusion and exclusion criteria?	X	
6. Care and protection of research participants and researcher. Have you given an account of any interventions, situations and risks which have the potential to cause harm to the participants and researchers?	X	
7. Access, storage, security and protection of participants' confidentiality. Have you identified who will have access to the data and what measures have been taken to ensure confidentiality and compliance with the Data Protection Act?	X	
8. Informed Consent. Have you given a full description of the process for requesting and obtaining informed consent?	X	
9. Community considerations. Have you considered how this study will benefit the participants or the community from which they have been drawn?	X	
10. Participant information Sheet and consent form. Are these attached?	X	
11. Source of External Funding if any 10 SenseWear PRO2 Armbands purchased SRIF funding		
Signature of student / staff [redacted]	Address Nursing, Midwifery and Healthcare, Faculty of HLS, Coventry University	Date 21/2/07
Signature of Supervisor	Print Name Internal Address	Date
Signature of Chair [redacted]	O Approved. O Approved with the conditions below:	Date 14/3/07
Conditions / Comments: No ethical issues		

Please complete in full and return to: **Research Manager, CU Ethics Committee, Richard Crossman B517, Coventry University.**

This form should be accompanied by the full research study proposal, or the COREC form if applicable. Further help & information can be found on W / HLS / Student / Ethics or call Rhoda Morgan on 024 7679 5945, or e-mail r.morgan@coventry.ac.uk.

W / HLS / Student / Ethics / CU Ethics Forms / CU Ethics PG and Staff Form 1
October 2005

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