The Development of an Intervention to Promote Physical Activity Among Adults Diagnosed with Asthma

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Abstract

Asthma is a major non-communicable disease, affecting more than 300 million people worldwide. Despite the availability of effective medication, asthma remains poorly controlled in numerous patients. Physical activity could be an important non-pharmacological approach to optimising asthma management. There is a need to develop interventions that promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. Mobile health (mHealth) technology has been highlighted as a way of increasing the number of patients who can receive help and support. Therefore, the overall aim of this project was to develop an mHealth intervention, specifically a smartphone app, to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma.

The development process was conducted via a series of studies. Firstly, a systematic review of existing interventions, which were found to increase physical activity, reduce sedentary behaviour, and improve quality of life and asthma symptoms. Secondly, qualitative research explored the perceived barriers and facilitators to physical activity. Beliefs about consequences, limited physical capabilities and reluctance to engage in group-based activities were identified as barriers. Social support and the desire to be healthy were identified as facilitators. Thirdly, further qualitative research identified the ideas and preferences of the target end-users for the intervention. Participants found smartphone apps acceptable and identified several important components for inclusion. Lastly, using a systematic approach, the findings were drawn together using the Behaviour Change Wheel to develop a fully specified intervention on paper.

This thesis follows the first step in the NIHR-MRC guidance for the development of complex interventions. Further qualitative research with stakeholders will be needed to refine the intervention and understand how it could be implemented in healthcare services. Once a prototype of the smartphone app has been developed, the next stage would be to conduct some early-user testing before a feasibility study.

Table of Contents

List of Figures

List of Tables

Publications and Presentations

Publications

Tyson, L., Hardeman, W., Marquette, M., Semlyen, J., Stratton, G. & Wilson A. M. (2021). A systematic review of the characteristics of interventions that promote physical activity in adults with asthma. *Journal of Health Psychology*. http://doi.org/ 10.1177/13591053211059386 (*Appendix A*)

Tyson, L., Hardeman, W., Stratton, G., Wilson, A. M. & Semlyen, J. (2021). The effects of social distancing and self-isolation during the COVID-19 pandemic on adults diagnosed with asthma: A qualitative study. *Journal of Health Psychology, 27*(6):1408-1420. http://doi.org/ 10.1177/13591053211012766 (*Appendix B*)

Conferences and Seminars

Poster presentation at the Asthma UK Centre for Applied Research Annual Scientific Meeting, *Development and Feasibility Testing of a Scalable Intervention to Promote Physical Activity Among Sedentary Adults with Moderate or Severe Asthma*. London UK, March 2019

Poster presentation at the University of East Anglia Faculty of Medicine and Health Sciences Student Conference, *A Systematic Review of the Characteristics and Efficacy of Alternative Physical Activity Interventions to Pulmonary Rehabilitation in Adults with Asthma*. Norwich UK, May 2019

Lightning Talk at the Asthma UK Centre for Applied Research Annual Scientific Meeting, *A Systematic Review of the Characteristics of Alternative Physical Activity Interventions to Pulmonary Rehabilitation in Adults with Asthma*. Online, March 2020

Poster presentation at the University of East Anglia Faculty of Medicine and Health Sciences Student Conference*, Identifying the Barriers and Facilitators to Physical Activity Among Adults with Asthma*. Online, June 2020

Poster Presentation at the UCL Centre of Behaviour Change Conference, *A Systematic Review of the Characteristics of Alternative Physical Activity Interventions to Pulmonary Rehabilitation in Adults with Asthma*. Online, September 2020

3 Minute Thesis Presentation at the Asthma UK Centre for Applied Research Seminar, *The Effects of Social-Distancing and Self-Isolation During the COVID-19 Pandemic on Adults Diagnosed with Asthma: A Qualitative Study*. Online, December 2020

Oral Presentation at the Asthma UK Centre for Applied Research Seminar, *Development of a Behavioural Change Intervention to Promote Physical Activity in Adults with Asthma*. Online, May 2021

Oral Presentation Division of Health Psychology Annual Conference, *The Impact of Social Distancing and Self-Isolation During the COVID-19 Pandemic on Adults with Asthma: A Qualitative Study*. Online, June 2021

Oral Presentation at the Asthma UK Centre for Applied Research Annual Scientific Meeting, *Identifying the Barriers and Facilitators of Physical Activity Among Adults with Asthma.* Online, October 2021

Oral Presentation at the Asthma UK Centre for Applied Research Annual Scientific Meeting, *Identifying the Barriers and Facilitators of Physical Activity Among Adults with Asthma.* Leeds UK, June 2022

Poster presentation at the University of East Anglia Faculty of Medicine and Health Sciences Student Conference, *The Effects of Social Distancing and Self-Isolation*

During the COVID-19 Pandemic on Adults Diagnosed with Asthma: A Qualitative Study. Norwich UK, June 2022

Other

Podcast, *Are People with Asthma who Exercise Healthier?* Health Check: BBC News World Service, January 2022

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Chapter 1: Introduction to the Thesis

This thesis describes the development of a behaviour change intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. Firstly, it examines the effectiveness and characteristics of existing interventions developed to promote physical activity and reduce sedentary behaviour in this patient group. Secondly, it explores the perceived barriers and facilitators to physical activity among adults diagnosed with asthma. Thirdly, it identifies user preferences for the content and features of the intervention and, lastly, describes the development of a new intervention. This chapter provides an introduction to the thesis, describing asthma and its management, the benefits of physical activity for people diagnosed with asthma, and the potential use of mobile health (mHealth) technology to deliver interventions. An outline of the aims and structure of the thesis is provided.

1.1. Overview of Asthma

"*Asthma is a heterogeneous disease, usually characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation. Airflow limitation may later become persistent*"

(Global Initiative for Asthma, 2022; p20)

1.1.1. Diagnosis and Management

Asthma affects more than 300 million people worldwide, while over eight million people, or approximately 12% of the UK population, have been diagnosed with asthma (NICE, 2022a). No single test can confirm an asthma diagnosis, instead, diagnosis is based on several factors, including a detailed medical history, physical exam, the patient's symptoms, and overall health and test results. Common signs and symptoms of asthma include recurrent wheezing, dyspnoea, chest tightness, coughing, and hyperreactivity of the airways (NICE, 2022b). The exact cause of asthma is not known. Instead, many factors have been linked to an increased risk of a person developing asthma, including their environment, job, family history or genes, and other allergy-related medical conditions, but it is often difficult to find a single direct cause (World Health Organization, 2022).

Asthma symptoms can occur in response to certain *'triggers'* (Kulakiewicz et al., 2021). In people with extrinsic or allergic asthma, allergens trigger respiratory symptoms. Common triggers for extrinsic asthma include pollen, mould, dust mites and pet dander. In people with intrinsic or non-allergic asthma, allergies are not responsible for the symptoms. Instead, the following triggers may cause the symptoms: cold, humidity, stress, exercise, smoke, and respiratory infections, such as colds and the flu. The severity of symptoms can change during the year and throughout a person's life (Holmes et al., 2019). All patients are at risk of episodic flare-ups (exacerbations) when symptoms get much worse and may be life-threatening (Holmes et al., 2019).

There is no cure for asthma, but effective self-management can help keep asthma symptoms under control. Self-management is defined as the day-to-day management of a chronic condition by individuals over the course of an illness (Lorig & Holman, 2003). In the context of asthma, self-management focuses on the medical aspects, such as keeping a supply of and remembering to take regular medication, avoiding triggers, recognising when asthma is deteriorating and making a decision about when to adjust medication, when to use emergency treatment and when to seek professional help (Pinnock, 2015). To support patients with the self-management of their disease, asthma action plans are written with their healthcare providers to facilitate the early detection and treatment of an exacerbation (Gibson et al., 2004). Asthma management is dynamic, and treatment needs to be continuously reviewed and tailored to the patient's current level of asthma severity (Holmes et al., 2019). Treatments for asthma are generally prescribed in inhaler form to enable the medication to enter the airways as quickly as possible. There are two main types of inhalers; 1) long-term asthma control medications that are taken regularly (even when a person does not have any symptoms) to control symptoms and prevent exacerbations, and 2) quick relief rescue medications that are taken as needed for rapid, short-term relief of symptoms and are used to treat exacerbations.

1.1.2. Burden of Asthma

Asthma now costs the UK society well in excess of £1.1 billion per year, with the overwhelming majority of these costs being incurred due to prescribing preventative treatments in primary care (Mukherjee et al., 2016). Despite this, asthma remains poorly controlled in numerous patients. Asthma control is determined by the frequency of daytime symptoms, limitations on activities, nocturnal symptoms, need for reliever medication, lung function, and exacerbations (Global Initiative for Asthma, 2022). A survey conducted by Asthma UK (2020) revealed that 40.1% of respondents had uncontrolled asthma, equivalent to 2.17 million people in the UK, and only 20.5% had fully controlled asthma. Poor asthma control has been associated with more emergency department visits, days spent in hospital and medical provider visits (Williams et al., 2009). Therefore, new approaches to improve asthma control are urgently required. Considerable attention in recent years has been given to non-pharmacological approaches that can be used in combination with medication to improve asthma control and quality of life; such approaches include avoidance of environmental triggers, physical activity, and educational interventions (Reddel, 2015).

1.2. Physical Activity as a Non-Pharmacological Approach for Managing Asthma

1.2.1. Physical Activity and Guideline Recommendations

Increasing physical activity may be an important overlooked component in optimising asthma management, especially for individuals with severe asthma or more difficult-to-treat asthma, who may not respond to traditional inhaled corticosteroid treatment. As there is accumulating evidence that links enhanced physical activity with favourable outcomes, including better overall asthma control, fewer exacerbations, and lower healthcare use, physical activity might be especially beneficial for these groups (Panagiotou, Koulouris & Rovina, 2020). Regular physical activity is recommended in national and international guidelines for asthma management (British Thoracic Society, 2019; Global Initiative for Asthma, 2018). Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure (Caspersen et al., 1985). It cannot be used interchangeably with exercise, a subcategory of physical activity that is planned, structured and repetitive and has a final or intermediate objective to improve or maintain one or more components of physical fitness (Caspersen et al., 1985). Recommendations are that each week, adults should accumulate at least 150 minutes of moderate-intensity activity (e.g., brisk walking or cycling), 75 minutes of vigorous-intensity activity (e.g., running), or even shorter durations of very vigorous-intensity activity (e.g., sprinting or stair climbing) (World Health Organization, 2020a). However, any increase in physical activity can be beneficial to health. A recent systematic review by Kuder and colleagues (2021) found that physical activity improves asthma control, quality of life and lung function, with no studies reporting worsening asthma symptoms.

However, a recent meta-analysis concluded that even though there is promising evidence regarding the positive effects of physical activity including improved asthma control and health related quality of life, there is insufficient evidence to draw a definitive conclusion regarding an optimal physical activity prescription for adults diagnosed with asthma (McLoughlin et al., 2022). This is because, even though the current asthma management guidelines recommend for people diagnosed with asthma to be physically active, there are currently no defined physical activity guidelines specifically for asthma. Notably, Global Initiative for Asthma states that there is “little evidence to recommend one form of physical activity over another” (Global Initiative for Asthma, 2022; p79). Therefore, it is important to establish some understanding of which physical activities and at what duration and intensity are best suited to this patient group so recommendations can be made. A review of the effectiveness of existing interventions developed to promote physical activity in adults diagnosed with asthma and their components, including physical activity, duration and intensity, as well as intervention provider, delivery focus and mode of delivery is presented in *Chapter 2 – Review of Existing Interventions*.

1.2.2. Asthma and Sedentary Behaviour

Despite the guidelines recommending physical activity for adults diagnosed with asthma, a systematic review by Cordova-Rivera and colleagues (2018) found that adults diagnosed with asthma engaged in less physical activity and were more sedentary than people without asthma. Physical activity tended to be lower in females compared with males and in older people compared with their younger counterparts. Physical inactivity and sedentary behaviour involve sitting, reclining or lying during waking hours, undertaking little movement or activity (Tremblay et al., 2017). Evidence suggests that sedentary behaviour predisposes adults with asthma to long-term deconditioning, sustaining a vicious cycle of inactivity, obesity and worse asthma control, and can increase the risk of cardiovascular and other related diseases (Westermann et al., 2008).

In the general population, cross-sectional studies have shown that self-reported reasons for physical inactivity include insufficient leisure time, inadequate social support, and lack of motivation (Herazo-Beltran et al., 2017; Moschny et al., 2011). Adults diagnosed with asthma may have additional disease-related barriers and facilitators that need to be considered. Surveys have shown that perceived barriers are more frequent, particularly in people with more severe asthma (Freeman et al., 2020); even people with relatively mild asthma avoid physical activity because of their fears of worsening asthma symptoms (Clarke & Mansur, 2015). In addition, those with more severe asthma often rely on oral corticosteroids to control their symptoms, which are known to have debilitating side effects such as weight gain and bone weakening (Kulakiewicz et al., 2021), which could make being physically active more difficult. Due to these additional barriers, people diagnosed with asthma may intuitively or purposely avoid physical activity and adopt a sedentary lifestyle (Panagiotou, Koulouris, & Rovina 2020). To understand how we can best support adults diagnosed with asthma to become more physically active it is important to understand additional perceived barriers and how we can facilitate behaviour change. The qualitative exploration of the perceived barriers and facilitators to physical activity in adults diagnosed with predominately severe asthma is presented in *Chapter 3 – Barriers and Facilitators*.

1.3. Pulmonary Rehabilitation: Promoting Physical Activity in Asthma

Pulmonary Rehabilitation is a comprehensive intervention designed to promote physical activity in patients with respiratory diseases. It is defined as "*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 diseases and to promote the long-term adherence to health-enhancing behaviours*" (Spruit, 2013; p14). Pulmonary rehabilitation programmes are usually implemented by a dedicated multi-disciplinary team of healthcare professionals within hospitals or community settings, delivered twice a week for 6-8 weeks (Spruit, 2013). Half of each session is spent on physical training, which includes lower body exercises (e.g., walking on a treadmill or around a track), upper body exercises (e.g., arm and chest exercises, including turning a crank against resistance or lifting arms against gravity) and strength training (e.g., weightlifting). The remainder of the time is spent educating patients on the importance of exercising, managing their anxiety and low mood, using their inhalers, eating healthy and what to do when they are unwell. The sessions aim to build patients' confidence and teach them how to exercise safely. Once completed, patients are encouraged to remain active and use techniques they have learnt, and patients can be referred to a follow-up exercise programme if needed (Bolton et al., 2013).

The benefits of pulmonary rehabilitation are well established, particularly in patients diagnosed with chronic obstructive pulmonary disease (COPD). A systematic review of 65 randomised controlled trials by McCarthy and colleagues (2015) found that physical activity had significant positive effects on quality of life and exercise capacity in patients diagnosed with COPD. However, as people diagnosed with asthma are increasingly being referred to the programme, we are beginning to see how the programme can benefit people diagnosed with asthma. A systematic review of nine studies concluded that pulmonary rehabilitation improves quality of life, exercise tolerance, and asthma symptoms, reduces the number of exacerbations and could improve pulmonary functions in asthma patients (Feng et al., 2021). Furthermore, recent studies have highlighted that patients with severe asthma are likely to be the ones who benefit the most from rehabilitation programmes (Zampogna et al., 2020).

An important distinction between behaviour change and behaviour change maintenance needs to be made. Pulmonary rehabilitation programmes have only shown improvements within the short-term (<1 year) in COPD patients (Egan et al., 2012), and the difficulties in maintaining any long-term benefits following the programme have been reported in patients with chronic lung diseases, such as COPD and asthma (Ries et al., 2003). This would suggest that the increased physical activity demonstrated within the rehabilitation centre is not being translated into the home and community setting once the programme has finished (Spruit et al., 2015). Benefits may not be maintained because pulmonary rehabilitation does not include sufficient motivational and self-regularly techniques to give patients the self-efficacy required to continue increasing their physical activity, and they no longer have the opportunity once the programme has been completed (Spruit et al., 2015).

Furthermore, despite the strong evidence and the guidelines recommending the use of pulmonary rehabilitation, asthma and COPD patients are significantly under-referred, and of those referred, uptake and completion are low (National Asthma and Chronic Obstructive Pulmonary Disease Audit Programme, 2020). A retrospective analysis found that of 711 COPD patients invited to attend the programme, 31.8% did not, and a further 29.1% were non-adherent (Hayton et al., 2013). Major barriers to the uptake and completion of pulmonary rehabilitation reported by COPD patients include travel to attend sessions, disruption to routines, inconvenient timing (Jones et al., 2017), and not being suitable or accessible to those with co-morbidities (Keating et al., 2011). Although this evidence comes from patients with COPD, reported barriers to the uptake and completion of pulmonary rehabilitation are external and it is likely that they would also be barriers for patients diagnosed with asthma too.

Therefore, there is a growing interest in seeking alternative approaches to promote physical activity in adults diagnosed with asthma to increase the number of patients who can access the help and support they need. Despite the patient-reported barriers to pulmonary rehabilitation, the benefits of physical activity are continuously being demonstrated in medically supervised programmes (Hallstrand et al., 2000). When this project was designed by my supervisory team, the purpose was to develop an intervention that promotes physical activity and reduces sedentary behaviour in adults diagnosed with asthma. Taking the barriers to the uptake and completion of pulmonary rehabilitation into consideration, it was decided by them that an alternative method of delivery would be used, and that the intervention would be delivered using mobile health (mHealth) technology. The importance of this has been further highlighted following the recent COVID-19 pandemic and the need to move away from traditional delivery methods toward alternative methods to provide guidance and support to people within their own homes after the significant suspension of face-to-face support (Association of Chartered Physiotherapists in Respiratory Care, 2020). We can expect, moving beyond the pandemic that patients might exercise more caution about attending face-to-face or group activities because of heightened awareness of cross-infection risk, which may exacerbate already low levels of pulmonary rehabilitation uptake (Houchen-Wolloff & Steiner, 2020).

1.4. mHealth Technology and Its Potential for Delivering Physical Activity Interventions

1.4.1. mHealth and Mobile Usage

mHealth refers to the use of mobile and wireless devices to support healthcare delivery and improve health outcomes (World Health Organization, 2019). Smartphone usage in the UK has increased across all age ranges since 2012, most notably among those aged 55-64 years. In 2016, less than half of those over the age of 55 owned a smartphone, rising to 83% in 2021 (Statista, 2021). As mobile technology continues to expand, mobile phones are increasingly used to deliver health interventions. Although SMS-based mobile intervention remains prominent, a systematic review by Dugas and colleagues (2020) revealed that mHealth is progressively moving towards the implementation of apps and wearable interventions. They also found that mHealth is being applied to a diverse range of lifestyle behaviours and health outcomes, reflecting its adaptability to different content and health domains. In terms of chronic diseases, systematic reviews have highlighted the use of digital interventions for self-management as they have been shown to improve symptoms and quality of life and reduce deaths and hospitalisation (Marcolino et al., 2018; Yi et al., 2018; Beratarrechea et al., 2014).

A European Asthma Research and Innovation Partnership report highlighted mHealth as a way of transforming how asthma care is delivered and how people self-manage their asthma (Asthma UK, 2016). Expanding the use of technology for healthcare services is also one of the NHS's long-term goals (NHS, 2019). mHealth technology is already being used to deliver self-management interventions in the asthma population to target adherence behaviours. A meta-analysis conducted by Xiao and colleagues (2018) showed that mHealth interventions (vs routine care) improved levels of asthma control, adherence to treatment and reduced exacerbations and hospital admission rates in individuals diagnosed with asthma. Using mHealth in a similar way to promote physical activity in asthma patients could be cost-effective and clinically efficacious (Wu, 2016). To date, only one walking intervention for African American women supplemented by mHealth technologies has been developed (Nyenhuis et al., 2020). The intervention comprised an informational study manual and three in-person group sessions. The supplemental mHealth tools included a wearable activity device and one-way text messages related to physical activity and asthma. A proof-of-concept study concluded that the intervention was safe and acceptable for participants.

1.4.2. mHealth Technology vs Traditional Face-to-Face Delivery

mHealth offers some advantages over traditional methods for delivering behaviour change interventions, including being adjustable to the needs of the user, being able to provide (computerised-) tailored feedback, which is more effective than generic information about physical activity, data for self-monitoring, and visually appealing interactive features (Griffiths et al., 2006). People carry smartphones and can access data anywhere and at any time. This allows for data to be collected in real-time or near time, allowing feedback to be delivered rapidly following a person's actions (Middelweerd et al., 2014). Having only a small interval between the desired behaviour and feedback may increase the likelihood that the behaviour is repeated. It also allows users to easily obtain and track self-relevant information allowing for the self-monitoring of physical activity and sedentary behaviour. Self-monitoring approaches involving people in their own behaviour change have shown considerable success among those with long-term illnesses (Michie et al., 2009). Most importantly, mHealth interventions can reach large numbers of patients by reducing barriers associated with cost and transport issues (Grekin, Beatty & Onderma, 2019) and have been reported as more convenient for patients to use (Müssener, 2021). Thus, overcoming patient reported barriers to traditional face-to-face pulmonary rehabilitation could in turn increase the uptake and completion of physical activity interventions in this patient group.

However, ensuring participants engage in mHealth interventions is of particular concern. Maintaining engagement can be especially difficult when mHealth interventions are used without human support, leading to high dropout and 'non-usage' attrition (Yardley et al., 2016). In a systematic review and meta-analysis by Meyerowitz and colleagues (2020), which explored app-based interventions for chronic diseases, dropout rates were high. They concluded that reducing dropout rates will make these apps more effective for disease management in the long-term.

When developing an mHealth intervention, a user-centred and iterative approach is integral to improving the uptake and engagement with digital interventions (Yardley et al., 2016). When users are engaged throughout the intervention development process, a number of key features can be identified that could have otherwise been missed (McCurdie et al., 2012). Consequently, there is a growing trend toward adopting a user-centred design approach, focusing on the target end-users and incorporating their perspectives in all stages of the development process. The target population were involved in the development of the proposed intervention presented in this thesis. Firstly, the intervention was developed to overcome the perceived barriers to physical activity reported by adults diagnosed with asthma and facilitate behaviour change (discussed in *Chapter 3 – Barriers and Facilitators*). Furthermore, the initial ideas for the intervention were shared with adults diagnosed with asthma to understand their preferences on what content and features to include (discussed in *Chapter 4 – User Preferences*). How the findings from both chapters informed the development of the proposed interventions is discussed in *Chapter 5 – Intervention Development*.

1.5. Purpose of the Thesis

1.5.1. Aim

The overall aim of this research was to develop an mHealth intervention, specifically a smartphone app, to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. The intervention development process presented in this thesis was based on NIHR-MRC guidance for developing complex interventions to improve health (Medical Research Council, 2006), which has recently been updated (Skivington et al., 2021), but the earlier version was predominately used as the project started before the updated guidance was published. NIHR-MRC guidance divides complex intervention development into four phases: development or identification of the intervention, feasibility, evaluation, and implementation (Skivington et al., 2021). This thesis focuses on the first phase. The guidance strongly advocates a theoretical basis and provides a broad outline approach to intervention development. However, it does not provide detailed guidance on choosing or applying appropriate theories (French et al., 2012; Michie et al., 2005). Therefore, the *Behaviour Change Wheel* (BCW) (Michie, Atkins & West, 2014) framework was used to inform the development of the proposed intervention to ensure that it was developed using appropriate theory. The BCW links general models of behaviour change (COM-B: *Capability, Opportunity, Motivation-Behaviour* and TDF: *Theoretical Domains Framework*) with an evidence-based approach to intervention design. The development process of the proposed intervention is presented in *Chapter 5 – Intervention Development*.

The BCW framework comprises three stages:

1. ***Understanding the Behaviour*** – Behavioural diagnosis of what needs to change for the desired behaviour to occur.
2. ***Identifying Intervention Options*** – Linking the behavioural diagnosis with functions that effective interventions are likely to serve and policy categories through which the intervention could be implemented.
3. ***Identifying Content and Implementation Functions*** – Identifying intervention content in terms of which behaviour change techniques (BCTs) best serve the intervention functions and which mode of delivery is appropriate to implement the intervention.

Each stage can be further divided into smaller steps, comprising eight sub-steps in total. As discussed earlier, user-centred design is integral to improving the uptake and engagement with digital interventions (Yardley et al., 2016). Therefore, an additional step was added to explore user preferences for the content and features included in the proposed intervention. Hence, a total of nine sub-steps arranged into two stages, as shown in *Figure 1.1*, were followed.

Figure 1.1. *Intervention Development Process and Sources of Evidence*

Stage One: Understanding the Behaviour

1. **Define the Problem** – *Reviewing the literature (Chapter 1: Introduction). Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*

2. **Select the Target Behaviour(s)** – *Reviewing the literature (Chapter 1: Introduction). Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*

3. **Specify the Target Behaviour(s)** -– *Reviewing the literature (Chapter 1: Introduction). Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*

4. **Understand the Problem (COM-B Model and TDF)** – *Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*

5. **Understand User Preferences** – *Focus groups with adults diagnosed with asthma (Chapter 4: User Preferences).*

Stage Two: Identifying Intervention Content and Implementation Options

6. **Select Intervention Functions (BCW)** – *Functions likely to bring about change in the specific COM-B and TDF domains identified in Sub-Step 4 (Chapter 5: Intervention Development).*

7. **Select Policy Categories (BCW)** – *Policy category that can be used to deliver the functions selected in Sub-Step 6 (Chapter 5: Intervention Development).*

8. **Identify BCTs (BCTTv1)** – *Systematic review of the characteristics of interventions that promote physical activity in adults with asthma (Chapter 2: Review of Existing Interventions). Interview and a focus group with adults diagnosed with asthma (Chapters 3: Barriers and Facilitators).*

9. **Select Mode of Delivery (BCW)** - *Interviews and focus groups with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators & Chapter 4: User Preferences).*

COM-B Model = Capability, Opportunity, Motivation, Behavioural Model; TDF = Theoretical Domains Framework; BCW = Behaviour Change Wheel; BCTTv1 = Behaviour Change Techniques Taxonomy version 1

1.5.2. Objectives

The objectives of this thesis were chosen to address the steps and sub-steps of the BCW framework. The objectives were:

1) Examine the effectiveness of existing interventions that promote physical activity on behavioural and health outcomes in adults diagnosed with asthma (*Chapter 2 – Review of Existing Interventions*).
2) Identify the behaviour change techniques and other intervention components, such as intensity, intervention provider, delivery focus and mode of delivery used within existing physical activity interventions (*Chapter 2 – Review of Existing Interventions*).
3) Explore the perceived barriers and facilitators to physical activity among adults living with asthma (*Chapter 3 – Barriers and Facilitators*).
4) Identify user preferences for the content and features of an intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma (*Chapter 4 – User Preferences*).
5) Develop a theory-based intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma (*Chapter 5 – Intervention Development*).

1.5.3. Thesis Overview

This thesis comprises six further chapters.

Chapter 2: A Systematic Review of the Characteristics of Interventions that Promote Physical Activity in Adults with Asthma.

As the benefits of pulmonary rehabilitation are already well established, *Chapter 2 – Review of Existing Interventions* presents a systematic review that explores the effectiveness of other interventions that have been developed to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. As there are no asthma-specific physical activity guidelines and not much is known about the components that make up these interventions, this review also identified the BCTs and other intervention components, such as physical activity, duration, intensity, intervention provider, delivery focus, and mode of delivery used. From this, I had hoped to identify key components from effective interventions to include in the proposed intervention. However, components across the effective and none-effective interventions were similar and therefore it was not possible to identify 'promising' components. However, recommendations are made on what evidenced based BCTs could be included in future interventions and influenced the development of the proposed intervention, discussed in *Chapter 5 – Intervention Development*. A modified version of this chapter has been published in *the Journal of Health Psychology* (Tyson et al., 2021a).

Chapter 3: Exploring the Perceived Barriers and Facilitators to Physical Activity Among Adults Diagnosed with Asthma

For the proposed intervention to be effective it is important to understand the perceived barriers to physical activity so they can be addressed, and the intervention can facilitate behaviour change. Adults diagnosed with asthma are likely to have asthma-specific barriers and facilitators to physical activity that need to be considered, particularly for those who have severe asthma. *Chapter 3 – Barriers and Facilitators* presents a qualitative study that used interviews and a focus group to identify perceived barriers and facilitators to physical activity in this target population. Findings from this chapter influenced the development of the proposed intervention, discussed in *Chapter 5 – Intervention Development*. Findings were deductively coded to the COM-B and TDF domains in order to determine what BCTs to include in the proposed intervention. This was done using the *Behaviour Change Techniques Taxonomy* (BCTTv1) which facilitates the selection of BCTs that are likely to be appropriate and effective in addressing the barriers and facilitating in each domain.

Chapter 4: User Preferences for an mHealth Intervention to Promote Physical Activity Among Adults with Asthma

Chapter 4 – User Preferences presents a qualitative study which used online focus groups to share initial ideas with adults diagnosed with asthma. Initial ideas for the intervention were developed based on the findings from *Chapter 2 – Review of Existing Interventions and Chapter 3 – Barriers and Facilitators.* I developed vignettes (brief descriptions) of the content and features of the intervention along with mock-up pictures and videos to show how the smartphone app would work from the users' point of view. The vignettes, pictures and videos were used to prompt discussion of participants' ideas and preferences for the proposed intervention. The focus groups were also used to establish the acceptability of an intervention delivered via a smartphone app, how best to promote initial and sustained engagement with the intervention and how it could be integrated into other aspects of asthma management. Findings from this chapter influenced the development of the proposed intervention, discussed in *Chapter 5 – Intervention Development*.

Chapter 5: Developing an mHealth Physical Activity Intervention for Adults Diagnosed with Asthma

Chapter 5 – Intervention Development describes the BCW (Michie, Atkins & West, 2014) in more detail and the other tools used in the development of the proposed intervention. A rationale for why this framework was chosen is also given. The chapter details the development of an intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. The development process brings together existing evidence and new primary data presented in this thesis. The chapter results in a fully developed mHealth intervention on paper and gives a description of the content and features of the smartphone app and how it is supposed to work in practice. Visual mock-ups of the intervention are also presented.

Chapter 6: Summary and Discussion of Research Findings and Implications for Research and Clinical Practice

The overall discussion and conclusions are presented in *Chapter 6 – Summary and Discussion*. The chapter describes how this thesis has contributed to the knowledge and implications for research and clinical practice. The strengths and weaknesses of the project overall are discussed. A personal reflection on my PhD journey is also presented.

Chapter 2: A Systematic Review of the Characteristics of Interventions that Promote Physical Activity in Adults with Asthma

Chapter 1: Introduction provided an introduction to asthma, the benefits of physical activity and the potential use of mHealth to deliver an intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. This chapter presents a systematic review of the effectiveness and characteristics of interventions developed to promote physical activity in this patient group. A retrospective analysis found that patients with asthma significantly increased their asthma control during a comprehensive 3-week pulmonary rehabilitation inpatient programme (Schneeberger et al., 2020), but not much is known about the effectiveness of other interventions that have been developed to promote physical activity. This chapter provides a discussion of the characteristics and effectiveness of other interventions that have been developed to promote physical activity and makes recommendations on what evidence-based behaviour change techniques should be considered for inclusion in future interventions. This review was conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2011) and published in the Journal of Health Psychology (Tyson et al., 2021a).

2.1. Background

As reported in *Chapter 1: Introduction*, the benefits of pulmonary rehabilitation for patients diagnosed with asthma are already well established and include improved quality of life, exercise tolerance, pulmonary functions and asthma symptoms, and reduced exacerbations (Feng et al., 2021). Despite the strong evidence and guidelines recommending the use of pulmonary rehabilitation, patients are significantly under-referred, and for those referred, uptake and completion are low in patients diagnosed with chronic obstructive pulmonary disease (COPD) and asthma (National Asthma and Chronic Obstructive Pulmonary Disease Audit Programme, 2020). Major barriers to uptake and completion of pulmonary rehabilitation reported by patients diagnosed with COPD include travel to attend sessions, disruption to routines, inconvenient timing (Jones et al., 2017), and not being suitable or accessible to those with co-morbidities (Keating et al., 2011). As these barriers to the uptake and completion are external, it is likely that these would also be barriers to patients diagnosed with asthma being referred to pulmonary rehabilitation too.

Consequently, there is a need to develop interventions that overcome the major patient-reported barriers and promote physical activity within the asthma population. No systematic reviews to date have examined the effectiveness of other interventions that have been developed to promote physical activity or their components. For instance, there is a lack of evidence regarding the behaviour change techniques (BCTs) used within them. A BCT is defined as "an observable, replicable, and irreducible component of an intervention designed to alter or redirect causal process that regular behaviour" (Michie et al., 2013; p82). BCTs that have been found to be effective in the promotion of physical activity in healthy adults include techniques included in the groupings '*Goals and Planning*' and '*Feedback and Monitoring*' categories, as well as techniques '*Prompts and Cues*', '*Graded Tasks*' and '*Behavioural Practice/Rehearsal*' (Howlett et al., 2018; Samdal et al., 2017). Furthermore, there is insufficient evidence to draw a definitive conclusion regarding an optimal physical activity prescription for adults diagnosed with asthma (McLoughlin et al., 2022), and there are no asthma-specific guidelines which suggest what physical activities and at what duration and intensity are best suited for this patient group. Therefore, it is important for us to understand what components, including physical activity, duration, and intensity, are most effective for adults diagnosed with asthma and should be considered for inclusion in the proposed interventions and future interventions.

2.2. Aims

The purpose of this review was to examine the effectiveness of interventions developed to promote physical activity, other than formal pulmonary rehabilitation programmes, on the behavioural and/or health outcomes of adults diagnosed with asthma. As the effectiveness of pulmonary rehabilitation is already well established, interventions using pulmonary rehabilitation were excluded. The review also aimed to identify the BCTs and other intervention components, such as physical activity, intensity, intervention provider, delivery focus, and mode of delivery used within them.

2.3. Methods

This systematic review was conducted in accordance with the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins et al., 2021) and *Preferred Reporting for Systematic Reviews and Meta-Analyses (PRISMA) checklist* (Moher et al., 2009) (*Appendix C*).

2.3.1. Eligibility Criteria

Through discussion with my supervisory team, we decided to include published randomised, non-randomised, quasi-experimental, before-and-after interventional studies and feasibility studies. Included interventions had to be designed to promote physical activity and assess relevant behavioural and/or health outcomes, including physical activity, sedentary behaviour, quality of life, asthma control, asthma symptoms and medication usage in adults diagnosed with asthma. The asthma diagnosis could be confirmed using medical records or self-reported. Participants had to be aged 18 years or over and have a diagnosis of asthma (any degree of severity). We excluded interventions using pulmonary rehabilitation, defined as exercise training, education, and behaviour change, delivered by a multi-disciplinary team of physicians and healthcare professionals. Having a comparator group was not a requirement for inclusion.

2.3.2. Data Sources

Comprehensive searches were conducted in *MEDLINE, EMBASE, PsycINFO, SPORTDiscus,* and *The Cochrane Central Register for Clinical Trials*. The search strategy (*Appendix D*) was used to search MEDLINE and modified for other databases. Papers were limited to those including adults and published in the English language, with date restrictions of 1990 and onwards. The original search was conducted in February 2019 and updated in August 2020.

2.3.3. Data Collection

2.3.3.1. Study Selection

Studies identified using the searchers were transferred into *Mendeley* (*Mendeley Desktop* Version: 1.19.8), and duplicates were removed. A second reviewer (Dr Malcolm Marquette) and I independently screened the titles and abstracts of identified studies. The full-text copies of all studies judged to be potentially eligible were then retrieved and screened by myself and the second reviewer. In case of disagreement, a consensus was reached through discussion, and reasons for exclusion were recorded (*Appendix E*).

2.3.3.2. Data Extraction

Data was extracted using a standardised data extraction form designed to capture all relevant information, including general study characteristics, characteristics of study participants, details of the intervention and control group components, and study outcomes. The second reviewer independently validated data extraction. Extraction of BCTs was undertaken independently by the second reviewer and I, using the Behaviour Change Technique Taxonomy v1 (BCTTv1) (Michie et al., 2013) based on the published manuscript and supplementary materials. Both of us completed online *BCTTv1* training before extraction [http://www.bct-taxonomy.com]. In the cases where there were disagreements, a consensus was reached through discussion, and a third reviewer (Professor Wendy Hardeman) was involved when the discussion did not lead to a consensus. BCTs were extracted following *BCTTv1* guidance, and they were coded as definitely (coded ++) or probably (coded +) present. BCTs were coded in relation to the target behaviours: physical activity and sedentary behaviour.

2.3.3.3. Risk of Bias

Using the criteria in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2021), risk of bias was assessed by assigning low, high, and unclear judgements. Risk of bias was independently validated by the second reviewer.

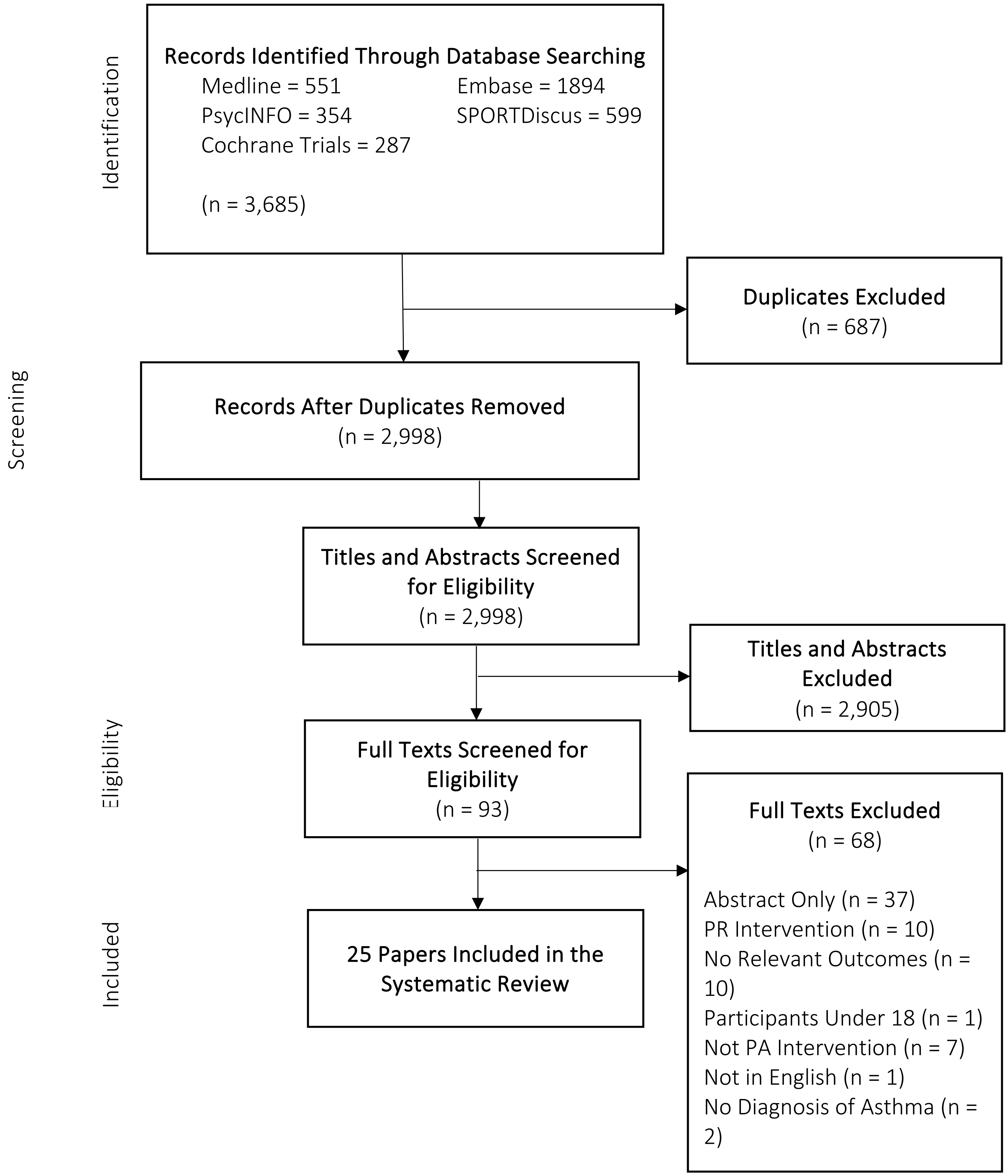
2.3.4. Synthesis of Results

Due to the range of very different studies included in this systematic review, such as research design, types of intervention and outcome data, the synthesis of the included studies needed to be narrative. The heterogeneity between studies meant that it was not possible to perform a numerical analysis. I tabulated results from the studies and organised them into groups based on the outcomes assessed, so patterns across the data set could be identified. Interventions were deemed effective if they reported significant positive results in all the relevant behavioural and/or health outcomes they assessed. For interventions with a comparator group, they were deemed effective if behavioural and/or health outcomes significantly improved compared to the comparator group. For pre-post interventions with no comparator group, interventions were deemed effective if there were significant changes in the behavioural and health outcomes pre-and post-intervention.

2.4. Results

The search yielded 3,685 citations, resulting in a total of 2,998 after the duplicates were removed. From this list, 93 were identified as potentially relevant, and full texts were retrieved for closer inspection. The second reviewer and I independently decided that 25 of these articles fulfilled the review's inclusion criteria. *Figure 2.1* shows the detailed process of study inclusion.

Figure 2.1. *PRISMA Flow Diagram of Study Selection*



2.4.1. Overview of Included Studies

Study characteristics are presented in *Table 2.1*. The 25 included studies were published between 1992-2020. Most studies were conducted in either Brazil (Evaristo et al., 2020; Coelho et al., 2018; Freitas et al., 2018; Freitas et al., 2017; Franca-Pinto et al., 2015; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008) or USA (Nyenhuis et al., 2020; Ma et al., 2015; Mancuso et al., 2013; Bidwell et al., 2012; Boyd et al., 2012; Mancuso et al., 2012; Hildenbrand et al., 2010; Sabina et al., 2005; Vedanthan et al., 1998), with others conducted in Australia (Scott et al., 2012), Canada (O'Neill & Dogra, 2021; Dogra et al., 2011; Dogra, Jamnik & Baker, 2010), Denmark (Toennesen et al., 2017), India (Jain & Talukdar, 1993; Vampati, Bijlani & Deepek, 2009), New Zealand (Robinson et al., 1992).

Eighteen randomised controlled trials were included (Evaristo et al., 2020; Coelho et al., 2018; Freitas et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Franca-Pinto et al., 2015; Ma et al., 2015; Mancuso et al., 2013; Bidwell et al., 2012; Boyd et al., 2012; Mancuso et al., 2012; Scott et al., 2012; Mendes et al., 2011; Mendes et al., 2010; Vampati, Bijlani & Deepek, 2009; Goncalves et al., 2008; Sabina et al., 2005; Vedanthan et al., 1998; Robinson et al., 1992), two non-randomised trials (Dogra et al., 2011), three before-and-after studies (O'Neill & Dogra, 2021; Hildenbrand et al., 2010; Jain and Talukdar, 1993), one quasi-experimental study (Dogra, Jamnik & Baker, 2010), and one feasibility study (Nyenhuis et al., 2020). Within these studies, 21 unique interventions were reported.

The number of participants in each study ranged from 10 to 330. Asthma severity varied across studies, with only two studies failing to report the asthma severity of their participants (Toennesen et al., 2017; Scott et al., 2012). Seven studies included participants with mild/moderate asthma (Mancuso et al., 2013; Bidwell et al., 2012; Boyd et al., 2012; Mancuso et al., 2012; Vampati, Bijlani & Deepek, 2009; Sabina et al., 2005; Vedanthan et al., 1998), ten studies included participants with moderate/severe asthma (Evaristo et al., 2020; Coelho et al., 2018; Freitas et al., 2018; Freitas et al., 2017; Franca-Pinto et al., 2015; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008; Jain and Talukdar, 1993; Robinson et al., 1992), and two studies included participants with mixed asthma severity (O'Neill & Dogra, 2021; Hildenbrand et al., 2010). Participants in two studies had partially controlled asthma (Dogra et al., 2011; Dogra, Jamnik & Baker, 2010), and two had uncontrolled asthma (Nyenhuis et al., 2020; Ma et al., 2015).

Table 2.1. *Study Characteristics*

Author (Year) and Country of Study	Study Design	Inclusion Criteria and Setting	Sample Size and Recruitment Methods	Participant Characteristics (Disease Severity, Age, Gender, Ethnicity and Co-Morbidities)
Bidwell (2012) USA	Randomised Study	FEV1/FVC ratio of <80% of predicted, use of bronchodilators at least once daily, and symptoms of wheezing and/or coughing for a minimum of 2-years that improves either spontaneously or with drug therapy. Setting NR.	N=19 Volunteers from flyers at various physicians' offices as well as campus news.	Mild/Moderate Asthma. M = 41.5 Years. Age Range 20-65 Years. 100% Female.
Boyd (2012) USA	Randomised Study	Persistent asthma (as defined by the NAEPP guidelines) with at least 12% FEV1 reversibility. Community.	N=19 Recruited at the UAB Lung Health Centre, Birmingham, AL.	Mild/Moderate Asthma. M = 53 Years, Age Range 33 – 78 Years. 6% Male. 94% Female. 38% Non-White.
Coelho (2018) Brazil	Randomised Study	Diagnosis for at least 6-months, under regular drug therapy and clinically stable during the run-in period. Self-directed (home-based).	N=37 Recruited from outpatient asthma clinic.	Moderate/Severe Asthma. M = 46 Years. 14% Male. 86% Female.
Dogra (2010) Canada	Quasi-Experimental	Current prescription for asthma mediation and were physically inactive as per the Canadian PA Guidelines. Self-directed (home-based).	N=30 Recruited from the Grater Toronto Area in Ontario, Canada.	Partially Controlled Asthma. M = 32.6 Years. 25% Male. 75% Female.
Dogra (2011) Canada	Non-Randomised Study	Current prescription for asthma medication and were physically inactive as defined by the Canadian PA Guidelines. Setting NR.	N=36 Recruited from the Greater Toronto Area in Ontario, Canada.	Partially Controlled Asthma. M = 34.1 Years. 27% Male. 73% Female.
Evaristo (2020) Brazil	Randomised Study	Body mass index <35 kg/m^2, sedentary (<60 minutes of PA/week during leisure time), under medical treatment for at least 6-months, and clinically stable (i.e., no crises or changes in medication for >30 days). Setting NR.	N=54 Recruited during a regular medical visit.	Moderate/Severe Asthma. M = 50.2 Years. Age Range 30-65 Years. 27% Male. 73% Female.

Franca-Pinto (2015) Brazil	Randomised Study	Inclusion criteria NR. Setting NR.	N=58 Recruited from a University Hospital.	Moderate/Severe Asthma. M = 42 Years. Age Range 20-59 Years. 21% Male. 79% Female.
Freitas (2017) Brazil	Randomised Study	Outpatients with a BMI greater than or equal to 35 and less than 40 kg/m2, who were under optimum medical treatment, clinically stable, and physically inactive. Secondary care.	N=55 Recruited from an outpatient asthma clinic.	Moderate/Severe Asthma. M = 47.2 Years. Age Range 30-60 Years. 2% Male. 98% Female.
Freitas (2018) Brazil	Randomised Study	Outpatients with grade II obesity, receiving optimal medical treatment for at least 6-months, were clinically stable and performed <60 minutes of structured or planned PA per week. Secondary care.	N=55 Recruited from an outpatient asthma clinic.	Moderate/Severe Asthma. M = 47.2 Years. Age Range 30-60 Years. 2% Male. 98% Female.
Goncalves (2008) Brazil	Randomised Study	Under outpatient medical treatment for at least 6-months and demonstrate clinical stability (without hospitalisation episodes or need for emergency care for, at least 30-days). Secondary care.	N=20 Selected after a medical consultation.	Moderate/Severe Asthma. M = 34.6 Years. Age Range 20-50 Years. 30% Male. 70% Female.
Hildenbrand (2010) USA	Before-and-After Study	Asthma which was being medically managed daily or on an 'as needed' basis. Community.	N=20 Public Forums.	Mixed Asthma Severities. M (SD) = 22 (5.27) Years. 44% Male. 56% Female. 75% Caucasian.
Jain (1993) India	Before-and-After Study	Inclusion criteria NR. Secondary care.	N=42 Recruited from outpatient clinic.	Moderate/Severe Asthma. M (SD) = 48.2 (4.17) Years. 74% Male. 26% Female.
Ma (2015) USA	Randomised Study	BMI greater than or equal to 30 kg/m2, and confirmation of uncontrolled persistent asthma through a multistage screening process. Setting NR.	N=330 Recruited from eight medical centres.	Uncontrolled Asthma. M (SD) = 47.6 (12.4) Years. Age Range 18-70 Years. 29% Male. 71% Female. 50% Non-Hispanic White. 20% Non-Hispanic Black. 8% Asian/Pacific Islander. 20% Hispanic/Latino.
Mancuso (2012) USA	Randomised Study	Mild/moderate asthma and speak English. Self-directed (home-based).	N=258	Mild/Moderate Asthma. M (SD) = 43 (12) Years. 25% Male. 75% Female.

			Recruited from primary care practice.	54% White. 22% African American. 24% Other.
Mancuso (2013) USA	Randomised Study	Mild/moderate asthma, speak English, access to a telephone, no limitations in mobility, and no other respiratory or major comorbidity. Self-directed (home-based).	N=258 Recruited from primary care practice.	Mild/Moderate Asthma. M (SD) = 43 (12) Years. 25% Male. 75% Female. 54% White. 22% African American. 8% Asian. 16% More than one.
Mendes (2010) Brazil	Randomised Study	Under medical treatment of >6 months and considered clinically stable. Secondary care.	N=101 Recruited from a University Hospital.	Moderate/Severe Asthma. M = 39.25 Years. Age Range 20-50 Years. 83% Male. 17% Female.
Mendes (2011) Brazil	Randomised Study	Under medical treatment of >6 months and considered clinically stable. Secondary care.	N=68 Recruited from a University Hospital.	Moderate/Severe Asthma. M = 36.95 Years. Age Range 20-50 Years. 19% Male. 81% Female.
Nyenhuis (2020) USA	Feasibility Study	Self-identified as African American and female, registered as a patient at the medical centre, were low-active as defined by self-report of <150 minutes of MVPA per week and had sub-optimally controlled asthma. Community and self-directed (home-based).	N=10 Recruited from a large urban medical centre.	Uncontrolled Asthma. M (SD) = 48.29 (11.22). Age Range 18-70 Years. 100% Female. 100% African American.
O'Neill (2021) Canada	Before and After Study	Non-smoking, moderately active with a current prescription for a short-acting bronchodilator. Setting NR.	N=20 Recruitment NR.	Mixed Asthma Severities. Mean (SD)=22.5 (3.2) Years. 45% Male. 55% Female.
Robinson (1992) New Zealand	Non-Randomised Study	Adults diagnosed asthma. Community.	N= 25 Asthmatics attending asthma clinic. Control group was recruited from new clients at the gymnasium.	Moderate/Severe Asthma. Age Range 20-45 Years. 44% Male. 56% Female.
Sabina (2005) USA	Randomised Study	Diagnosis for at least 6-months, taking at least 1 of the following: inhaled B-agonists, methylxanthines, anticholinergics, inhaled corticosteroid, leukotriene inhibitors or receptor antagonists, or mast cell-stabilising agents for at	N=62 Newspaper advertisements, posting in pulmonary clinics and the community at large, and	Mild/Moderate Asthma. M = 51.1 Years. Age Range 18-76 Years. 26% Male. 74% Females. 84% White. 10% African American. 6% Hispanic.

		least 6-months and stable medication dosing for the past month. Research centre.	direct mailing to patients of pulmonary clinics and primary care centres.	
Scott (2012) Australia	Randomised Study	Inclusion criteria NR. Community and secondary care.	N=46 Recruitment from the John Hunter Hospital, Australia.	M = 40.26 Years. Age Range 18-65 Years. 47% Male. 53% Female.
Toennesen (2017) Denmark	Randomised Study	Body mass index of more than 20 and less then 30 kg/m, and ACQ score of 1.0 or more, and at least 1 positive diagnostic test demonstrating variable airflow obstruction. Should either have been on a stable prophylactic treatment regime with inhaled corticosteroids (ICSs), ICS + long-acting beta1-agonsit, and/or leukotriene antagonist or have had no prophylactic treatment at least 3-months before enrolment. Secondary care.	N=149 Recruitment methods NR.	Age Range 18-65 Years. 31% Male. 69% Female.
Vempati (2009) India	Randomised Study	Diagnosis for at least 6-months, taking at least one of the following xanthines, anticholinergics and/or inhaled corticosteroids, and stable medication doing for the past month. Secondary care and self-directed (home-based).	N=60 Referred to *the Integral Health Clinic of the All India Institute of Medical Sciences* or came to IHC in response to an advertisement.	Mild/Moderate Asthma. M = 33.45 Years. Age Range 18-65 Years. 58% Male. 42% Female.
Vendanthan (1998) USA	Randomised Study	Inclusion criteria NR. University health centre.	N=17 Recruited from an allergy and asthma clinic.	Mild/Moderate Asthma. M = 26.62 Years. Age Range 19-53 Years. 47% Male. 53% Female.
FEV/FVC: Forced Expiratory Volume in 1-Second/Forced Vital Capacity; *NR:* Not Reported; *PA*: Physical Activity; *MVPA*: Moderate-Vigorous Physical Activity; *ACQ*: Asthma Control Questionnaire.				

2.4.2. Risk of Bias Within Studies

All 25 studies were judged to be at high risk of bias in at least one domain (see *Figures 2.2 and 2.3*). The most common sources of bias were blinding of participants (21 studies judged as high risk) and blinding of outcome assessors (12 studies judged as high risk).

Figure 2.2. *Risk of Bias Summary: Review authors' judgements about each risk of bias for each included study.*

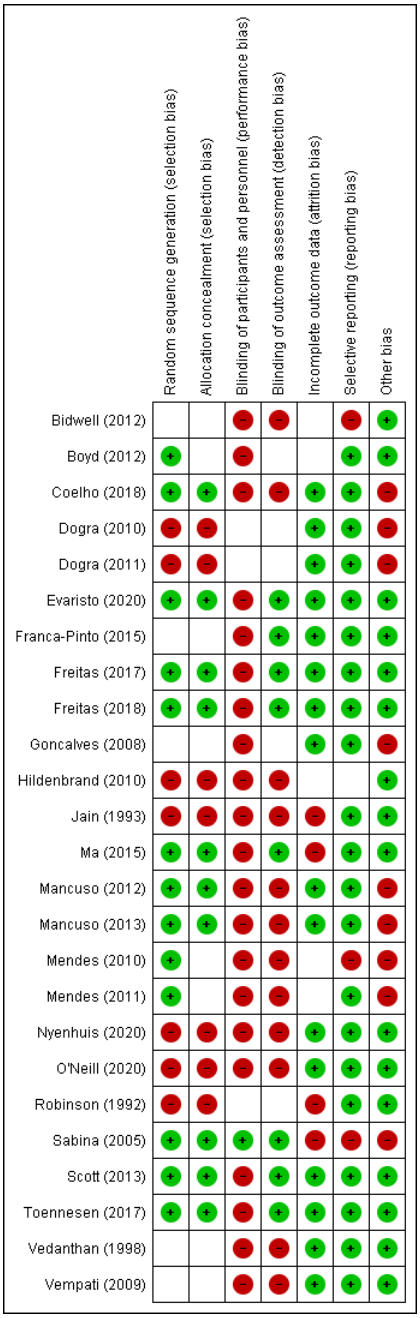
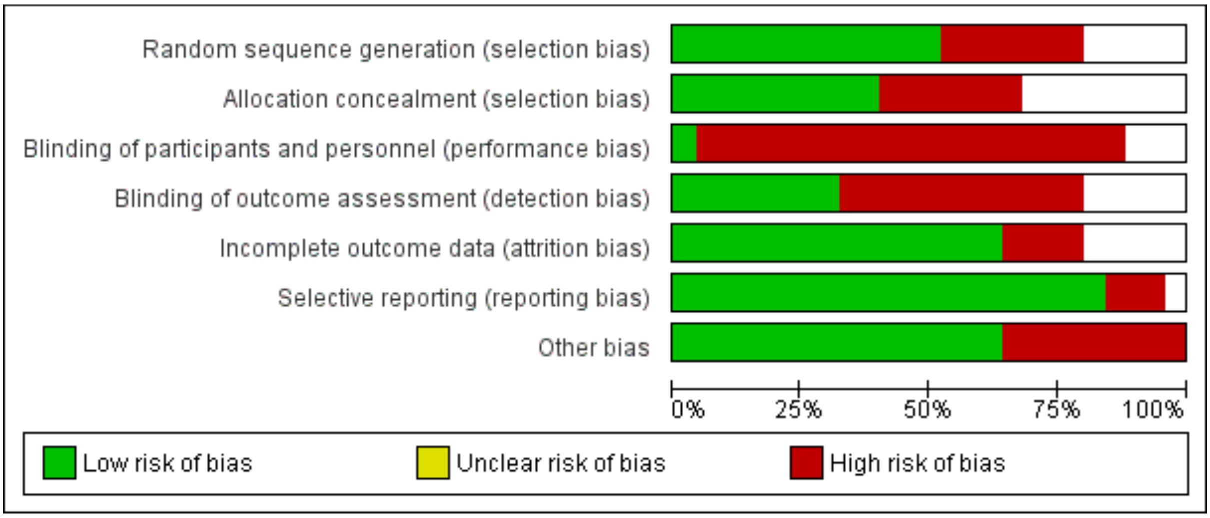


Figure 2.3. *Risk of Bias Graph: Review Authors' Judgements about each risk of bias item presented as percentages across all included studies.*



2.4.3. Effectiveness of Interventions

Ten out of 25 studies, eight unique interventions, reported significant improvements in all the relevant behavioural (e.g., physical activity and sedentary behaviour) and/or health outcomes (e.g., quality of life, asthma control, asthma symptoms, and medication usage) they assessed (O'Neill & Dogra, 2021; Freitas et al., 2017; Toennesen et al., 2017; Bidwell et al., 2012; Mancuso et al., 2012; Dogra et al., 2011; Mendes et al., 2011; Mendes et al., 2010; Vampati, Bijlani & Deepek, 2009; Goncalves et al., 2008).

2.4.3.1. Behavioural Outcomes

Intervention effects on behavioural outcomes are presented in *Table 2.2*.

Table 2.2. *Intervention Characteristics and Behavioural Outcomes*

Author (Year) and Country of Study	Description of Intervention and Comparator Group(s)	Intervention Length and Intensity	Intervention Provider(s) and Mode and Focus of Delivery	Behavioural Outcome(s)	
				Outcome: Measurement Tool	Intervention Effect
Coelho (2018) Brazil	**IG**: Unsupervised pedometer-based programme. PA subscription, consisting of targets calculated weekly. **CG**: Individual standard education session. Received exacerbation diary and encouraged to start walking.	≤3 months 5x p/w, 30mins.	Physiotherapist(s). Face-to-face and telephone. Individual.	**PA**: Pedometer.	**PA**: Statistically sig difference in daily steps between-groups (p=0.003). No longer sig after 24-28 weeks (p=0.310).
Evaristo (2020) Brazil	**IG**: Education and aerobic exercise training programme, performed on an indoor treadmill. **CG**: Education and breathing exercise programme.	≤3 months. 2x p/w, 40mins.	Care providers, teams, or centre preforming the intervention. Face-to-face. Group.	**PA**: Accelerometer.	**PA**: Changes between-groups were not sig (P>0.05).
Freitas (2017) Brazil	**WL+E**: Weight-loss programme incorporating aerobic and resistance muscle training. **WL+S**: Weight-loss programme incorporating breathing and stretching exercises.	≤3 months. 2x p/w.	Nutritionist(s), psychologist(s) and physiotherapist(s). Face-to-face. Combination.	**PA**: Accelerometer.	**PA**: IG demonstrated a sig increase in daily life PA levels compared to the CG (p<0.001).
Freitas (2018) Brazil	**WL+E**: Weight-loss programme incorporating aerobic and resistance muscle training. **WL+S**: Weight-loss programme incorporating breathing and stretching exercises.	≤3 months. 2x p/w.	Nutritionist(s), psychologist(s) and physiotherapist(s). Face-to-face. Combination.	**PA**: Accelerometer. **SB**: Accelerometer.	**PA**: IG demonstrated a sig increase in daily step count (p<0.001) and MVPA (p<0.001) compared to the CG. **SB**: Neither group demonstrated sig changes (p=0.784).
Nyenhuis (2020) USA	Received tailored walking prescription and pedometer (optional walking sessions), asthma education session, written materials on	≤3 months. Increase 150 steps p/d.	Intervention provider(s) NR.	**PA:** Accelerometer and *Fitbit.*	**PA:** Small, but not sig negative effect on step count and positive effect on MVPA (p>0.05).

	exercise with asthma, group discussions to address goals and barriers, and motivational telephone calls and text messaging.		Face-to-face, written materials, telephone and SMS messages. Combination.	**SB:** Accelerometer and *Fitbit*.	**SB**: Statistically sig difference between the total and adjusted time in week 1 (p=0.006), 2 (p=0.01), 3 (p=0.009), 4 (p=0.049), 5 (p=0.04), and 6 (p=0.04).
Ma (2015) USA	**IG**: Lifestyle intervention, dually targeting modest weight-loss and increased PA. **CG**: Usual care enhanced with a pedometer, a weight scale, information about existing weight management services at participating clinics, and an asthma education DVD.	≤12 months. 150mins p/w of MPA.	Intervention provider(s) NR. Face-to-face and telephone. Combination.	**PA**: Stanford 7-Day PA Interview.	**PA**: Sig between-group difference in change of leisure-time PA and total daily energy expenditure (p<0.05).
Mancuso (2012) USA	**IG**: Contract to increase PA and received a pedometer and an asthma workbook. Received bimonthly follow-up telephone calls and small gifts and instructions in fostering positive affect and self-affirmation. **IG**: Identical protocol but did not receive small gifts and instructions.	≤12 months. Intervention intensity NR.	Intervention provider(s) NR. Face-to-face, post and telephone. Individual.	**PA**: Puffenarger PA and Exercise Index.	**PA**: Energy expenditure significantly increase in the CG (p=0.02) and IG (p=0.002).
Mancuso (2013) USA	**IG**: Contract to increase PA and received a pedometer and an asthma workbook. Received bimonthly follow-up telephone calls and small gifts and instructions in fostering positive affect and self-affirmation. **IG**: Identical protocol but did not receive small gifts and instructions.	≤12 months. Intervention intensity NR.	Intervention provider(s) NR. Face-to-face, post and telephone. Individual.	**PA**: Puffenarger PA and Exercise Index.	**PA**: Energy expenditure increased by a clinically important change (p<0.05).
Robinson (1992) New Zealand	**IG**: Training programme, consisting of a warm-up and between one and four circuits of seven exercises.	≤3 months. Increase the number of circuits.	Intervention provider(s) NR. Face-to-face. Group.	**PA**: Life in New Zealand Survey.	**PA**: Two variables were found to be significantly higher following training in both groups (p<0.05).

	CG: Identical protocol except that they did not receive salbutamol or have PEFE measurements.				
Scott (2012) Australia	**EG**: Aerobic and resistance training. Received a 12-week gym membership and personal training session and educational materials regarding national PA recommendations. **DG**: Dietary restrictions. **E/DG**: Aerobic and resistance training and dietary restrictions.	≤3 months. Personal training session for 1h p/w. Attend gym 3x p/w. Increase steps by 10%.	Nutritionist(s), psychologist(s) and physiotherapist(s). Face-to-face and telephone. Combination.	**PA**: International PA Questionnaire. **SB**: International PA Questionnaire.	**PA**: EG demonstrated a sig increase in PA (p=0.022). **SB**: EG demonstrated a sig reduction in physical inactivity (p=0.031).
IG: Intervention Group; *PA:* Physical Activity; *CG:* Control Group; *p/w:* Per Week; *sig*: Significant; *SB:* Sedentary Behaviour; *WL+E*: Weight-Loss and Exercise; *WL+S*: Weight-Loss and Sham; *MVPA:* Moderate-Vigorous Physical Activity; *MPA:* Moderate Physical Activity; *p/d:* Per Day; *PEFE:* Peak Expiratory Flow; *EG:* Exercise Group; *DG:* Diet Group; *E/DG:* Exercise and Diet Group; NR: Not Reported.					

2.4.3.1.1. Physical Activity

Ten of the 25 included studies assessed physical activity as an outcome (Evaristo et al., 2020; Nyenhuis et al., 2020; Coelho et al., 2018; Freitas et al., 2018; Freitas et al., 2017; Ma et al., 2015; Mancuso et al., 2013; Mancuso et al., 2012; Scott et al., 2012; Robinson et al., 1992), five of which measured the outcome objectively. Four studies found evidence of significant positive between-group effects (Coelho et al., 2018; Freitas et al., 2018; Freitas et al., 2017; Ma et al., 2015), and four found significant positive within-group effects (Mancuso et al., 2013; Mancuso et al., 2012; Scott et al., 2012; Robinson et al., 1992). However, the only study to follow-up participants beyond the intervention period found that differences between groups were no longer significant 3 months post-intervention ($p=0.31$) (Coelho et al., 2018). Although not significant, the remaining two studies did report improvements. Evaristo et al. (2020) found that participants in the intervention and control group increased their daily step count by approximately 2,000 steps after the intervention, reaching 10,000 steps. Similarly, Nyenhuis et al. (2020) found evidence of a small effect on moderate-to-vigorous physical activity.

2.4.3.1.2. Sedentary Behaviour

Sedentary behaviour was only assessed in three out of the 25 included studies (Nyenhuis et al., 2020; Freitas et al., 2017; Scott et al., 2012). Of these, two studies found evidence of a significant within-group decrease in time spent sedentary (Nyenhuis et al., 2020; Scott et al., 2012). Freitas et al. (2017) reported no significant between-group differences ($p<0.05$), but the intervention did not specifically target sedentary behaviour.

2.4.3.2. Health Outcomes

Intervention effects on health outcomes are presented in *Table 2.3*.

Table 2.3. *Intervention Characteristics and Health Outcomes*

Author (Year) and Country of Study	Description of Intervention and Comparator Group(s)	Intervention Length and Intensity	Intervention Provider(s) and Mode and Focus of Delivery	Health Outcome(s)	
				Outcome: Measurement Tool	Intervention Effect
Bidwell (2012) USA	**IG:** Supervised yoga training session. Required to perform written lesson plans at home. **CG:** No yoga or related breathing practiced.	≤3 months. 2x p/w, 60mins. Home practice 1x p/w, 30mins.	Certified yoga instructor(s). Face-to-face. Group.	**QoL:** SGRQ.	**QoL:** IG significantly improved compared to the CG, who showed no improvements ($p<0.05$).
Boyd (2012) USA	**IG:** Walking programme exercising at 60-75% of MRmax and brief education. Received 3-month free gym membership. **CG:** Brief education.	≤3 months. 3x p/w, 30 mins.	Intervention provider(s) NR. Face-to-face. Focus NR.	**AC:** ACQ.	**AC:** Changes between-groups were not sig ($p>0.05$), but changes did exhibit a trend towards improvements.
Coelho (2018) Brazil	**IG**: Unsupervised pedometer-based programme. PA subscription, consisting of targets calculated weekly. **CG**: Individual standard education session. Received exacerbation diary and encouraged to start walking.	≤3 months 5x p/w, 30mins.	Physiotherapist(s). Face-to-face and telephone. Individual.	**AC:** ACQ. **QoL**: AQLQ. **Medication Usage**: NR.	**AC:** Changes between-groups were not sig ($p=0.58$). **QoL**: Changes between-groups were not sig ($p=0.65$). **Medication Usage:** Changes between-groups were not sig ($p=0.50$).
Dogra (2010) Canada	**IG:** Self-directed individualised exercise programme. Sent pictures and descriptions of strength and stretching exercises, modified every 3-weeks. **CG:** Maintain current lifestyle.	≤3 months. Intensity progressively increased.	Exercise specialist(s). Postal. individual.	**AC:** ACQ. **QoL:** Mini-AQLQ	**AC:** Changes between-groups were not sig ($p=0.956$), but changes in perceived asthma control were significant between-groups ($p=0.014$). **QoL:** Changes between-groups were not sig ($p=0.466$).

Dogra (2011) **Canada**	**IG:** Exercise training followed by a period of prescribed self-administered exercise. **CG:** Maintain current lifestyle.	≤6 months. Intensity progressively increased.	Exercise specialist(s). Face-to-face. individual.	**AC:** ACQ. **QoL:** Mini-AQLQ	**AC:** ACQ without spirometry significantly improved in the IG compared to the CG ($p<0.05$). **QoL**: Clinically sig improvements in IG ($p<0.05$), maintained over the follow-up period ($p<0.05$).
Evaristo (2020) **Brazil**	**IG**: Education and aerobic exercise training programme, performed on an indoor treadmill. **CG**: Education and breathing exercise programme.	≤3 months. 2x p/w, 40mins.	Care providers, teams, or centre preforming the intervention. Face-to-face. Group.	**AC:** ACQ. **QoL:** AQLQ. **Medication Usage:** Daily Diary. **Symptoms:** Daily Diary.	**AC:** IG demonstrated a sig decrease in scores ($p<0.001$), maintained over the follow-up period ($p<0.001$). **QoL**: IG demonstrated clinically sig improvements ($p<0.05$), maintained over the follow-up period ($p<0.05$). **Medication Usage**: 34% of participants from the IG and 8% from the CG showed a reduction in using recuse medication of more than 5-days ($p<0.04$). **Symptoms**: Number of asthma symptoms-free days increased during the intervention period ($p=0.004$).
Franca-Pinto (2015) **Brazil**	**IG:** Education, breathing exercise and aerobic training programme, completed on an indoor treadmill. **CG:** Education and breathing exercise programme.	≤3 months. 2x p/w, 30mins.	Physiotherapist(s). Face-to-face. Focus NR.	**AC:** ACQ. **QoL:** AQLQ. **Symptoms**: Daily Diary.	**AC:** Changes between-groups were not sig ($p=0.457$). **QoL:** Between-group differences were observed in the activity limitation domain ($p=0.009$) and total score ($p=0.034$), in favour of the IG. **Symptoms:** Number of symptom-free days significantly increased in the IG ($p=0.043$). Frequency of exacerbations during the

					intervention with lower in the IG compared to the CG (p=0.021).
Freitas (2017) **Brazil**	**WL+E**: Weight-loss programme incorporating aerobic and resistance muscle training. **WL+S**: Weight-loss programme incorporating breathing and stretching exercises.	≤3 months. 2x p/w.	Nutritionist(s), psychologist(s) and physiotherapist(s). Face-to-face. Combination.	**AC:** ACQ. **QoL:** AQLQ.	**AC:** Scores significantly improved in the IG (p<0.0001), but not in the CG. **QoL:** Between-group differences were observed in the activity limitation domain and total score (p<0.05) in favour for the IG. Sig within-group improvements in the other three domains in the IG (p<0.01).
Freitas (2018) **Brazil**	**WL+E**: Weight-loss programme incorporating aerobic and resistance muscle training. **WL+S**: Weight-loss programme incorporating breathing and stretching exercises.	≤3 months. 2x p/w.	Nutritionist(s), psychologist(s) and physiotherapist(s). Face-to-face. Combination.	**Symptoms:** Daily Diary.	**Symptoms:** IG had a sig increase in the number of asthma-free days, compared to the CG (p<0.05).
Goncalves (2008) **Brazil**	**IG:** Education and respiratory exercise programme. Submitted to aerobic training on a treadmill. **CG:** Education and respiratory exercise programme.	≤3 months. 2x p/w, 30mins.	Intervention provider(s) NR. Face-to-face. Group.	**QoL:** EPM Questionnaire. **Symptoms:** Daily Diary.	**QoL:** IG significantly improved in the following domains: physical limitations, frequency of symptoms, psychosocial limitations, and the total score (p<0.001). **Symptoms**: Sig increase in the number of symptom-free days in the IG after 30 days, maintained over 60- and 90-days (p<0.05).
Hildenbrand (2010) **USA**	Aquatic exercise programme.	≤3 months. 3x p/w, 30-45mins.	Swimming Instructor(s). Face-to-face. Group.	**QoL:** AIS and a 7-question survey. **Medication Usage**: NR.	**QoL:** Changes within-group were not sig (p=0.645). **Medication Usage**: Changes within-group were not sig (p=0.203).
Jain (1993) **India**	Admitted to hospital for a period of 40-days. Given vegetarian diet and daily yoga training.	≤3 months. 1h 30mins morning and 1h evening.	Intervention provider(s) NR. Face-to-face and mail. Focus NR.	**Symptoms:** MRC Dyspnoea Scale.	**Symptoms**: 18 patients initially with moderate-severe asthma remained asymptomatic for 1-year.

Ma (2015) USA	**IG**: Lifestyle intervention, dually targeting modest weight-loss and increased PA. **CG**: Usual care enhanced with a pedometer, a weight scale, information about existing weight management services at participating clinics, and an asthma education DVD.	≤12 months. 150mins p/w of MPA.	Intervention provider(s) NR. Face-to-face and telephone. Combination.	**AC:** ACQ and ACT. **QoL:** Mini-AQLQ. **Medication Usage:** Electronic Health Record.	**AC:** Changes between-groups were not sig at 6-months (p=0.15) or 12-months (p=0.92). **QoL:** Changes between-groups were not sig at 6-months (p=0.28) or 12-months (p=0.42). **Medication Usage:** Groups did not differ in any measures.
Mancuso (2013) USA	**IG**: Contract to increase PA and provided with a pedometer and an asthma workbook. Received bimonthly follow-up telephone calls and small gifts and instructions in fostering positive affect and self-affirmation. **IG**: Identical protocol but did not receive small gifts and instructions.	≤12 months. Intervention intensity NR.	Intervention provider(s) NR. Face-to-face, post and telephone. Individual.	**AC**: ACQ. **QoL**: AQLQ.	**AC**: IG significantly improved from 1.43 to 0.83 (p<0.0001). **QoL**: Changes between-groups were not sig (p>0.05).
Mendes (2010) Brazil	**IG:** Aerobic training programme. Received an educational programme and taught yoga breathing exercises. **CG:** Received an educational programme and taught yoga breathing exercises.	≤3 months. 2x p/w, 30 mins.	Intervention provider(s) NR. Face-to-face. Group.	**QoL:** Simplified AQLQ. **Symptoms:** Daily Diary.	**QoL:** Sig improvements in the physical limitations, frequency of symptoms, psychosocial domains and total score occurred only in the IG (p<0.001). **Symptoms:** IG showed a sig increase in the number of symptom-free days after 30-days (p<0.001), maintained after 60- and 90-days (p<0.001).
Mendes (2011) Brazil	**IG:** Aerobic training programme. Received an educational programme and taught yoga breathing exercises. **CG:** Received an educational programme and taught yoga breathing exercises.	≤3 months. 2x p/w, 30 mins.	Intervention provider(s) NR. Face-to-face. Group.	**Symptoms:** Daily Diary.	**Symptoms:** IG showed a sig increase in the number of symptom-free days after 30-days (p<0.001), maintained after 60- and 90-days (p<0.001).

O'Neill (2021) **Canada**	High-intensity interval training.	≤3 months. 3x p/w.	Intervention provider(s) NR. Face-to-face. Focus NR.	**AC:** ACQ. **Symptoms:** RPD Scale.	**AC:** Sig improvements were observed when comparing pre- and post-intervention sessions (p=0.02). **Symptoms:** Sig improvements were observed when comparing pre- and post-intervention sessions (p=0.01).
Robinson (1992) **New Zealand**	**IG**: Training programme, consisting of a warm-up and between one and four circuits of seven exercises. **CG**: Identical protocol except that they did not receive salbutamol or have PEFE measurements.	≤3 months. Increase the number of circuits.	Intervention provider(s) NR. Face-to-face. Group.	**Medication Usage**: Daily Diary. **Symptoms**: Daily Diary.	**Medication Usage:** No sig changes (p>0.05). **Symptoms**: No sig changes (p>0.05).
Sabina (2005) **USA**	**IG:** Yoga training programme. Provided with printed materials and audiocassettes and encouraged to practice at home. **CG:** Shame intervention of basic muscle stretching exercises. Provided with printed materials and audiocassettes and encouraged to practice at home.	≤3 Months. 2x p/w, 90mins. Home practice for 20 mins p/d.	Exercise specialist(s). Face-to-face and printed materials and audiocassettes. Combination.	**QoL:** Mini-AQLQ. **Medication Usage:** Brief Questionnaire. **Symptoms**: Daily Diary.	**QoL:** Changes between-groups were not sig (p>0.05). **Medication Usage:** Changes between-groups were not sig (p>0.05). **Symptoms:** Sig improvement in morning symptoms in the IG and CG at 4 weeks (p=0.03) and 16 weeks (p=0.001).
Scott (2012) **Australia**	**EG**: Aerobic and resistance training. Received a 12-week gym membership and personal training session and educational materials regarding national PA recommendations. **DG**: Dietary restrictions. **E/DG**: Aerobic and resistance training and dietary restrictions.	≤3 months. Personal training session for 1h p/w. Attend gym 3x p/w. Increase steps by 10%.	Nutritionist(s), psychologist(s) and physiotherapist(s). Face-to-face and telephone. Combination.	**AC:** ACQ. **QoL:** AQLQ.	**AC:** No sig improvement in the EG (p>0.05) but sig improvement in the E/DG (p<0.05) were observed. **QoL:** Sig within-group improvements in the EG (p<0.05) and E/DG (p<0.01) were observed.
Toennesen (2017)	**EG:** High-intensity interval training. **DG:** High protein and low glycaemic diet.	≤3 Months. 3x p/w.	Trained spinning instructor(s) and dietician(s).	**AC:** ACQ. **QoL:** Mini-AQLQ.	**AC:** Sig within-group improvements in all treatment groups, but when compared to

Denmark	**E&DG**: High-intensity interval training and diet. **CG**: No intervention.		Face-to-face. Combination.		the CG only E/DG had statistically sig improvements ($p<0.05$). **QoL:** Sig within-group improvements in all treatment groups, but when compared to the CG only E/DG had statistically sig improvements ($p<0.01$).
Vampati (2009) **India**	**IG:** Yoga-based lifestyle modification and stress management programme. Provided with printed materials, audiocassettes and telephonic support. **CG**: Waiting list.	≤3 Months. 4h p/d.	Qualified yoga instructor(s) and physician(s). Face-to-Face, telephone and printed materials and audio cassettes. Combination.	**QoL:** AQLQ. **Medication Usage:** Daily Diary.	**QoL:** Significantly improved in both groups but achieved earlier in the IG ($p=0.013$). **Medication Usage:** Significantly decreased in both groups but the decrease was achieved earlier in the IG ($p<0.05$).
Vendanthan (1998) **USA**	**IG:** Yoga training. Received audio cassettes and written information to continue practicing at home. **CG:** No intervention.	≤6 Months. 3x p/w, 45 mins.	Trained yoga teacher(s). Face-to-face. Group.	**Medication Usage:** NR. **Symptoms:** Weekly symptom questionnaire.	**Medication Usage:** Changes between-groups were not sig ($p>0.05$), but changes did exhibit a trend towards improvements. **Symptoms**: Average weight score for the IG was much higher than for the CG, but between-group differences were not sig ($p>0.05$).
IG: Intervention Group; *CG:* Control Group; *p/w:* Per Week; *QoL*: Quality of Life; *SGRQ*: St Georges Quality of Life Questionnaire; *HRmax*: Maximum Heart Rate; *NR*: Not Reported; *AC*: Asthma Control; *ACQ*: Asthma Control Questionnaire; *AQLQ*: Asthma Quality of Life Questionnaire; *AIS*: Asthma Impact Survey; *PA*: Physical Activity; *WL+E*: Weight-Loss and Exercise; *WL+S*: Weight-Loss and Sham; *MRC*: Medical Research Council; *ACT*: Asthma Control Test; *p/d*: Per Day; *EG*: Exercise Group; *DG*: Diet Group; *E/DG*: Exercise and Diet Group.					

2.4.3.2.1. Quality of Life

Sixteen of the 25 included studies assessed quality of life as an outcome (Evaristo et al., 2020; Coelho et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Franco-Pinto et al., 2015; Ma et al., 2015; Mancuso et al., 2013; Bidwell et al., 2012; Scott et al., 2012; Dogra et al., 2011; Dogra, Jamnik & Baker, 2010; Hildenbrand et al., 2010; Mendes et al., 2010; Vampati, Bijlani & Deepak, 2009; Goncalves et al., 2008; Sabina et al., 2005). Of these, seven studies found evidence of a significant positive within-group effect (Evaristo et al., 2020; Toennesen et al., 2017; Scott et al., 2012; Dogra et al., 2011; Mendes et al., 2010; Vampati, Bijlani & Deepak, 2009; Goncalves et al., 2008) and three found significant positive between-group effects (Freitas et al., 2017; Franco-Pinto et al., 2015; Bidwell et al., 2012).

2.4.3.2.2. Asthma Control

Twelve studies assessed asthma control as an outcome using the Asthma Control Questionnaire and/or Asthma Control Test (Evaristo et al., 2020; O'Neill & Dogra., 2021; Coelho et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Franco-Pinto et al., 2015; Ma et al., 2015; Mancuso et al., 2013; Boyd et al., 2012; Scott et al., 2012; Dogra et al., 2011; Dogra, Jamnik & Baker, 2010). Five reported significant positive within-group effects (Evaristo et al., 2020; O'Neill and Dogra, 2021; Freitas et al., 2017; Toennesen et al., 2017; Mancuso et al., 2013), and one reported a significant between-group effect (Dogra et al., 2011). Although not significant, several of the remaining studies reported a trend of improved asthma control in the intervention group compared to the control (Franco-Pinto et al., 2015; Ma et al., 2015; Boyd et al., 2012; Scott et al., 2012). Although Dogra, Jamnik & Baker (2010) did not report significant positive effects on asthma control, participants perceived asthma control significantly improved post-intervention ($p=0.014$).

2.4.3.2.3. Asthma Symptoms

Although quality of life and asthma control questionnaires include questions about asthma symptoms, some studies also collected self-reported data on asthma symptoms and reported the results separately. Asthma symptoms were assessed as an outcome in 11 studies (Evaristo et al., 2020; O'Neill and Dogra, 2021; Freitas et al., 2018; Franca-Pinto et al., 2015; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008; Sabina et al., 2005; Vedanthan et al., 1998; Jain and Talukdor, 1993; Robinson et al., 1992), with seven reporting significant positive within-group effects (Evaristo et al., 2020; O'Neill and Dogra., 2021; Franco-Pinto et al., 2015; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008; Sabina et al., 2005) and one reporting a significant positive between-group effect (Freitas et al., 2018). Although not significant, two of the remaining studies reported improved asthma symptoms in the intervention group over time (Vedanthan et al., 1998; Jain and Talukdor, 1993).

2.4.3.2.4. Medication Usage

Eight out of the 25 included studies assessed medication usage as an outcome (Evaristo et al., 2020; Coelho et al., 2018; Ma et al., 2015; Hildenbrand et al., 2010; Vampati, Bijlani & Deepak, 2009; Sabina et al., 2005; Vedanthan et al., 1998; Robinson et al., 1992). Only two of the eight studies found within-group evidence of a significant reduction in the use of reliever medication in the intervention group (Evaristo et al., 2020; Vampati, Bijlani & Deepak, 2009).

2.4.4. Intervention Components

Interventions were heterogeneous in terms of intervention duration, type of physical activity, intensity and duration, mode of delivery, delivery focus and intervention provider. These are presented in *Table 2.2* and *Table 2.3*.

2.4.4.1. Intervention Duration/Intensity and Physical Activity

The majority of the 21 unique included interventions lasted no more than 3 months (Evaristo et al., 2020; Nyenhuis et al., 2020; O'Neill & Dogra, 2021; Coelho et al., 2018; Freitas et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Franca-Pinto et al., 2015; Mancuso et al., 2013; Bidwell et al., 2012; Boyd et al., 2012; Scott et al., 2012; Mendes et al., 2011; Dogra, Jamnik & Baker, 2010; Hildenbrand et al., 2010; Mendes et al., 2010; Vampati, Bijlani & Deepek, 2009; Goncalves et al., 2008; Sabina et al., 2005; Jain & Talukdar, 1993; Robinson et al., 1992), with others lasting no more than 6 months (Dogra et al., 2011; Vedanthan et al., 1998), and no more than 12 months (Ma et al., 2015; Mancuso et al., 2012).

The physical activity performed within the intervention varied across studies but included aerobic exercises and/or strength/resistance training (Evaristo et al., 2020; Freitas et al., 2018; Freitas et al., 2017; Franca-Pinto et al., 2015; Ma et al., 2015; Scott et al., 2012; Dogra et al., 2011; Mendes et al., 2011; Dogra, Jamnik & Baker, 2010; Mendes et al., 2010; Goncalves et al., 2008), yoga training (Bidwell et al., 2012; Toennesen et al., 2017; Sabina et al., 2005; Vedanthan et al., 1998; Jain & Talukdar, 1993), walking only (Nyenhuis et al., 2020; Coelho et al., 2018; Mancuso et al., 2013; Boyd et al., 2012; Mancuso et al., 2012), high-intensity interval training (O'Neill & Dogra, 2021; Toennesen et al., 2017), indoor circuit training (Robinson et al., 1992), and aquatic training (Hildenbrand et al., 2010). Participants were most commonly asked to perform the activity two or three times per week, for between 30-60 minutes (Evaristo et al., 2020; O'Neill & Dogra, 2021; Freitas et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Franca-Pinto et al., 2015; Bidwell et al., 2012; Boyd et al., 2012; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008; Hildenbrand et al., 2010; Vedanthan et al., 1998). However, two studies did not report information on the intensity of the intervention (Mancuso et al., 2013; Mancuso et al., 2012).

2.4.4.2. Intervention Provider, Mode of Delivery and Delivery Focus

In most interventions, the provider was not reported (Nyenhuis et al., 2020; O'Neill & Dogra, 2021; Ma et al., 2015; Mancuso et al., 2013; Boyd et al., 2012; Mancuso et al., 2012; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008; Vedanthan et al., 1998; Jain & Talukdar, 1993; Robinson et al., 1992) with others using exercise specialists, including yoga and swimming instructors (Bidwell et al., 2012; Dogra et al., 2011; Dogra, Jamnik & Baker, 2010; Hildenbrand et al., 2010; Sabina et al., 2005), physiotherapists (Coelho et al., 2018; Franca-Pinto et al., 2015), or a combination of providers (Evaristo et al., 2020; Freitas et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Scott et al., 2012; Vampati, Bijlani & Deepek, 2009).

Intervention providers delivered most of the interventions face-to-face (Evaristo et al., 2020; O'Neill & Dogra, 2021; Freitas et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Franca-Pinto et al., 2015; Bidwell et al., 2012; Boyd et al., 2012; Dogra et al., 2011; Mendes et al., 2011; Hildenbrand et al., 2010; Mendes et al., 2010; Goncalves et al., 2008; Vedanthan et al., 1998; Robinson et al., 1992), or using a combination of methods, including face-to-face and telephone, post, printed materials and/or tapes (Coelho et al., 2018; Ma et al., 2015; Mancuso et al., 2013; Mancuso et al., 2012; Scott et al., 2012; Vampati, Bijlani & Deepek, 2009; Sabina et al., 2005; Jain & Talukdar, 1993). Nyenhuis et al. (2020) was the only intervention that used data collected from the participant's activity tracker to send tailored SMS messages to participants. Only one of the included interventions had no face-to-face contact and was delivered via post only (Dogra, Jamnik & Baker, 2010).

The majority of interventions were delivered in groups only (Evaristo et al., 2020; Bidwell et al., 2012; Mendes et al., 2011; Hildenbrand et al., 2010; Mendes et al., 2010; Goncalves et al., 2008; Vedanthan et al., 1998; Robinson et al., 1992), or used a combination of group and individual sessions (Nyenhuis et al., 2020; Freitas et al., 2018; Freitas et al., 2017; Toennesen et al., 2017; Ma et al., 2015; Scott et al., 2012; Vampati, Bijlani & Deepek, 2009; Sabina et al., 2005). Four interventions used individual sessions only (Coelho et al., 2018; Mancuso et al., 2013; Mancuso et al., 2012; Dogra et al., 2011; Dogra, Jamnik & Baker, 2010), and four studies did not report the focus of delivery (O'Neill & Dogra, 2020; Franca-Pinto et al., 2015; Boyd et al., 2012, Jain and Talukdor, 1993).

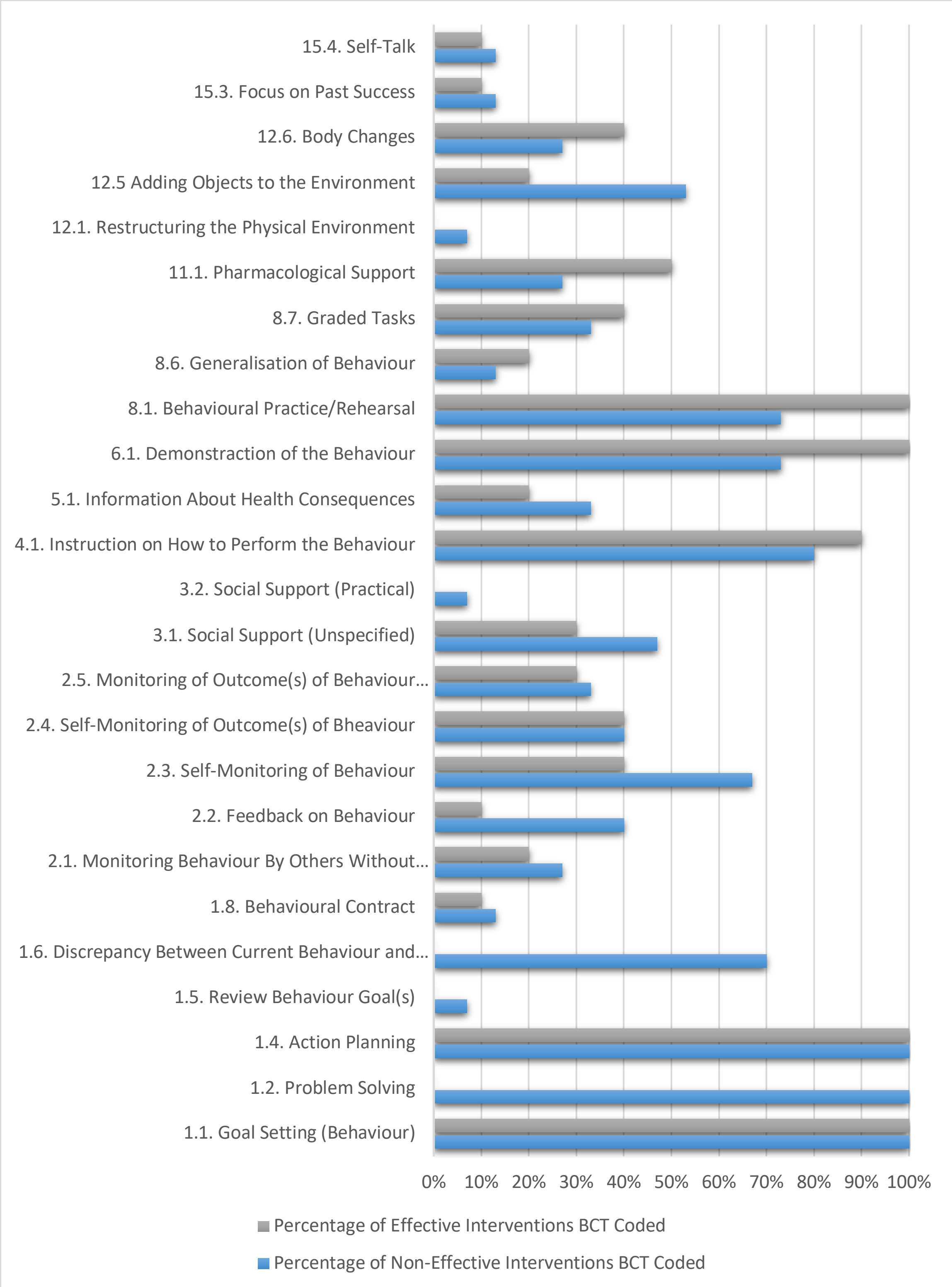
2.4.4.3. Intervention Components in Effective Interventions

Six of the eight unique interventions found to be effective only reported short-term effects (<3 months) (O'Neill and Dogra, 2021; Freitas et al., 2017; Toennesen et al., 2017; Bidwell et al., 2012; Mendes et al., 2011; Mendes et al., 2010; Vampati, Bijlani & Deepak, 2009; Goncalves et al., 2008). Participants in these interventions were most commonly asked to perform aerobic exercise and/or strength/resistance training (Freitas et al., 2017; Dogra et al., 2011; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008), two or three times per week for 30-60 minutes (O'Neill & Dogra, 2020; Freitas et al., 2017; Toennesen et al., 2017; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008). Most interventions were delivered by a combination of providers (Freitas et al., 2017; Toennesen et al., 2017; Vampati, Bijlani & Deepak, 2009) or did not report the provider (O'Neill & Dogra, 2020; Mancuso et al., 2012; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008). They were mostly delivered face-to-face (O'Neill & Dogra, 2020; Freitas et al., 2017; Toennesen et al., 2017; Bidwell et al., 2012; Dogra et al., 2011; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008), and within groups (Bidwell et al., 2012; Mendes et al., 2011; Mendes et al., 2010; Goncalves et al., 2008) or used a combination of group and individual sessions (Freitas et al., 2017; Toennesen et al., 2017; Vampati, Bijlani & Deepak, 2009).

2.4.4.4. Behaviour Change Techniques

A total of 25 of the 93 BCTs from the BCTTv1 were identified *(*see *Figure 2.4.)*. BCTs related to increasing physical activity and, in some studies, reducing sedentary behaviour. The number of BCTs identified in individual interventions ranged from 6 to 15, with an average of nine BCTs per intervention. The most prevalent BCTs (coded in at least 25% of interventions) were: '*Action Planning*' (n = 25); '*Goal Setting (Behaviour)*' (n = 25); '*Instruction on How to Perform Behaviour*' (n = 22); '*Demonstration of Behaviour*' (n = 20); '*Behavioural Practice/Rehearsal*' (n = 20); '*Self-Monitoring of Behaviour*' (n = 14); '*Self-Monitoring Outcome(s) of Behaviour(s)*' (n = 11); '*Social Support (Unspecified)*' (n = 10); '*Adding Objects to the Environment*' (n = 10); '*Graded Tasks*' (n = 9); '*Pharmacological Support*' (n = 9); '*Monitoring of Outcome(s) of Behaviour Without Feedback*' (n = 8); '*Body Changes*' (n = 8); '*Feedback on Behaviour*' (n = 7); and '*Information About Health Consequences*' (n = 7). In terms of '*Pharmacological Suppor*t', this concerned intervention providers encouraging participants to adhere to their asthma medication. Twenty of the 25 identified BCTs were identified in the seven effective interventions. The most commonly used BCTs in effective interventions were: '*Action Planning*' (100%); '*Goal Setting (Behaviour)*' (100%); '*Instruction on how to Perform Behaviour*' (89%); '*Demonstration of Behaviour*' (89%); '*Behavioural Practice/Rehearsal*' (89%). BCTs included in these interventions were also included in interventions that did not show evidence of effectiveness.

Figure 2.4. *BCTs Coded in Non-Effective Interventions vs. Effective Interventions*



2.5. Discussion

Interventions developed to promote physical activity had significant benefits in terms of increasing physical activity (eight out of ten studies), decreasing sedentary time (two out of three studies), improving quality of life (ten out of 16 studies) and decreasing asthma symptoms (eight out of 11 studies). However, there was no evidence of a positive effect on asthma control (six out of 12 studies) and medication usage (two out of eight studies). Ten of the 25 included studies, comprising 786 out of 1,849 participants, reported significant positive effects in all the relevant outcomes they assessed and were deemed effective. Participants in these interventions were most commonly asked to perform aerobic exercise and/or strength/resistance training two or three times per week for 30-60 minutes. Most interventions were delivered by a combination of providers or did not report the provider. They were delivered face-to-face and within groups or used a combination of group and individual sessions. However, it cannot be said for definite that these intervention components increased effectiveness as components were similar across all interventions regardless of their effectiveness. The most commonly used BCTs in effective interventions (vs. non-effective interventions) were: '*Action Planning*' (100% vs. 100%); '*Goal Setting (Behaviour)'*; (100% vs. 100%); '*Demonstration of Behaviour*' (100% vs 73%); '*Behavioural Practice/Rehearsal*' (100% vs 73%); and '*Instruction on how to Perform the Behaviour*' (90% vs. 80%). Due to the similarities of the BCTs used across all intervention and control groups, it was not possible to identify specific techniques that showed promise of effectiveness.

Notably absent from the BCTs extracted from the included interventions were techniques that help self-regulate behaviour and sustain motivation, which are important for adopting and maintaining behaviour change. For example, '*Problem Solving*', '*Reviewing Behavioural Goals*', '*Prompts/Cues*', '*Habit Formation*' and '*Self Reward*' have all been associated with behaviour maintenance (Howlett et al., 2019; Samdal et al., 2017), but were not identified in the included interventions. Although the majority of interventions found a significant increase in physical activity, the only intervention to follow-up participants beyond the intervention period showed that the increase was not maintained (Coelho et al., 2018). For changes to be maintained, future interventions should consider including the above techniques.

In terms of active ingredients of the intervention, '*Goal Setting*' and '*Action Planning*' were the most commonly used BCTs. A meta-analysis has shown that setting a specific and detailed plan on when, where and how to perform a behaviour and providing instructions increases self-efficacy (one's belief in their ability to engage in the behaviour successfully) and physical activity (Williams & French, 2011). Qualitative studies have found that major barriers to physical activity for adults with asthma are low self-efficacy and negative beliefs about their capabilities to be active (Nyenhuis et al., 2019; Mancuso et al., 2006). This would suggest that these techniques are important for behaviour change in this patient group, and although it cannot conclude that these are '*promising'* or more likely to increase effectiveness as they were identified in both effective and ineffective interventions, the evidence supporting the use of these techniques is well established (Howlett et al., 2018; Samdal et al., 2017).

Although identified in a small number of interventions, some evidence based BCTs could be used more often to increase the likelihood of interventions being effective. For example, social support has been reported as a facilitator of physical activity in this patient group (Nyenhuis et al., 2019; Mancuso et al., 2006) and incorporating '*Practical Social Support*' has been associated with better intervention effects. Planning how to elicit social support from individuals makes participants feel more in control and ensures that they are supported to make behavioural changes (Olander et al., 2013), but this technique was only identified in one of the included studies. Including this technique in future interventions could increase their effectiveness by ensuring that participants are supported and could help them cope with possible setbacks following an asthma flare-up. Another BCT associated with increased physical activity is '*Self-Monitoring of Outcomes of Behaviour*' (Olander et al., 2013). One of the major barriers to physical activity reported by adults with asthma, even for those with mild asthma, is fear and anxiety about triggering symptoms (Clarke & Mansur, 2015). If participants could see the benefits of physical activity to their asthma outcomes for themselves, it could reduce negative feelings towards physical activity and encourage them to continue to make positive changes to increase their activity levels. Other BCTs that reduce negative emotions and conserve mental resources and techniques in the '*Self Belief*' group, such as '*Verbal Persuasion About Capability*' and '*Focus on Past Success*', could be included.

As limited facilities and funding are available to deliver pulmonary rehabilitation to patients, alternative interventions to pulmonary rehabilitation could increase the number of patients who can access help and support to improve their physical activity levels. However, although the interventions included in this review were not pulmonary rehabilitation, most of them would not have overcome the major barriers previously reported by patients as they still required participants to travel and would not have been suitable for those living with co-morbidities. These barriers need to be considered in the development of future physical activity interventions, and alternative delivery methods should be considered to provide patients with tailored interventions at a convenient time and place for them. To help overcome these barriers, home-based programmes have been proposed as an alternative to traditional pulmonary rehabilitation. Randomised controlled trials have shown that home-based pulmonary rehabilitation can produce short-term clinical outcomes equivalent to traditional pulmonary rehabilitation (Holland et al., 2017), including improving exercise capacity and quality of life (Pradella et al., 2015). Home-based pulmonary rehabilitation could be optimised by incorporating BCTs most commonly used in effective interventions highlighted in this review. Our findings also highlight the potential use of digital interventions that have unique advantages over traditional in-person interventions, being more accessible and convenient for participants (Griffiths et al., 2006). Except for Nyenhuis et al. (2020), none of the included interventions were digital or had a digital component. Future research should investigate the development of digital-physical activity interventions tailored to adults with diagnosed with asthma, and good-quality randomised trials should be carried out to understand their effectiveness in this patient group.

2.5.1. Strengths and Limitations

This review followed a structured search protocol that used five electronic databases. Following a discussion with my supervisory team, the inclusion criteria were broad, and we included a wide range of study designs and interventions with all asthma severities. A detailed categorisation of BCTs with reference to standardised classifications was also used. However, some limitations need to be considered. Firstly, the search strategy did not include terms for specific physical activities, such as yoga or stretching. Although some of the included studies did have participants perform some of these activities, there is a risk that some studies were not picked up in the search results. The search strategy used could have been improved by seeking the advice of a librarian when it was developed. Also, due to time restraints, hand searching of key journals and reference lists of included studies was not performed and relevant studies could have been overlooked. Additionally, there was a great deal of heterogeneity in the included studies in relation to the research design, type of intervention and outcome data. Therefore, a numerical analysis could not be conducted, and only a narrative review could be produced.

Furthermore, the level of detail needed for extracting BCTs was often not present in published intervention descriptions; included interventions might have used more techniques than those extracted in this review. I tried to address this problem by validating my data extraction with a second reviewer and included techniques that were both probably (coded +) and definitely (coded ++) present. Lastly, it was not always clear whether an intervention would qualify as pulmonary rehabilitation or not due to the lack of detail provided in the intervention descriptions. Again, I tried to address this problem with a second reviewer validating the inclusion and exclusion of papers with the option to discuss with a third reviewer if there was a discrepancy. Nevertheless, this review provided an update to the literature on interventions that have been developed to promote physical activity in adults diagnosed with asthma and their effects on behavioural and health outcomes and provides insight into the literature gaps that need to be addressed in future research.

2.6. Conclusion

The review included 25 studies that reported 21 unique physical activity interventions. Interventions significantly increased physical activity and decreased sedentary behaviour in adults diagnosed with asthma. They also positively affected quality of life and asthma symptoms, but not asthma control and medication usage. Ten of the 25 included studies reported significant positive effects in all the relevant behavioural and/or health outcomes they assessed and were deemed effective. Participants in these interventions were most commonly asked to perform aerobic exercise and/or strength/resistance training two or three times per week for 30-60 minutes. Most interventions were delivered by a combination of providers or did not report the provider. They were delivered face-to-face and within groups or used a combination of group and individual sessions.

The most commonly used BCTs in effective interventions were: '*Action Planning*'; '*Goal Setting (Behaviour)*'; '*Instruction on how to Perform the Behaviour*'; '*Demonstration of the Behaviour*'; and '*Behavioural Practice/Rehearsal*'. Due to the similarities in components and techniques used across all intervention and control groups, it was not possible to identify specific intervention components that showed promise of effectiveness. Future interventions should consider including evidence-based techniques that promote self-regulation of behaviour and sustained motivation and behaviour change.

Although I was able to establish the effectiveness of interventions developed to promote physical activity in adults diagnosed with asthma, promising components could not be identified, and evidence from the literature may not be generalisable to the target end-users of this intervention. Therefore, it was important for me to identify the perceived barriers and facilitators to physical activity among adults diagnosed with asthma so the most appropriate BCTs to change behaviour could be selected during intervention development, discussed more in *Chapter 5: Intervention Development*. Thus, I conducted a qualitative exploration of the perceived barriers and facilitators to physical activity among adults diagnosed with asthma. These findings are presented in *Chapter 3: Barriers and Facilitators*.

Chapter 3: Exploring the Perceived Barriers and facilitators to Physical Activity Among Adults Diagnosed with Asthma

Chapter 2: Review of Existing Interventions discussed the effectiveness and characteristics of existing interventions developed to promote physical activity in adults diagnosed with asthma. However, due to the similarities in behaviour change techniques (BCTs) used across studies, regardless of effectiveness, it was not possible to ascertain which BCTs were 'promising' or most effective (Tyson et al., 2021a). For the proposed intervention to be effective it is important to understand the perceived barriers to physical activity so they can be addressed, and the intervention can facilitate behaviour change. This chapter presents a qualitative study that used interviews and focus groups to identify perceived barriers and facilitators to physical activity among adults diagnosed with predominately severe asthma. Findings from this chapter will be used in the development of the proposed intervention, discussed in Chapter 5: Intervention Development, and can be used in the development of future interventions.

3.1. Background

In the general population, cross-sectional studies have shown that reasons for physical inactivity include insufficient leisure time, inadequate social support, and lack of motivation (Herazo-Beltran et al., 2017; Moschny et al., 2011). As reported in *Chapter 1: Introduction*, adults living with asthma may have additional disease-related barriers and facilitators that need to be considered.

Two qualitative studies to date have investigated perceived barriers and facilitators to physical activity by conducting interviews or focus groups with adults diagnosed with asthma. Mancuso et al. (2006) reported that lack of asthma knowledge (i.e., ability to recognise triggers, understand the role of maintenance and rescue medications and manage exacerbations), lower asthma self-efficacy (i.e., confidence to accurately interpret symptoms and follow through with appropriate self-management), and extreme weather conditions such as humidity and wind were barriers to physical activity in men and women. Having a motivated companion was the most common facilitator reported by participants in this study, usually a friend or a family member. The encouragement and confidence of their healthcare providers was another facilitator reported by participants. They wanted to work with them to develop healthier lifestyles and were depending on them to give them instructions and support to become (more) physically active. Lastly, participants' desire to be healthy was found to be a facilitator and included focusing on feeling well and improving asthma and overall health.

In a study by Nyenhuis et al. (2019), similar themes were noted in a group of African American women with poorly controlled asthma who participated in focus groups designed to identify barriers to walking. Barriers included limited physical capabilities to be active because of their asthma, lack of knowledge of the benefits of physical activity to asthma, lack of self-monitoring skills and education on how to prevent and manage asthma symptoms when being physically active, lack of social support from their friends and family, lack of areas to walk, beliefs about capabilities and their vulnerability because of their asthma and beliefs about consequences and the perception that physical activity is dangerous for their asthma.

This study is the first to conduct an in-depth qualitative analysis of the perceived barriers and facilitators to physical activity in adults diagnosed with asthma within the UK. Going beyond previous findings by Mancuso et al (2006) who explored this topic in adult males and females with predominately moderate asthma severity, this study uses a sample made up of participants with predominately severe asthma. This is because findings suggest that adults with severe asthma are more likely to believe that physical activity worsens asthma and experience additional barriers to participation (Mancuso et al., 2006). To help adults with asthma to become more physically active, it is necessary to determine how they view their asthma, physical activity and their perceived barriers and facilitators to physical activity. Findings from this study informed the development of the proposed intervention and can inform future interventions that are developed to promote physical activity and reduce sedentary behaviour in this target population.

3.2. Aim

The purpose of this study was to conduct in-depth qualitative research to explore the perceived barriers and facilitators to physical activity among adults living predominately with severe asthma in the UK.

3.3. Methods

3.3.1. Design

I conducted a qualitative study using semi-structured interviews and a focus group with adults diagnosed with asthma. Interviews were conducted over the telephone, and the focus group was conducted in-person on the University of East Anglia campus (East of England) on the 19th October 2019. Qualitative methods were used as they generate detailed insight and understanding of why people behave in certain ways and the relationship between their beliefs and behaviours, making them useful when researching relatively unexplored topics in which understanding participants' perspectives are critical (Jaye, 2002). Focus groups were conducted to generate discussion amongst participants and encourage group interactions. These interactions would allow participants to raise issues of importance to them individually and explore them as a group, thus generating new ideas and questions, and highlighting any concerns and priorities. For participants who were unable to attend face-to-face, they had the option to take part in a semi-structured interview over the telephone. Having the option of a telephone interview, enabled participants from different geographical areas to participate in the study.

3.3.2. Ethical Approval

The study was approved by the University of East Anglia Faculty of Medicine and Health Sciences Research Ethics Committee (Reference: 2018/19-147) (Appendix F)

3.3.3. Participants and Recruitment

I recruited participants through convenience sampling, using strategies that would allow me to recruit participants relatively quickly with minimal resources. An advertisement

(*Appendix G & H*) was posted on the social media outlets Facebook and Twitter. Advertisements were posted in asthma-specific support groups on Facebook and then more generally on Norfolk and Norwich groups to try and increase recruitment for the focus groups. Asthma UK Centre for Applied Research shared the advertisement on their Twitter account. Advertisements were also emailed to the Research and Policy Volunteers at Asthma UK (now part of Asthma+LungUK), a group of volunteers diagnosed with asthma willing to participate in research studies.

The advertisement briefly explained the study to potential participants and invited anyone interested to contact me for more information. A Participant Information Sheet (Appendix I) along with a link to an online eligibility questionnaire were sent to participants who contacted me for more information. Participants were eligible if they were over 18 years old with a diagnosis of asthma (evidenced by potential participants self-reporting that they were currently prescribed asthma medication). Anyone unable to speak English, unable or unwilling to provide informed consent, or diagnosed with any other respiratory condition was not eligible to participate. As part of the eligibility questionnaire, potential participants were asked to self-report the severity of their asthma (i.e., mild, moderate or severe) and indicate if they would like to take part in the in-person focus group or a telephone interview.

Potential participants who met the inclusion criteria and self-reported that they had moderate/severe asthma received an invitation by email to participate in the study. Those still interested were asked to complete and sign a consent form, which was emailed to them (*Appendix J and K*). I arranged interviews for a convenient date and time for the participant, and the focus group was arranged when an adequate number of eligible participants were available. Participants received £20 worth of shopping vouchers in return for their participation.

3.3.4. Data Collection

The semi-structured interviews and focus group were conducted in September and October 2019. Participants were asked to complete a brief demographic questionnaire (*Appendix M*) prior to the commencement of the interview or the focus group, where age, gender, ethnicity, and employment status were recorded. Physical activity levels were assessed using the *General Practice Physical Activity Questionnaire* (Department of Health and Social Care, 2013), which is a validated screening tool that is used in primary care to assess the physical activity of adults (16 to 74 years) and used to determine if any intervention is needed. Asthma control was determined by the validated *Asthma Control Test* (Nathan et al., 2004), which reports values from 5 to 25, with higher scores reflecting greater asthma control. This was emailed to participants taking part in telephone interviews or completed in person by participants attending the focus groups.

A standardised topic guide (*Appendix N*) was used during the interviews and the focus group. The guide was informed by the aim of the study, using questions that explored participants' views about asthma and physical activity, and their perceived barriers and facilitators to physical activity. Questions included: What (if anything) makes it difficult for you to stay physically active? and What could motivate you to become more physically active? Questioning remained flexible to allow for full probing of any relevant issues raised by the participants. With the participants' permission, the interviews and focus group were audio-recorded. All the audio recordings were transcribed verbatim, except the names of participants and references to specific places; these were anonymised to assure confidentiality.

3.3.5. Data Analysis

Thematic Analysis (Braun & Clarke, 2006) was used to analyse the interviews and focus group narratives. Thematic analysis is a method of identifying, analysing, and reporting patterns (themes) in the data set and was chosen as it can be used flexibly across a range of theoretical frameworks and methodologies to generate descriptions of data sets or a detailed account of a particular aspect (Braun and Clarke, 2006). In this study, an inductive, bottom-up approach was used, which allows the data to determine the themes, as appose to a deductive approach which involves coming to the data with some preconceived themes you expect to find, based on theory or existing knowledge (Braun & Clarke, 2006). The initial stage of the analysis started with the familiarisation process. This process involved reading, and re-reading transcripts, highlighting points of interest and significance (Braun, Clarke & Weate, 2016). Focus groups were independently coded. Sections of the transcripts relevant to the research objectives were highlighted and given shorthand labels or 'codes' to describe their content (Braun & Clarke, 2006). Initial themes and sub-themes were then generated by reviewing codes and identifying the similarities and overlaps between them (Braun, Clarke & Weate, 2016). Thematic mapping was used to explore the relationships between codes and themes, and themes and sub-themes. My supervisors and I revised and refined the initial themes and sub-themes by assessing the data associated with each theme. We devised theme names to capture the sense of each theme, and then the final themes were evidenced by data extracted directly from the transcripts (Braun & Clarke, 2006).

3.4. Results

3.4.1. Participant Characteristics

Participants characteristics are presented in *Table 3.1*. Eleven participants (two males and nine females) participated in six individual interviews and one focus group. They were mostly aged 18-44 years (64%), White British (82%), and in full-time employment (45%) or a student (27%). Seven participants reported uncontrolled asthma, and the remaining four had moderately well-controlled asthma. Five participants were considered moderately inactive, with most participants experiencing asthma symptoms only sometimes (42%) or every time during and/or after physical activity (33%).

Table 3.1. *Barriers and Facilitators - Participant Characteristics [n=11]*

Characteristic	N
Gender	
Male	2
Female	9
Age	
18-24	4
25-44	3
45-54	2
55+	2
Employment Status	
Unemployed	1
Part-Time	1
Full-Time	5
Student	3
Retired	1
Ethnicity	
White British	9
White Non-European	2
Length of Time with Asthma (Years)	
1-9	1
10-19	2
20-29	5
30-49	2
50+	1
Asthma Symptoms During/After Physical Activity	
Only Sometimes	4
Most of the Time	3
Every Time	4
Asthma Control Questionnaire	
Uncontrolled (Score Less Than 20)	7
Reasonably Well Controlled (Score 20-24)	4
Physical Activity Index	
Active	1
Moderately Active	3
Moderately Inactive	5
Inactive	2

3.4.2. Themes Identified

We identified four key themes from analysing the data:

- How Perceived Risks of Physical Activity Outweigh Benefits;
- Limited Physical Capabilities to be Active;
- Other Peoples Misconceptions of Asthma; and
- Lack of Practical Support to Become (More) Active

The four key themes identified from the data are described below and presented in *Figure 3.1* and an overview of all themes, sub-themes, and codes along with direct quotes from the transcripts is presented in Table 3.2.

Figure 3.1. *Barriers and Facilitators - Thematic map, with the four main themes (a dotted line indicates a relationship between themes)*

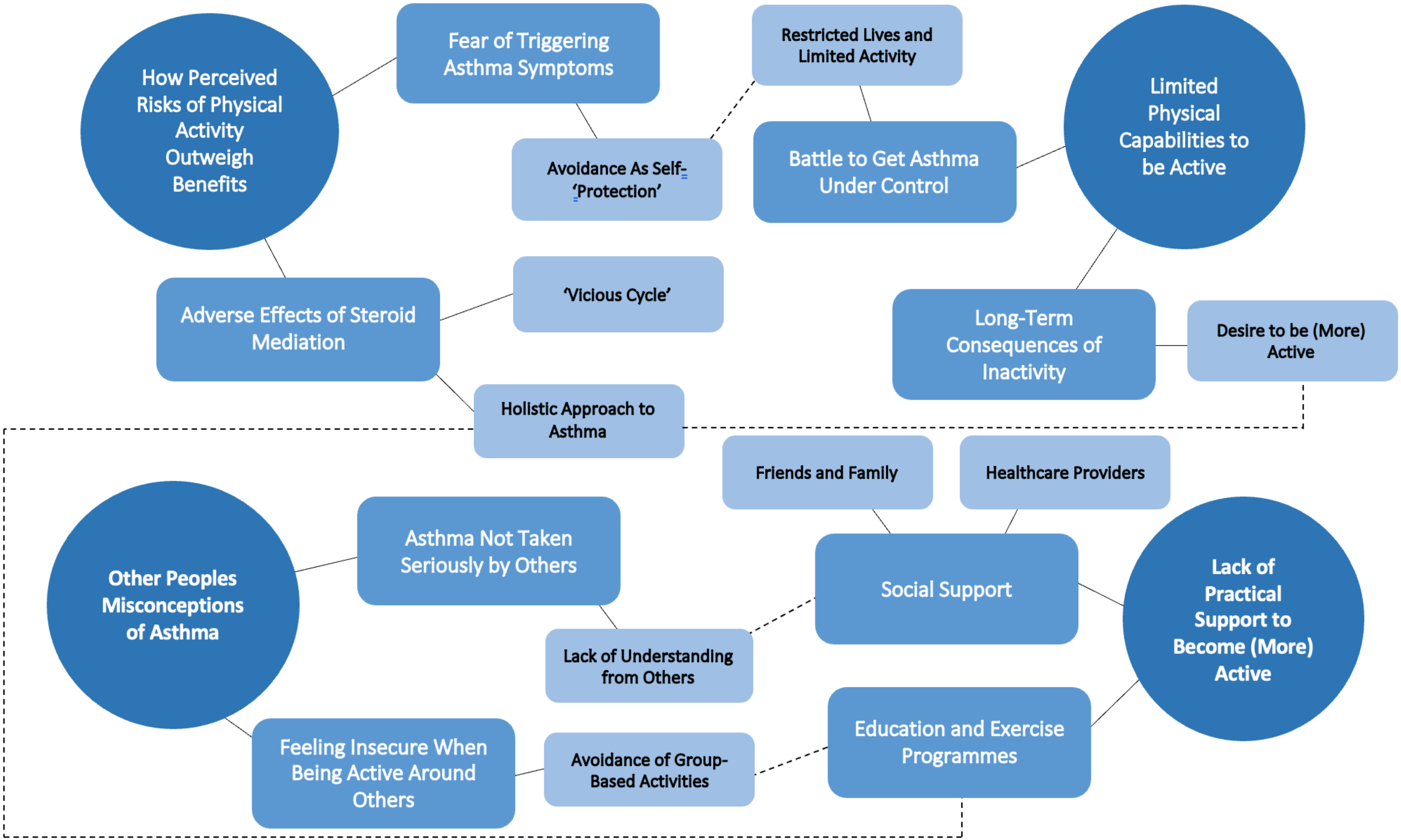


Table 3.2. *Overview of Themes, Sub-Themes and Codes. Evidenced by Quotes Directly from Transcripts*

Theme	Subtheme	Code	Example of Direct Quotes
How Perceived Risks of Physical Activity Outweigh Potential Benefits	Fear of Triggering Asthma Symptoms	Aware of the benefits of physical activity	*"You know I try and exercise because I know it's good for me"* (Participant 5) *"It [physical activity] is hugely beneficial in every other way. I mean just moving your body around and everything erm…well its use it or lose it"* (Participant 6)
		'Catch 22' – Risks vs. Benefits	*"It's that kind-like that 'Catch 22' isn't it? You know you should do it [exercise] because it will help your breathing and that in turn is good, but it's like, it's getting that tricky balance"* (Participant 1)
		Worried about being physically active	*"Just you know exercise to me like I said has always been a bit of a worry"* (Participant 2)
		Asthma symptoms can be easily triggered	*"You know, from carrying a load of shopping back to the car, to you know-to doing anything physical. It always worry's me because I can tip over to having an asthma attack at any time"* (Participant 2) *"Yep, which basically I just didn't have any wheeze. I basically went from being a bit out of breath, to a full-blown asthma attack, with nothing in between sort of thing"* (Participant 2) *"Literally the slightest thing and they [asthma symptoms] are triggered"* (Participant 4)
		Previous bad experiences of physical activity	*"Obviously you start secondary school and people go "Oh you've got asthma, you'll be fine". So, I was pushed to do PE one lesson and I said, "I don't want to do it, I don't feel very well" and I actually ended up in hospital having a major asthma attack after that"* (Participant 4)

		Difficult to find a balance	*"…it's getting that tricky balance"* (Participant 1) *"So…you know it-it's-it's a difficult one because you now, I know I should be doing more, but it's that balancing act"* (Participant 2) *"It-it makes me feel regretful that I don't do more than I do, but I've also got to earn a living"* (Participant 6)
		Avoidance as *'Self-Protection'*	*"So yeah, I think-I think, again I think having the disease for as long as I've had it does make you quite self-protective and that's one of the reasons, I don't like doing some things"* (Participant 6)
	The Adverse Effects of Steroid Medication	'Vicious Cycle' - Weight gain and inactivity	*"Yeah, cos I know like-I do know that I'm stuck in a cycle of, sort of deconditioning as well, causing as much of the problem as the asthma. But yeah, it's very difficult to know where to start to break the cycle"* (Participant 3) *"But with an asthmatic you're like "Oh we'll give you some steroids, then you'll weight gain, and you won't be able to exercise because it triggers your asthma" and then you get more steroids, and your like "What do I do?""* (Participant 4) *"Yeah. It is, it is horrid to be in that vicious cycle because you feel like there's no way out. You cannot get out of that cycle"* (Participant 7) *"It's a bit like I got stuck in that loop, do exercise it will help your asthma. I'd walk 500 meters to uni, get blue-lighted off to A&E-resus. Be put on steroids, which then make you weight-gain weight, and they go "You've gained weight. Go do some exercise""* (Participant 9)
		Pre-empting the worst	*"Yeah, I don't want to trigger something. So, you know, you know, there is always that in the back of me [my] mind"* (Participant 2)
		Negative effects of prescribed steroid medication	*"Erm I was on a lot of steroids, erm…oral steroids, pred [prednisolone] and erm as you could imagine sitting in bed for a month on steroids"* (Participant 2) *"But with an asthmatic you're like "Oh we'll give you some steroids, then you'll weight gain, and you won't be able to exercise because it triggers your asthma" and then you get more steroids, and your like "What do I do?""* (Participant 4) *"Erm…that is-that is absolutely right. Erm and the other physical benefits, because for a long time, you know for a long time I was on a diet of oral steroids, antibiotics, and all of that and has terrible effect on your health"* (Participant 6)

		Hospital admissions allowing an attack	*"You know being bed ridden and erm you know, not so much bed ridden but bed bound for much of the time. They should have had me up and doing stuff"* (Participant 2)
		Concerns about weight gain	*"Yeah, cos obviously I'm on steroids and all sorts as well. So, I do keep a close eye on my weight"* (Participant 4)
		No consideration of the side effects when prescribing medication	*"All we're told is breathing is better than the other side effects, but no. Because yeah obviously breathing is more important…"* (Participant 4)
		Main focus is medication	*"All they were bothered about was pill popping. You know, they just wanted me to take tablets"* (Participant 2) *"…the GPs just throw blue inhalers out like sherbet buttons…"* (Participant 4)
		Need for a more holistic approach to asthma management	*"As we know now there are different kinds of asthma and so many different treatments that the one size fits all doesn't really work"* (Participant 6) *"Erm…but you know, just drugs is not enough. It's a very bad-a very bad approach to managing disease, I think"* (Participant 6)
Limited Physical Capabilities to be Active	Battle to Stay in Control of Their Asthma	Asthma controlling their lives	*"You shouldn't let asthma control you, but it-it does control your life because the slightest thing and then the lungs are irritated, you can't breathe and what do you do when you can't breathe? So yeah, it very much impacts on your daily life and what you can do and not to push yourself and plan things, so you aren't doing too much, because even that making you tired…"* (Participant 4)
		Knowing your personal limits when it comes to physical activity	*"Cos, if like, doing more like, everyday normal things trigger your asthma, then you're not going to push yourself to do something more physical"* (Participant 1) *"So, it's just not pushing yourself, and knowing how much you can do…"* (Participant 4)
		Managing Expectations when it comes to physical activity	*"I think it's more about worrying about the embarrassment, or sort of like the disappointment in myself if I can't do as much as I want to"* (Participant 3)

		Good and bad days with asthma symptoms	*"So, but other times I can go up and I'm fine. You know, there isn't a one erm…reason for it. You know, it's just some days I'm better than others"* (Participant 2) *"…and you know if you are an asthmatic, you're not going to be able to you know do exactly what you want all of the time"* (Participant 6)
		Physical activity cannot always be a priority	*"You might like, prioritise something else instead of the exercising"* (Participant 1) *"It depends on, I guess the thing that influences it a lot more Is like you know that you've got something big to do the next day…"* (Participant 1)
	Long-Term Consequences of Inactivity	Loss of physical fitness overtime	"Because you know, regardless of what you say about my asthma symptoms, I don't have the physical fitness at the moment to do that" *(Participant 2)* "Erm…and less able to manage the-you know, the physical exertion, I suppose on that basis" *(Participant 2)*
		Not currently capable of being physically active	"Yeah. Yeah, because I know what my current level is and it's not good. Erm…er you know it's-it doesn't take much for me erm…I-I can do I can walk for an hour, but I'll probably need my inhaler three or four times in that hour" *(Participant 2)*
		Concerned about the negative consequences of inactive	"Erm…yeah, you don't want to be too inactive do you really?" *(Participant One)* "Yeah…cos obviously-cos there is then like other health things that can (.) affect you later on if you are like less active now" *(Participant 1)*
		Not getting any better	"I've got severe asthma, and I've got to manage it on that basis. So erm…so you know, I realise that I've got a potential life limiting condition and erm…I've got-I've got something that's gonna, that's not going to get any better" *(Participant 2)*
Misconceptions of Being Active with Asthma	Asthma Not Taken Seriously by Others	Lack of understanding from others	"I find society doesn't understand that its different if you've got asthma because it's just asthma" (Participant 9)
		'Hidden Disabilities' - Feeling judged by others	"*Well, it's quite a difficult one, because obviously I was on the mobility scooter and someone just said, "You're too young to be on that, why are you on that?". Luckily my sister was with me, and they did step back a bit, but is just like there's hidden disabilities aren't there?"* (Participant 4)

			"This was like when I was about 20, and everyone was walking past looking at me like I was some really unfit fatso. It's just because I can't breathe" (Participant 9)
		Need to educate non-asthmatics about asthma	*"So yeah, it's just educating, education about asthma"* (Participant 4)
	Feeling Insecure When Being Active Around Others	Embarrassment about experiencing symptoms in public	*"Yeah, and erm some of it is [experiencing asthma symptoms] embarrassment"* (Participant 3)
		Embarrassment About Taking Medication in Public	*"I find using my, you know my inhaler or sort of when I start coughing or wheezing quite loudly, I find that quite embarrassing as well"* (Participant 3)
		Received negative comments	*"Erm…I would-I had a mobility scooter, but I wouldn't go out cos I did have a few negative comments"* (Participant 4) *"Not all of it. Not all of it, but you know it does get to you sometimes. Being overweight gets to me, cos I can hear people in my mind, my dad especially although he didn't do it this time, last time he was here he was like, "You're too fat" you know"* (Participant 5)
		'Unfit' - Worried about what others think	*"You wouldn't be running with loads of normal people, and they wouldn't understand, because the thing with asthma as well if you did some running and got out of breath people just think "Oh you're unfit", but obviously it's not. It's a bit further with asthma"* (Participant 4)
		Avoidance of group-based activities with non-asthmatics	*"Like, forget this. So, erm…that's the sort of thing I'll avoid-mainly you know erm class-based stuff"* (Participant 5) *"So, but I do try and have my blue inhaler on me just in case, but I still felt kind of bad coming and going back in"* (Participant 10)
Lack of Practical Support to Become (More) Active	**Social Support**	*'Big Gap'* that needs to be addressed	"For the asthma community. It's a big gap" *(Participant Six)*
		Support from family and friends	*"I think I do. I think I do. I mean my husband and my close friends are very supportive of this"* (Participant 5)
		Isolating condition	*"I-I think asthma is quite an isolating illness"* (Participant 6)

		Alone in managing their asthma	*"It's you're not alone, if that makes sense? I know no one's alone, but you do feel it sometimes" (Participant 4)*
		No one to talk to about their asthma and increasing their physical activity	*"Erm I'm under-er 'Steps to Change' but that's only CBT. But yeah, no one to talk to"* (Participant 4)
		No support/guidance from healthcare providers	*"I find when I'm sort of told to try and exercise more that's just sort of all I'm told. There isn't really any guidance…"* (Participant 3) *"So, no they didn't really [support me]-they just said, "Oh you need to do this [physical activity]""* (Participant 4)
		Physical activity is not A priority	*"That side of things never really gets the time, and sometimes you know, I've had sort of occasions where I've booked an appointment with the aim of talking about stuff like physical activity, but then no, I've had an asthma flare-up and that takes over"* (Participant 3)
		Too focused on medication	*"All they were bothered about was pill popping. You know, they just wanted me to take tablets"* (Participant 2) *"…the GPs just throw blue inhalers out like sherbet buttons…"* (Participant 4) *"All we're told is breathing is better than the other side effects, but no. Because yeah obviously breathing is more important, but…"* (Participant 4) *"Erm but you know, just drugs is not enough. It's a very bad-a very bad approach to managing disease, I think"* (Participant 6) *"Erm, you know which is like carpet bombing isn't it? Erm, it destroys-it kind of destroys pretty much anything"* (Participant 6)
		Not enough time to discuss physical activity	*"Because for all the reasons that we understand, GPs are very busy. Their very over worked, they have very little time to give individual patients, and the idea of a GP coming up with a whole person plan for asthma is very difficult, but that's where it needs to happen"* (Participant 6) *"But as I said, in fairness to the doctors, the system is they got 10 minutes to diagnosis you, to treat you, in that 10 minutes. God, forbid you go over. They haven't got the time, to take time and say, "I'm seeing this patient now let me have a glance through medical history just in case""* (Participant 7)

		No information given about physical activity	*"When I came out of hospital, I didn't even get any leaflets about doing activity, and I had a three-months wait to see. From coming out of hospital-from somebody who has been in hospital for a month, erm to go under a GP, erm the, erm GP, and when I went to see the GP 2-days after I come out of a hospital"* (Participant 2)
		Physical activity not discussed	*"You know, there was no breathing techniques discussed, no physio, there no physical activity. His one focus was those two little things I my chest"* (Participant 2)
		Need for gentle encouragement and positive reinforcement	*"But to try and gently encourage people to do it, rather than…you're sort of being told off for being-not doing as much as they think you should"* (Participant 3)
		Should not feel pressured into being physically active	*"Yeah definitely, and obviously if you are feeling poorly you are going to be reluctant to do anything and you shouldn't be punished for it, because it's not your fault"* (Participant 4) *"No, no I don't like being told what to do"* (Participant 6) *"You know "Get up you lazy bastard and go for a walk" that kind of thing, people don't like that"* (Participant 6)
	Exercise and Education Programmes	Need for physical activity programmes/resources specifically for asthma	*"Erm, I don't think so. Not specifically for asthma"* (Participant 3) *"Nope. This is like what we were saying, there is no support groups for asthma. There obviously is for diabetes and everything, but there is nothing for asthma. As such, in my area"* (Participant 4) *"Yeah, because we all feel the same. You wouldn't be running with loads of normal people, and they wouldn't understand…"* (Participant 4) *"A support group yeah, but also an exercise group where we can say, "Okay, we are all young fit and healthy in here, we are going to do arm palates. Let's just forget the fact that this is aimed at 90-year olds, we are going to do it as a group"" (Participant 9)*
		Difficulties keeping up with general exercise classes	*"Again, I can't keep up with the class. I can't see what the teachers doing. A friend and I went to an aerobics class once, and she had-she spent more time showing me what to do, then she did doing the exercises"* (Participant 5)

		Unsure what to do or where to start	*"At that level of asthma, there isn't any advice about exercise. It is "Get stable. When you're controlled, you can exercise", but they tell uncontrolled asthmatics that they can exercise. But you can't exercise until you're controlled (.) and you end up sort of going for it and end up in hospital, or don't go for it and be told off for not doing it"* (Participant 9)
		Long wait times for referrals	*"Cos like it took me quite a while to be referred to a specialist when I was having trouble"* (Participant 1) *"I-I-It took an incredibly long time [to be referred]"* (Participant 6)

3.4.2.1. Theme One: How Perceived Risks of Physical Activity Outweigh Benefits

Although participants were aware of the physical and psychological benefits of regular physical activity, they thought that the benefits did not outweigh the potential risks to their asthma.

3.4.2.1.1. Fear of Triggering Asthma Symptoms

Participants participated in limited or no structured physical activity for fear of triggering their asthma symptoms. The unpredictability of their illness made it difficult for them to find a balance between being active and triggering asthma symptoms.

> *"It's kinda like that 'Catch 22' isn't it? You know you should do it [exercise] because it will help, it will help your breathing and that in turn is good, but it's like, it's getting that tricky balance"* (Participant 1 – Female, 25-45, Moderately Inactive with Uncontrolled Asthma)

Participants were worried about being physically active and the thought of triggering their asthma symptoms frightened them. This was particularly relevant to participants who had previous bad experiences when trying to be physically active, usually during their school years. As they knew how easily their symptoms could be triggered, they regarded the avoidance of physical activity as *'self-protective'*.

> *"I think having the disease for as long as I've had it does make you quite self-protective and that's one of the reasons, I don't like doing some things"* (Participant 6 – Male, 55+, Moderately Inactive with Uncontrolled Asthma)

3.4.2.1.2. The Adverse Effects of Steroid Medication

Participants protected themselves from being stuck in what they described as the *'vicious cycle'*. They were always pre-empting the worst, and if asthma symptoms were triggered, there was a chance that they could be admitted to hospital and be prescribed steroid medication. Concerns regarding the adverse effects of steroid use were frequently reported, particularly weight gain. Additional weight gain would make it more challenging for participants to remain active, losing any progress they had made and needing to start the cycle again.

> *"It's a bit like I got stuck in that loop, do exercise it will help your asthma. I'd walk 500 meters to uni, get blue-lighted off to A&E-resus. Be put on steroids, which then make you weight-gain weight, and they go 'You've gained weight. Go do some exercise'"* (Participant 9 – Female, 25-45, Active with Uncontrolled Asthma)

> *"It is horrid to be in that vicious cycle because you feel like there's no way out. You cannot get out of that cycle"* (Participant 7 – Female, 46-55, Inactive with Reasonably Well Controlled Asthma)

Participants regarded medication as a fundamental aspect of asthma management, but they expressed that healthcare providers focus too heavily on pharmacological therapies without considering the side effects. Many participants wanted a more holistic approach to asthma management, providing support that looked at the whole person, focusing on patients' wellness and not just their condition. They agreed that management plans should be tailored to the individual, as no two patients are the same, incorporating lifestyle changes such as diet and physical activity. Having a choice was important for participants; they wanted to play an active role in their asthma management, make decisions and have input into their treatment options.

> *"As we know now there are different kinds of asthma and so many different treatments that the one size fits all doesn't really work"* (Participant 6 – Male, 55+, Moderately Inactive with Uncontrolled Asthma)

3.4.2.2. Theme Two: Limited Physical Capabilities to be Active

3.4.2.2.1. Battle to Get Asthma Under Control

Participants described being in a constant battle to get their asthma under control, but instead, asthma controlled them. They would have *'good and bad'* symptom days, but they could never anticipate how they were going to feel from one day to the next. Participants mentioned that their condition restricted their lives, and this had an effect on how active they could be.

> *"You shouldn't let asthma control you, but It does control your life because the slightest thing and then your lungs are irritated, you can't breathe and what do you do when you can't breathe? So yeah, it's very much impacts on your daily life and what you can do and not do"* (Participant 4 – Female, 18-24, Moderately Inactive with Uncontrolled Asthma)

Participants had to come to terms with not always being able to do what they wanted. They had to learn about their own personal limitations and manage their own expectations to avoid disappointment when they were unable to do as much as they would have liked.

> *"I think it's more about worrying about the embarrassment, or sort of like the disappointment in myself if I can't do as much as I want to"* (Participant 3 – Female 18-24, Moderately Inactive with Uncontrolled Asthma)

This meant that physical activity could not always be a priority, especially when they had other daily living activities such as cleaning or shopping to do, as this alone would leave some participants feeling breathless and fatigued.

> *"It depends on what else is going on. Erm, but yeah, not really a fear, but more what else is going on in your life. You might like, prioritise something else instead of the exercising"* (Participant 1 - Female, 25-45, Moderately Inactive with Uncontrolled Asthma)

3.4.2.2.2. Long-Term Consequences of Inactivity

As their condition worsened, participants mentioned becoming less physically active and discussed their concerns regarding the long-term effects of inactivity, and they worried about the additional health problems that inactivity could cause.

> *"Yeah…cos obviously-cos there is then like other health things that can affect you later on if you are like less active now"* (Participant 1 - Female, 25-45, Moderately Inactive with Uncontrolled Asthma)

Participants expressed the desire to be more active to avoid these effects but believed they could only do this once they had gained control over their asthma. Participants had been forced to accept their illness to be able to live with it, but in the process, some participants had accepted that they would never get any better and thus could not be as active as they would have liked.

> *"I've got severe asthma, and I've got to manage it on that basis. So erm…so you know, I realise that I've got a potential life limiting condition and erm…I've got-I've got something that's gonna, that's not going to get any better"* (Participant 2 – Male, 46-55, Inactive with Uncontrolled Asthma)

3.4.2.3. Theme Three: Other Peoples Misconceptions of Asthma

3.4.2.3.1. Asthma Not Taken Seriously by Others

Participants thought they were the only ones who could understand what it was like to live with asthma and the difficulties they faced when trying to be physically active. Described as a *'hidden disease'* by participants, they did not think that other people could relate to symptoms such as extreme breathlessness. They expressed that asthma was not taken seriously by people without asthma and was seen by others as something that could easily be managed using conventional pharmacological therapies instead of a life-threatening illness. Therefore, asthma should not affect their ability to be physically active. Participants believed that this lack of understanding was due to the absence of media attention asthma received compared to other illnesses and that other people needed to be educated about how life-threatening asthma can be.

"I find society doesn't understand that it's different [being physical activity] if you've got asthma because it's just asthma. They say, 'it's only asthma, it's not like…' – I've actually heard this, 'it's not like you've got cancer'" (Participant 9 – Female, 25-45, Active with Uncontrolled Asthma)

3.4.2.3.2. Feeling Insecure When Being Active Around Others

Many recalled receiving insensitive comments when trying to be active which still affected them to this day. Participants expressed a sense of embarrassment about experiencing asthma symptoms and taking inhalers in public as they worried about what they were thinking.

"I find using my, you know my inhaler or sort of when I start coughing or wheezing quite loudly, I find that quite embarrassing as well" (Participant 3 – Female 18-24, Moderately Inactive with Uncontrolled Asthma)

Consequently, participants felt reluctant to engage in physical activity around others – resulting in many avoiding group-based activities. Those who had experienced weight gain from taking high doses of steroid medication had lower self-esteem, which increased their reluctance to be active around others, as they felt like they were being judged by other people around them.

"You wouldn't be running with loads of normal people, and they wouldn't understand, because the thing with asthma as well if you did some running and got out of breath people just think 'oh you're unfit', but obviously it's not. It's a bit further with asthma" (Participant 4 – Female, 18-24, Moderately Inactive with Uncontrolled Asthma)

3.4.2.4. Theme Four: Lack of Practical Support to Become (More) Active

Participants expressed that there was a *'big gap'* that needed to be addressed, as they wanted more support and resources made available to help people living with asthma become more physically active.

3.4.2.4.1. Social Support

Although family and friends were supportive, participants believed they did not understand the challenges they faced. They felt like they had no one to talk to and were alone in managing their asthma and increasing their physical activity levels, contributing to feelings of frustration and isolation.

> *"I-I think asthma is quite an isolating illness" (*Participant Six – Male, 55+, Moderately Inactive with Uncontrolled Asthma*)*

Instead, participants wanted the support of their healthcare providers. However, they mentioned being let down by their healthcare providers because even though they had asked for help to be more active, they had not received the help they needed.

> *"I find when I'm sort of told to try and exercise more that's just sort of all I'm told. There isn't really any guidance…"* (Participant Three 3 – Female 18-24, Moderately Inactive with Uncontrolled Asthma)

They had tried to discuss physical activity with their healthcare providers, but it could not always be a priority if something more immediate needed their attention. They acknowledge that healthcare providers were busy, but they believed that there was never enough time to address all their concerns, including physical activity. When it was discussed, participants felt they were being 'punished' rather than given the positive reinforcement and gentle encouragement they needed.

> *"But to try and gently encourage people to do it rather than…you're sort of being told off for being-not doing as much as they think you should"* (Participant Three 3 – Female 18-24, Moderately Inactive with Uncontrolled Asthma)

3.4.2.4.2. Exercise and Education Programmes

With a lack of resources available, participants faced long waiting times for places to become available on pulmonary rehabilitation programmes to help them increase their physical activity. In the meantime, they felt unsure what of to do or where to start when it came to increasing their physical activity levels.

> *"At that level of asthma, there isn't any advice about exercise. It is "Get stable. When you're controlled, you can exercise", but they tell uncontrolled asthmatics that they can exercise. But you can't exercise until you're controlled, and you end up sort of going for it and end up in hospital, or don't go for it and be told off for not doing it"* (Participant 9 – 25-45, Active with Uncontrolled Asthma)

Participants wanted physical activity to be more social and believed they could be best supported by other people diagnosed with asthma and would like the opportunity to attend group-based sessions with them. This would give them the reassurance they needed that they were not alone in their struggles with physical activity and could be active without fear of being judged. They also believed that there would be a shared understanding of what it was like to have asthma and the adaptations they had to make when engaging in physical activity.

> *"A support group yeah, but also an exercise group where we can say, 'Okay we are all young fit and healthy here, we are going to do arm Pilates. Let's just forget the fact that this is aimed at 90-year-olds, were going to do this as a group'"* (Participant 9 – 25-45, Active with Uncontrolled Asthma)

3.5. Discussion

Using interviews and a focus group with people diagnosed with asthma, I explored the perceived barriers and facilitators to physical activity and identified four key themes: *'How Perceived Risks of Physical Activity Outweigh Benefits'*; *'Limited Physical Capabilities to be Active'*; *'Other Peoples Misconceptions of Asthma'*; and *'Lack of Practical Support to Become (More) Active'*. Participants acknowledged the importance of physical activity and knew the benefits, but many limited or did not participate in structured physical activity because of their asthma. Evidence suggests that adults with severe asthma are more likely to believe that physical activity worsens asthma and face additional barriers to participation (Freeman et al., 2020). Findings from this study support this, with participants identifying more illness-related barriers to physical activity than facilitators. Barriers identified included beliefs about the negative consequences of physical activity to asthma, beliefs about limited physical capabilities to be active, reluctance to engage in physical activity around others and embarrassment about experiencing asthma symptoms and taking inhalers in public. Good social support, particularly from healthcare providers and other people with asthma, and the desire to be healthy were identified as facilitators of physical activity.

Contradictory to the findings by Nyenhuis et al. (2019), participants in this study were aware of the physical and psychological benefits of physical activity. However, for most participants, these benefits did not outweigh the potential risks to their asthma, and they worried about triggering their asthma symptoms. These findings are in line with the *Necessity-Concerns Framework* which states that patients weigh the cost against the benefits of treatment when deciding whether or not to adhere to the treatment (Phillips et al., 2014). Adherence is influenced by judgements of a personal need for the treatment and concerns about the potential negative consequences of taking the treatment (Horne et al., 2013). Although the framework is normally used to understand medical adherence it has been used to understand physical activity, and findings support the application of the framework to physical activity in long-term health conditions (Kayes et al., 2014). Necessity beliefs and Concerns may trigger intentional nonadherence, for example, if patients decide against the treatment due to concerns regarding potential or actual adverse consequences (Horne et al., 2013). Fear and anxiety about triggering symptoms have previously been reported as major barriers (Clarke & Mansur, 2015), leading to intuitive and pre-emptive avoidance of physical activity (Panagiotou, Knulouris & Rovina, 2020). This was the case in our sample, with participants seeing the act of avoiding physical activity as self-protective. The challenge is to address doubts about the necessity of physical activity and concerns about the potential negative consequences of being active to enhance adherence.

In addition, Rottman and colleagues' (2017) *Value-Expectancy Cognitive Framework* assumes that a patient's belief, based on their own experiences, may in turn lead to cyclic patterns of nonadherence. For participants in this study, having previous bad experiences of physical activity made it more likely that they would have a negative view of physical activity, and fear triggering their asthma symptoms when being active. The framework proposes reconceptualising these common themes of treatment being effective, necessary and tolerable, as a kind of *'causal learning'* and that patients learn whether a treatment is effective, necessary, and tolerable, from their own experiences with the treatments, or in the case of this study, physical activity. Conceptualising non-adherence as a causal learning process can more effectively address a patient's misconceptions and biases, helping patients to develop a more accurate impression of the treatment (Rottman et al., 2017).

Lack of knowledge of preventing and managing symptoms could be an underlying factor in this conceptualisation. In terms of intervention development, providing information on how to exercise safely with asthma could help reduce anxiety around triggering asthma symptoms. Healthcare providers could play a crucial role in providing this information to patients, as our participants identified receiving practical support from healthcare providers as a facilitator to physical activity. Evidence suggests that healthcare providers can positively impact patient behaviour by routinely assessing physical activity levels and by using brief practical interventions (advice or counselling on how to initiate and maintain healthy behaviours) (Jelley & Lake, 2013). Encouraging patients to self-monitor their asthma (e.g., peak flow, medication usage, and symptoms) could also help reduce anxiety about physical activity. Seeing the benefits of regular physical activity on these asthma outcomes could help reduce negative feelings towards physical activity and encourage people to continue making positive behaviour changes.

The Self-Determination theory (Ryan & Deci, 2017) is commonly used to help explain motivation in physical activity. The theory comprises of three basic needs considered to influence an individual's intrinsic motivation to carry out a behaviour; autonomy (a desire to be in control of one's own destiny), relatedness (a desire to connect or interact with others) and competency (a desire to be able to achieve a goal). It was evident that participants in this study had the desire to be more physically active. However, concurrent with previous findings (Nyenhuis et al., 2019; Mancuso et al., 2006), they believed that asthma restricted them physically from undertaking physical activity, and so they were not capable of becoming more active, which in turn could have a negative effect on their motivation to increase their physical activity. Not feeling sufficiently competent to be physically active, feeling either not physically fit enough or skilled enough to exercise, or having limitations that present as a barrier to activity, can lead to a lack of motivation to be physically active (Ryan & Deci, 2017). Interventions for this patient group must target self-efficacy (one's beliefs about their abilities to perform a behaviour successfully) and increase their confidence in being physically active. Increasing self-efficacy has been shown to increase the likelihood that an individual will initiate and maintain regular physical activity (Pekmezi et al., 2009)

A unique barrier to physical activity identified in this study was reluctance to engage in physical activity around others and embarrassment about experiencing asthma symptoms and taking inhalers in public, which stemmed from other people's misunderstandings about being active with asthma. The stigma attached to having asthma is potentially an important barrier to effective self-management strategies (Ahmad & Ismail, 2015); in this study, it increased participants' reluctance to be active around others. In a study by De Simoni et al. (2016), adolescents reported feeling embarrassed about their asthma diagnosis and using their inhalers. Some participants thought people around them would negatively react to their condition, leading to mocking and social exclusion. Findings from this study would suggest that stigma is also a problem among adults diagnosed with asthma. Being active around other people diagnosed with asthma could overcome these negative feelings as there would be a shared understanding of what it is like to have asthma and the adaptations that must be made to be active. In addition, it would provide social support, a well-established facilitator to physical activity in this population group (Nyenhuis et al., 2019; Mancuso et al., 2006). Incorporating social support in future interventions ensures that participants are supported and could help them cope with setbacks following a flare-up.

Access to resources such as pulmonary rehabilitation is limited, and participants have faced long waiting times for places to become available to help them become more active. With insufficient facilities and funding available to deliver pulmonary rehabilitation programmes to patients, alternative interventions need to be considered to increase the number of patients who can access the help and support they need. This is more important now than ever in light of the COVID-19 pandemic and the significant suspension of face-to-face support (Association of Chartered Physiotherapists in Respiratory Care, 2020). Moreover, looking into the future, we are already thinking differently about how services will be delivered to patients.

3.5.1. Strengths and Limitations

To my knowledge, this is the first study in the UK to use interviews and a focus group to explore the barriers and facilitators to physical activity among adults diagnosed predominately with severe asthma. This study provides detailed insight into the barriers and facilitators of physical activity to inform the development of future interventions to promote physical activity in this patient group. However, this study has several limitations that should be noted. The sample consisted of predominantly White British females, offering a limited understanding of more diverse population groups. However, among adults, women have an increased prevalence of asthma compared to men (Fuseini & Newcomb, 2017), which might explain why the sample is comprised primarily of women.

In addition, it is important to consider the potential influences of self-selection bias due to the voluntary nature of the study. Participants registered their interest in taking part, and a subsection of the participants were research and policy volunteers from Asthma UK. Therefore, the participants in this study could arguably be more engaged with reflections on their asthma. Lastly, using the telephone for qualitative interviews has generally been considered an inferior alternative to face-to-face interviews (Novick, 2008). Some of the most commonly reported concerns about telephone interviews include challenges in establishing rapport with participants, the inability to respond to visual cues and the potential loss of contextual data (Novick, 2008). However, as I was only able to conduct one focus group due to limited recruitment in the Norfolk area (East of England), having the option to conduct telephone interviews allowed me to recruit participants all over the UK.

3.5.2. Reflexivity and Personal Reflection

Although I had previous experience conducting qualitative research before this project, I had only conducted focus groups. Conducting the interviews as part of this study was very different and was a learning experience. Even though I felt prepared for my first interview and had my topic guide in hand, I ended the interview feeling disappointed. I felt as though I rushed through the questions, the interview only lasted approximately thirty-five minutes, and because of this, I was left feeling that I did not fully engage with the participant. After the interview, I did some personal reflection and made some notes on how I could improve for the next interview. For example, I felt that I did not build up enough of a rapport with the participant. I did not want to just come across as a researcher collecting data for a study when I had personal reasons for wanting to do this project and I believed if I shared this with them, they would be more open to discussing their personal experiences with me. I also felt that I strictly followed the topic guide, even though it was supposed to be a semi-structured interview. The questions I asked came from the topic guide and I did not prompt the participant to give more detail about certain points of interest.

Learning from my first interview, I went into my second interview knowing what I wanted to change and how I was going to improve. I took the time to build a rapport with the participant before any questions were asked. We built a mutual understanding of why I personally wanted to conduct the research and why they wanted to participate in the study. The participant shared a more personal reflection of their experience with asthma and the difficulties they face when trying to be physically active. I listened more to the participants' answers to the questions and prompted them to go into more detail about anything of interest. This interview lasted over one hour, and I knew when it finished that I had got some really useful data for the study. Not only that, but I felt more confident moving forward with future interviews. I carried on making notes after each interview on improvements I could make and of interesting points that had been discussed in the previous interview to cover in the next one. The more interviews I conducted the more I improved as a qualitative researcher and the better data I collected from my participants.

As I had conducted focus groups before I was not as apprehensive about conducting the one in this study, but it was a challenge to recruit participants for the focus group and arrange it. Firstly, the recruitment methods I used made it difficult for me to recruit participants in the Norfolk area, and on reflection, I should have done more recruitment locally. Lack of recruitment in the area meant that I was only able to conduct one focus group, and it took a while to be able to recruit enough participants for that one focus group. When it came to organising and arranging the focus group, it was difficult to find a date and time that suited all participants who wanted to take part. It was important for me that all the participants could attend so that I had enough participants to conduct the focus group. All my interviews had been conducted over the telephone, so I did not have to book rooms and make arrangements for participants to attend the university. For the focus group, I had to book a room and email participants instructions on how to get to the university along with a map of where the focus group was going to be held. It took a lot of planning and organising which is something I had never done before. My previous experience helped me when conducting the focus group and I felt that I had to do very little to moderate the group. Participants discussed questions amongst themselves and did not just answer me and my questions. I felt satisfied after the focus groups, and having the participants thank me for bringing them together with other local people in the area and making them feel heard, only further justified my reasoning for why this project was so important.

3.6. Conclusion

This study shows that participants with asthma know the importance of physical activity but limit or do not participate in structured physical activity because of their asthma. Concurrent with previous findings, beliefs about consequences and limited physical capabilities were identified as barriers, whereas social support, particularly from healthcare providers and other people diagnosed with asthma, and the desire to be healthy were identified as facilitators. Adding to the evidence base, participants were reluctant to engage in physical activity around people who do not have asthma because of their lack of understanding of the disease. They felt embarrassed when experiencing symptoms and when using their inhalers in public, and those who had experienced weight gain had lower self-esteem, which increased their reluctance to be active around others.

Based on these findings, future interventions developed to promote physical activity in adults diagnosed with asthma should aim to address the necessity of physical activity and any concerns regarding being physically active and increase self-efficacy and confidence. Adults diagnosed with asthma need to be educated on preventing and managing asthma symptoms and how to be active safely with asthma, so they can feel more motivated to increase their physical activity levels. Lastly, it is important to make sure that they have practical social support to ensure that they are supported in making changes and are able to cope with any setbacks as a result of their asthma.

The next step in the intervention development process was to identify user preferences for the content and features of the proposed smartphone app. Initial ideas for the intervention were developed based on the findings from *Chapter 2: Review of Existing Interventions* and this chapter. Focus groups were conducted with the target end-users of the smartphone app to share my initial ideas with them. Results from these focus groups are presented in *Chapter 4: User Preferences.*

Chapter 4: User Preferences for an mHealth Intervention to Promote Physical Activity Among Adults Living with Asthma

Chapter 2: Review of Existing Interventions* highlighted the effectiveness of physical activity interventions on the behavioural and health outcomes of adults diagnosed with asthma, but interventions would not have overcome the previously reported patient barriers to attending traditional medical interventions, such as travelling to attend sessions and not being suitable for those with comorbidities (Tyson et al., 2021a). *Chapter 3: Barriers and Facilitators* identified the perceived barriers and facilitators to physical activity among adults diagnosed with asthma. Beliefs about consequences and limited physical capabilities were identified as barriers, whereas social support, particularly from healthcare providers and other people diagnosed with asthma, and the desire to be healthy were identified as facilitators. This chapter describes how I shared my initial ideas for the intervention, based on the findings from the previous chapters, with the target end-users. This allowed me to understand the end-users' ideas and preferences for the proposed interventions' content and features.

4.1. Background

As reported in *Chapter 1: Introduction*, in the UK, physical activity is traditionally promoted through medically supervised programmes delivered face-to-face within local hospitals and healthcare centres by a dedicated team of healthcare professionals (Spruit, 2013). However, not all patients who could benefit are being referred due to the lack of local capacity, and for those referred, uptake and completion are low in patients with chronic obstructive pulmonary disease (Morgan, 2017). Therefore, there is a growing interest in seeking alternative approaches to promote physical activity in adults diagnosed with asthma to increase the number of patients who can access help and support. The importance of this is further highlighted following the COVID-19 pandemic and the significant suspension of face-to-face support (Association of Chartered Physiotherapists in Respiratory Care, 2020).

A long-term goal of the NHS is to expand the use of technology for healthcare services (NHS, 2019). Using mobile health (mHealth) technology would allow researchers to deliver a range of behaviour change techniques (BCTs), with additional advantages over traditional methods of delivery, including convenience, ease, cost-effectiveness, scalability, personalisation, and the ability to send time-sensitive messages to an 'always on' device (Whittaker et al., 2016). Although there is evidence that mHealth technology can be effective, maintaining engagement can be especially difficult when mHealth interventions are used without human support, typically leading to high drop-out and non-usage attrition (Yardley et al., 2016). User-centred design is integral to improving the uptake of and engagement with mHealth interventions. Gaining an insight into the views of the intended end-users will help tailor the intervention content and features and likely increase effectiveness (Yardley et al., 2016).

4.2. Aims

Firstly, I aimed to share my initial ideas for the proposed intervention, based on the findings from the previous chapters, with adults diagnosed with asthma by conducting focus groups to discuss and identify preferred content and features. Secondly, I aimed to establish the acceptability of an intervention delivered via a smartphone app, examine how to promote initial and sustained engagement with the intervention and gain insight into the integration of the smartphone app into other aspects of asthma management.

4.3. Methods

4.3.1. Design

As this study was conducted during the COVID-19 pandemic when the UK was under national lockdown measures, the recruitment of participants and the focus groups had to be conducted online. Therefore, I carried out a qualitative study, using data collected from online semi—structured focus groups with adults diagnosed with asthma. For the same reasons as explained in *Chapter 3: Barriers and Facilitators*, qualitative methods were used as they generate detailed insight and understanding of why people behave in certain ways and the relationship between their beliefs and behaviours, making them useful when researching relatively unexplored topics in which understanding participants perspectives are critical (Jaye, 2002). Focus groups were conducted to generate discussion amongst participants and encourage group interactions. These interactions would allow participants to discuss content and features that would be important to them and explore them as a group, thus generating new ideas and questions, and highlighting key content and features for inclusion in the intervention. Focus groups were conducted using the video-conferencing application *Zoom* (Zoom Video Communications Inc, Version: 5.0.3).

4.3.2. Ethical Approval

The study was approved by the University of East Anglia Faculty of Medicine and Health Sciences Research Ethics Committee (Reference: 2019/20-100) (Appendix O).

5.3.3. Participant and Recruitment

As the online recruitment in *Chapter 3: Barriers and Facilitators* was successful, I used the same recruitment methods for this study. Participants were recruited through convenience sampling, using advertisements posted in asthma support groups on Facebook (*Appendix P*). The advertisements briefly explained the study to potential participants and requested anyone interested to complete an online eligibility questionnaire. The questionnaire also collected self-reported data on their asthma severity (i.e., mild, moderate, or severe) and physical activity levels (i.e., inactive, moderately active, or extremely active). This was done to ensure there were variations in asthma severity and physical activity levels within the sample.

Potential participants were deemed eligible if they were over 18 years old with a diagnosis of asthma (evidenced by potential participants self-reporting that they were currently prescribed asthma medication) and had access to a smartphone, computer, laptop, or tablet with an internet connection. Anyone unable to speak English, unable or unwilling to provide informed consent, or with a diagnosis of any other respiratory condition was not eligible to participate. Potential participants who met the inclusion criteria were emailed an invite to participate in the study with a link to an online Participant Information Sheet (*Appendix S*). Those still interested were asked to complete an online Consent Form

(*Appendix T*). Consent was verbally reaffirmed at the start of the focus group, which was audio-recorded.

Participants were allocated to different focus groups based on their asthma severity and each group included participants reporting different levels of physical activity. Focus groups were arranged when an adequate number of eligible participants were available. Four focus groups were conducted: two focus groups were conducted with participants with moderate asthma, and two focus groups with participants with severe asthma. Although data was collected from participants with moderate asthma separately from those with severe asthma, the same themes were present across both groups. Therefore, all participants and their narratives were analysed together. Participants were compensated with £20 worth of shopping vouchers for focus group participation.

4.3.4. Data Collection

The semi-structured online focus groups were conducted in May 2020. Participants were asked to complete a brief online questionnaire before the commencement of the focus group. This was the same questionnaire that was used in *Chapter 3: Barriers and Facilitators* and this was used to collect demographic information (e.g., age, gender, ethnicity, and employment status), physical activity levels and to determine the level of asthma control (*Appendix U*).

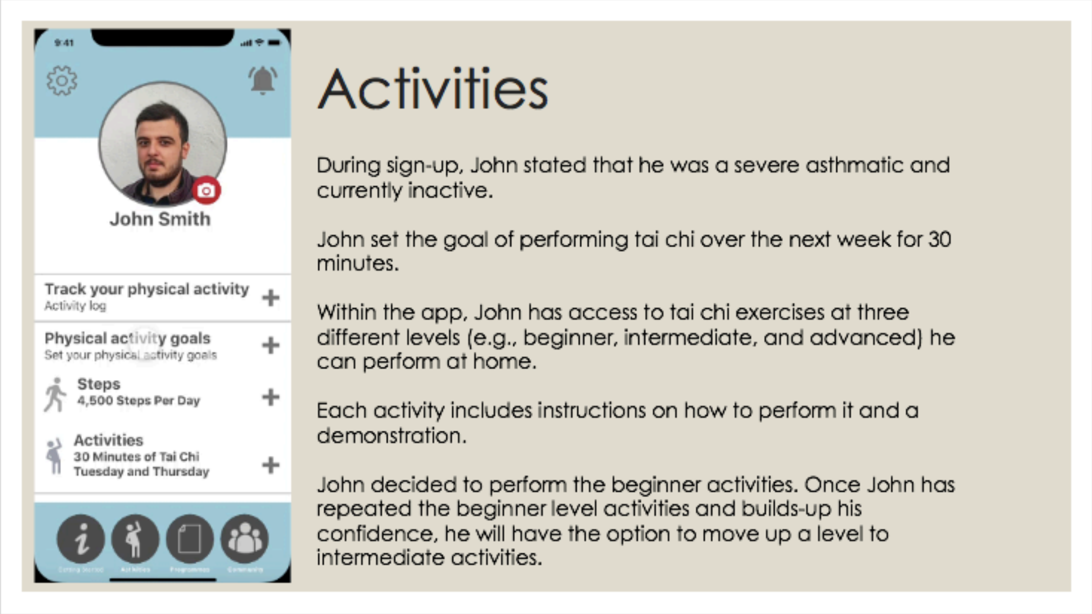
Every effort was made to ensure data security and protection of the focus groups by using the highest levels of security available to ensure that only consenting participants could join. Participants joined the focus groups through the available two-factor authorisation, and following admission via the *'waiting room'*, a virtual staging area that stopped participants from joining automatically, participants were admitted. Once all participants had been admitted, the virtual room was 'locked' to prevent uninvited entry and create a secure environment free from interruption. With the participant’s permission, all focus groups were audio-recorded.

A standardised topic guide (*Appendix T*) was used during the focus groups, informed by the aims of the study. Questions to explore user preferences included: How often do you use smartphone physical activity/health apps? and What features would need to be included if you were to continuously use an app? Questioning remained flexible to allow for a deeper exploration of any relevant ideas the participants raised.

As well as the questions included in the topic guide (Appendix T), short vignettes (Appendix W) were developed based on the findings from *Chapter 2: Review of Existing Interventions* and *Chapter 3: Barriers and Facilitators*. Vignettes are short stories about a hypothetical person, presented to participants during qualitative research to gain information about their own beliefs and attitudes and are commonly used in social sciences (Payton & Gould, 2023). The methodology is well suited to intervention research, establishing a partnership between target populations and researchers to define a problem and potential solutions (Gourlay et al, 2014) and have been used to inform and guide the development of digital interventions (Cruz-Martinez et al., 2022). Vignettes were shared with participants to outline potential key content and features, along with pictures and videos of the proposed smartphone app. To develop the pictures and videos I taught myself how to use *Adobe XD* (*Adobe Inc,* Version: 33.1.12.4), which is a vector design tool for web and mobile applications. This programme allowed me to design a mock-up of the proposed smartphone app and export pictures and videos to be used in the focus groups to show how the app would work from the user's point of view.

For example, in *Chapter 3: Barriers and Facilitators* it was evident that participants had the desire to be more active. However, they did not know where to start when it came to being physically active with asthma. Therefore, a vignette along with pictures and videos were developed to show participants how the app would help users to choose suitable activities with varying levels of difficulty – *'During sign-up, John stated that he was a severe asthmatic and currently inactive. John set the goal of performing tai chi over the next week for 30 minutes. Within the app John has access to tai chi exercises at three different levels (e.g., beginner, intermediate, and advanced) he can perform at home. Each activity includes instructions on how to perform it and a demonstration. John decided to perform the beginner activities. Once John has repeated the beginner level activities and builds-up his confidence, he will have the option to move up a level to intermediate activities"*. Screen sharing was used to show a PowerPoint presentation to participants which contained the vignettes, pictures and videos during the online focus groups and used as stimulus material for the discussion (Figure 4.1.). Focus groups lasted between 76-96 minutes. All audio recordings were transcribed verbatim, except for names of participants and references to specific places; these were anonymised to assure confidentiality.

Figure 4.1. *Example of PowerPoint Slide Shown to Participants During Focus Groups*



4.3.5. Data Analysis

Framework Analysis, based on that developed by Ritchie and Spencer (1994), was used to analyse the transcripts, collected in the online focus groups. This form of analysis is an inherently comparative form of thematic analysis which employs an organised structure of inductive- and deductive-derived themes (i.e., a framework) to organise and analyse qualitative data in a structured and transparent manner (Goldsmith, 2021). Each row of the framework represents a participant, each column represents a theme, and the cells contain summarised data, which provides a structure that enables the researcher to systemically develop and reduce data to analyse by participant and theme (Collaço et al., 2021). The framework allows for greater transparency in the data analysis process and ensures that the context of individual participants' views is not lost (Collaço et al., 2021). It allows the researcher to identify patterns, themes and relationships in the data that are relevant to the research questions and objectives (Hassan, 2022). This analysis process was particularly useful for this study, as it allowed me to see similarities and differences between the participants. I could see individual participants' preferences for the content and features of the smartphone app and compared them as a group. This then helped me to make decisions on the final design of the intervention by being able to see when content and features would be more useful and beneficial for the target end users.

For the analysis process, I followed the five main stages of Framework analysis: During the familiarisation process, transcripts were read and re-read whilst listening to the audio recordings, with key ideas and recurrent themes being noted (Thomas, 2003). Through discussion with my supervisory team, emergent themes from the data and prior themes, based on the study objectives and topic guide questions, were combined to form the first iteration of the coding frame (Srivastava & Thomas, 2009). The main themes and subthemes within the coding frame were labelled using numeric codes. Using these codes, I systematically indexed the first transcript. The coding frame was then refined, additional codes were added, and others were combined to reduce overlap (Srivastava & Thomas, 2009). The coding frame was then applied to all focus group transcripts. Participants' accounts were compared across the themes and sub-themes, and patterns and associations were identified, forming the final concepts.

4.4. Results

4.4.1. Participant Characteristics

Participant characteristics are depicted in *Table 4.1*. Overall, a total of 27 participants (two men and 25 women) took part across four focus groups. The majority of participants were between the ages of 21-29 (33%), white British (93%) and in full-time employment (59%). Fifteen participants (56%) had moderate asthma, and the remaining 12 (44%) had severe asthma, with most participants symptoms being reasonably well controlled (48%) or uncontrolled (48%). Length of time with asthma varied, but the majority of participants had had asthma for 10-29 years (55%). Twelve participants (44%) were considered active, with most participants occasionally (41%) or very frequently (37%) experiencing asthma symptoms during or after physical activity.

Table 4.1. User Preferences - Participant Characteristics [n=27]

Characteristic	*N*
Gender	
Male	2
Female	25
Age	
18-20	3
21-29	9
30-39	6
40-49	6
50+	3
Employment Status	
Unemployed	1
Part-Time	1
Full-Time	16
Self-Employed	1
Voluntary	1
Student	7
Ethnicity	
White British	25
Asian British	1
Mixed Race	1
Asthma Severity	
Moderate	15
Severe	12
Length of Time with Asthma (Years)	
Less Than One	3
1-9	4
10-19	9
20-29	6
30-39	3
40+	2
Asthma Symptoms During/After Physical Activity	
Rarely	2
Occasionally	11
Very Frequently	10
Always	4
Asthma Control Questionnaire	
Not Controlled (Score Less Than 20)	13
Reasonably Well Controlled (Score 20-24)	13
Under Control (Score 25)	1
Physical Activity Index	
Active	12
Moderately Active	3
Moderately Inactive	8
Inactive	4

4.4.2. Concepts and Main Themes Identified

We identified four main themes from the data:

- Use of Existing Physical Activity and Health Apps;
- Preferred Content and Features for a Physical Activity App;
- Integration of Other Aspects of Asthma and Weight Management; and
- Promoting Initial and Sustained Engagement

4.4.2.1. Theme One: Use of Existing Physical Activity and Health Apps

Table 4.2. *Theme One: Use of Existing Physical Activity and Health Apps*

Theme One: *Use of Existing Physical Activity and Health Apps*			
Focus Group Number	Participant Number	1.1. Reasons for Continued Use of Existing Apps	1.2. *Problems with Existing Apps*
Focus Group 1	Participant 1	Daily use of apps. Tracking and monitoring food intake and activity for weight management. Tracking physical activity gives structure. User friendly and reliable. Does what the user want it to do. Gives the user information and feedback.	Unaware of exiting apps that are available specifically for people diagnosed with asthma but interested in them.
	Participant 2	Use of smartwatch. Use of apps to track and monitor peak flow. Use of apps to track and monitor sleep.	*"So, I know that some, and I also know that there are some out there that aren't as great as well"*
	Participant 3	Use of smartphone and smartwatch to track activity. Use of apps specifically for people diagnosed with asthma during a flare-up.	No definite answer which apps are best – Trial and error. Not one app that does everything – More likely to stop using. Other apps are too difficult for people living with asthma.
Focus Group 2	Participant 4	Daily use of apps. Use of smartwatch to track activity, mainly swimming and cycling.	
	Participant 5	Use of smartwatch. Becomes part of daily routine – "*And I actually love it now, I've become quite obsessed with it and yeah, I find it really-is really useful. It's really good"*	
	Participant 6	Daily use of aps to track and monitor activity Wears smartwatch every day.	
	Participant 7	Does exercise but does not necessarily track it. Use of apps to track distance and steps walked.	
	Participant 8	Use of a smartwatch.	

	Participant 9	Use of smartphone to track steps. Becomes part of daily routine – *"It does get a bit of an addiction"*	
	Participant 10	Use of smartphone apps to track distance and steps walked. Proven effective – Helped to increase steps walked daily.	
	Participant 12	Use of a smartwatch.	
Focus Group 3	**Participant 14**		Variability means people with asthma cannot always make use of subscription services. Not one app available that does everything.
	Participant 17	Daily use of apps.	Normally have to pay to access everything. Variability means people with asthma cannot always make use of subscription services. Not one app available that does everything. Always going between apps.
Focus Group 4	**Participant 19**	Use of apps to track and monitor physical activity and diet.	
	Participant 20	Use of '*Couch to 5K*' to help increase activity levels and improve fitness. Proved effective – Apps can help to build-up activity gradually. Apps allow users to do things at their own pace. Can be motivational.	
	Participant 21	Not using apps as much. Use of smartwatch for general health, but only when they remember.	
	Participant 22	Use of apps to track and monitor activity and calorie intake. Only way to get biofeedback (e.g., heart rate and cardiovascular health).	Lack of awareness of apps specifically for people diagnosed with asthma.
	Participant 23	Did wear smartwatch but not anymore.	

	Participant 24	Did wear smartwatch but not anymore. Use of app to track and monitor calories to maintain weight loss.	
	Participant 25	Daily use of apps to track and monitor activity. Wears smartwatch to monitor general fitness.	
	Participant 26	Did wear smartwatch but not anymore. Use of apps to monitor eating habits and fitness, to ensure they are staying active.	
	Participant 27	Did wear smartwatch but not anymore - Forgets to check. Use of apps to track and monitor sleep.	

4.4.2.1.1. Reasons for Continued Use of Existing Apps

Physical activity and health apps were used daily by the majority of participants. Reasons for using apps included tracking and monitoring physical activity, exercise, diet, weight loss, and promoting/supporting sleep. Very few participants used apps to self-manage their asthma; if they did, they were only used for a brief period during a flare-up to track and monitor symptoms and medication usage. Participants said they were more likely to use apps long-term if they could be easily integrated into their daily routines, were user-friendly and reliable, and gave them the information and feedback they needed. Instead of looking at what may be newly available, participants were more likely to continue to use apps that had proven to be effective, such as helping them to become more active or lose weight.

> *"Once I start getting a bit better and I was going to start doing the Couch to Five K and began just so I can build my stamina. So that's one which I've used previously, that I'm probably going to use again because I found that quite helpful because I could do it gradual"* [Participant 20 - Female, 40-49, Moderately Inactive, Moderate Uncontrolled Asthma]

4.4.2.1.2. Problems with Existing Apps

Many participants were unaware of the apps available to help them self-manage their asthma. Those who had used them had found from trial and error that there was not one app that had all features they wanted to help them self-manage their asthma, resulting in them downloading multiple apps and discontinuing use after a while.

> *"I kinda stopped using them [health apps], because it was almost like they didn't do what I wanted all in one"* [Participant 1 – Male, 31-39, Moderately Inactive, Severe Uncontrolled Asthma]

In terms of physical activity apps, due to the variability of their asthma, participants did not want to pay for subscriptions to unlock additional features. They worried that they would not use them or that the physical activity suggestions would be too challenging and not suitable for someone with asthma.

> *"I think one of the downsides of the subscription apps as well as where our conditions can be so variable, you feel like you're paying monthly, but actually you might not be able to use it for a few weeks. You're not getting you use from the subscription fee"* [Participant 14 - Female, 21-29, Active, Severe Reasonably Well Controlled Asthma]

4.4.2.2. Theme Two: Preferred Content and Features for a Physical Activity App

Table 4.3. *Theme Two: Preferred Content and Features of a mHealth Physical Activity Intervention*

Theme Two: *Preferred Content and Features of a mHealth Physical Activity Intervention*							
Focus Group Number	Participant Number	**2.1.** ***Tailored Physical Activity Suggestions***	**2.2.** ***Goal Setting***	**2.3.** ***Feedback and Notifications***	**2.4.** ***Information and Guidance***	**2.5.** ***Compatibility with Other Apps and Devices***	**2.6.** ***Social Support***
Focus Group 1	**Participant 1**	Tailored to physical limitations. Video demonstrations of activities. Encourage activities the user already does.	Goal setting to keep users on track. See improvements.	Feedback encouraging - Confirmation users are doing the right thing. Future predictions if behaviour continues. Customise notifications (e.g., how many and how often).	Information on what to do in an emergency. Signposting to credible resources.	Pull data from other sources. Compatible with smartwatches, cannot always carry phone.	Build a community for app users. Could be difficult to monitor. Use already existing infrastructure.
	Participant 2	Tailored to medical conditions and physical limitations. Video demonstrations or signposting to online videos suitable for people with asthma.	Set own goals, even if they are small. Big goals could be discouraging.	Weekly progress reports. Positive feedback as motivational - Less likely to ignore. Usually turns off notifications but depends on what the notifications are and how frequent they are sent.	Information on what to do in an emergency. Signposting to credible resources.	Compatible with smartwatches.	Connect with other people with asthma. Would need careful monitoring. Use already existing infrastructure.
	Participant 3	Tailored to personal limitations. Different levels of intensity, but suitable for people with asthma.	Setting goals keeps users on track and is encouraging when completed. Prompts to be more ambitious with goals.	Positive feedback as motivational. Negative feedback hold users accountable for inactivity. Would leave 'Reminder' notifications on. Need to be honest about what notifications will be sent.	Signposting to creditable resources. Information on asthma action plans.	Compatible with smartwatches. Cannot always have phone.	Password protected Facebook group for users only.

Focus Group 2	**Participant 4**			Visual representations of progress. Compare weeks to see progress.			
	Participant 5	Video demonstrations of activities.	Prompts to change goals if not being achieved.	Negative notifications hold users accountable for inactivity.			
	Participant 6	Schedule activities ahead of time.	Guidance setting goals. Prompts to set days/times of the week.	Negative notifications hold users accountable for inactivity. Biofeedback to learn more about your body.	Signposting to credible resources.	Compatible with smartwatches. Cannot always have phone.	
	Participant 7	Different levels of intensity. Freely move up and down levels depending on asthma.		Visual representation of progress. Inputting data for inactivity could be disheartening and cause excuses. Reminders in the morning.			
	Participant 8			Visual representations of progress. Biofeedback to see improvements.		Pull data from other apps into one place. Honest about where data is being pulled from. Compatible with smartwatches. Cannot always have phone.	
	Participant 9			Weekly overview of progress. Weekly comparison to see progress.			

	Participant 10	Variety of physical activity suggestions.			Signposting to creditable resources.		
	Participant 11	Record intensity not just physical activity.		Positive notifications as motivational. Negative notifications as criticism. Would only like praise.	Disclaimers on activities.	Own product, usable without other devices.	
	Participant 12	Different levels of intensity. Video demonstrations.		Feedback on goal progress and physical activity the previous week.	Disclaimers on activities.	Compatible with smartwatches.	
Focus Group 3	**Participant 13**		Set your own goals - Easy goals or challenge yourself.	Positive notifications. Weekly overview of physical activity and goal progress.			
	Participant 14	Different levels of intensity and difficulty. Move up and down levels accordingly. All levels open, instead of an unlocking system.	Goal suggestions based on average of information collected.	Give reasons for inactivity. Prompts to reflect on past success. Feedback as motivational but also holds users accountable.	Testimonials from athletes with asthma.	Pull data from other apps into one place. Compatible with smartwatches. Cannot always have your phone.	
	Participant 15	Different levels of intensity and difficulty. Move up and down levels. Upper body exercises.	Setting own goals as motivational.	Feedback as motivational and encouraging. Prompts to reflect on past success.			
	Participant 16			Reflect and give reasons for inactivity. Praise for completing goals.	Testimonials from athletes with asthma.	Compatible with smartwatches.	

	Participant 17	Tailored to physical limitations and disabilities. Low impact or seated workouts.	Setting own goals as motivational. Based on what users think they can do.			Compatible with smartwatches. Cannot always have your phone.	Group people together based on demographic information. Build a network of similar people with asthma.
Focus Group 4	**Participant 19**	Different levels of intensity.	Setting own goals more likely to do it.	Hold users accountable for inactivity. Variability in notifications and not too often.	Information on being active with asthma and controlling symptoms.	Pull data from other apps into one place.	
	Participant 20			Reminders to be active.			
	Participant 22					Pull data from other apps into one place.	
	Participant 23			Variability in notifications.			
	Participant 24	Suited to people just starting out. Different levels of intensity.		Feedback on progress.	Information on how to be active safely with asthma.		
	Participant 25	Suited to people just starting out.					
	Participant 26	Tailored physical activity suggestions.	Visually see when goals are complete. Prompts to increase goals.	Positive feedback for completing goals. Visual representations of progress. Prompts to reflect on past successes. Negative feedback could make users feel	Signposting to other creditable resources. Resources all in one place.	Pull data from other apps into one place. Compatible with smartwatches.	

				judged. Giving reasons for inactivity like users are being told off. Notifications to match goals (more goals, more notifications).			
	Participant 27			Visual representations of progress. Variability of notifications and not too often.			

4.4.2.2.1. Tailored Physical Activity Suggestions

Participants wanted the app to learn about them, encourage activities they were already doing and provide suggestions based on their asthma status and physical limitations, including seated workouts and upper body exercises. They suggested that this could be done initially by completing a short questionnaire after downloading the app. From the short vignette, participants liked that the activity suggestions had different levels of intensity (e.g., beginner, intermediate and advanced), which they would be able to increase or decrease depending on their asthma.

> *"I think the different levels [of intensity] sound really good as well. Particularly if you were to say-have an exacerbation and you needed to move back a bit to you know, build up your strength and fitness again"* [Participant 7 – Female, 50+, Moderate Reasonably Well Controlled Asthma]

They did not like the still images of the activities used in the examples shown and would prefer video demonstrations.

4.4.2.2.2. Goal Setting

Goal setting was considered one of the most important features described in the vignettes. They liked that the goals were specific, including the day and time they would undertake the physical activity with reminders. However, it was essential for them that they were achievable, as a too-ambitious goal could be discouraging.

> *"Make it that you set your own goals, they don't have to be big goals either. You won't feel like you've got such a big goal, then you're not letting yourself down if you don't make it"* [Participant 2 – Female, 40-49, Severe Uncontrolled Asthma]

Initially, participants would appreciate guidance when setting goals based on previous activity data collected by the app and to be prompted to be more ambitious when goals are completed to ensure progress was made.

"I like the fact that you can then increase again because sometimes you get stuck on, I don't know 4,500 and then that gets easy and then you kinda get a bit complacent. Whereas actually if you try and up it, even by 500 it kinda gives you something to aim at each time" [Participant 3 - Female 21-29, Active, Severe Reasonably Well Controlled Asthma]

4.4.2.2.3. Feedback and Notifications

Participants preferred feedback in the form of weekly progress reports with visual representations and the ability to see activity levels across weeks. From the examples in the vignettes, participants liked the idea of receiving notifications of praise when goals were completed and being held accountable if progress was not met. However, they did not want to feel as if they were being *'told off'*, so the terminology and wording of these messages would need careful consideration.

"Having an app that goes 'Yey, you've done it!', it's like a mini pat on the back" [Participant 2 – Female, 40-49, Severe Uncontrolled Asthma]

The ability to customise the notifications they received was essential for participants as they were concerned about how many and how often these would be sent. They thought that notifications should be personal and reflect goals: the more goals, the more notifications.

"It kind of depends on your goals as well. If you've got lots of goals, and you're trying to do a lot of things in a day, then maybe more [notifications] would be more appropriate" [Participant 26 – Female, 30-39, Moderately Inactive, Moderate Uncontrolled Asthma]

4.4.2.2.4. Information and Guidance

From the examples shared with participants, they agreed that the following information and guidance should be included within the app: being active with asthma and controlling symptoms, being active safely with asthma and what to do in an asthma-related emergency. They also wanted the app to signpost users to other credible resources and wanted more emphasis on following asthma action plans.

> *"You could also include-like-links to various other resources. So, you know link to-like-Asthma UK and NHS websites things like that, so it's all in the one place and focused on asthma. It seems simple, but I don't have any other asthma apps or anything that would collect all these"* [Participant 26 – Female, 30-39, Moderately Inactive, Moderate Uncontrolled Asthma]

4.4.2.2.5. Compatibility with Other Apps and Devices

Compatibility with smartwatches was frequently discussed amongst participants, as they could not always carry their phones. However, it was crucial that the app was its own product that could be used without other devices. They wanted the option to be able to pull data from other apps, such as *Strava and MyFitnessPal*, so they could continue to use them and be able to view all the data together within the proposed app.

> *"Other activities that you can do, like you know, hit training or yoga, all those kinds of things which I record on my watch for it to be able to pull that data in. I think would be really a must, because you don't always have your phone on you"* [Participant 8 – Male, 21-29, Inactive, Moderate Uncontrolled Asthma]

4.4.2.2.5. Social Support

Social support emerged as important. Participants wanted to feel like part of a community and have the ability to connect with other people with asthma. It was acknowledged that this would be difficult as it would need careful monitoring. However, it was thought that an already existing infrastructure, such as *Facebook*, could be used to set up a group for app users only.

> *"I would say it'd be nice to have a community of people [with asthma] and maybe one way of doing it would be to have a Facebook group for app users"* [Participant 1 – Male, 31-39, Moderately Inactive, Severe Uncontrolled Asthma]

4.4.2.3. Theme Three: Integration of Other Aspects of Asthma and Weight Management

Table 4.4. *Theme Three: Integration of Other Aspects of Asthma Management*

Theme Three: *Integration of Other Aspects of Asthma Management*				
Focus Group Number	Participant Number	3.1. *Tracking and Monitoring Asthma Outcomes*	3.2. Guidance on *Inhaler Techniques and Breathing Exercises*	3.3. Weight *Management Support*
Focus Group 1	Participant 1			Information about what activities burn the most calories (optional feature). Pull data together from other apps into one place. Track and monitor food intake.
	Participant 2	See the effects of physical activity on asthma outcomes. Track and monitor peak flow. Less notifications when peak flow is low. Record medication usage when active – See which activities users needed to use more reliever medication.		Help with weight loss. Information on how many calories are burnt per activity – Pick activities based on calories burnt.
	Participant 3	Track and monitor everything in one app. See the effects of physical activity on medication usage. Track and monitor peak flow and medication usage. Asthma outcomes can be used as a reason for inactivity.		
Focus Group 2	Participant 4	Track and monitor asthma symptoms and medication usage. Record feelings after physical activity (e.g., symptoms and medication usage).		
	Participant 5	See the effects of physical activity on asthma outcomes. Encouraging and	Include inhaler and breathing techniques.	Information on how many calories are burnt per activity.

		motivational. Track and monitor asthma outcomes.		
	Participant 6	Track and monitor everything in one app. See relationship between physical activity and asthma outcomes. Track and monitor asthma symptoms. Recordings feelings after physical activity. Medication and peak flow reminders.	Examples of breathing exercises. Prompts to practice breathing exercises. Video demonstration of inhaler techniques.	
	Participant 7		Include yoga exercises to help with breathing exercises. Links to videos of inhaler techniques.	
	Participant 8	Track and monitor asthma symptoms and medication. Record feelings after physical activity.	Video demonstrations of inhaler techniques.	
	Participant 9			Optional feature.
	Participant 10			Reminders to eat healthy and drink more water.
	Participant 11	Physical activity aspects are not 'unique' enough. Not specific to asthma.		Track water intake.
	Participant 12	Track and monitor peak flow and asthma symptoms. Reminders to take medication and peak flow.		
Focus Group 3	Participant 13	See the benefits of physical activity on asthma outcomes. See improvements in asthma outcomes - Sense of achievement. Medication and peak flow reminders.		

	Participant 14	Record feelings after physical activity. Rate users' symptoms daily on a scale. Medication reminders.		
	Participant 15	Everything in one app. Track and monitor peak flow. Medication and peak flow reminders.		
	Participant 16	Everything in one app.		Track and monitor weight.
	Participant 17	Rate users' asthma symptoms on a scale.		
Focus Group 4	Participant 21	Physical activity aspects in other apps, nothing asthma specific.		
	Participant 22	See effects of physical activity on asthma outcomes. Record medication usage during/after physical activity.	Breathing techniques to help during a flare-up. Yoga based activities to help with breathing.	
	Participant 23	Record feelings after physical activity. Worse asthma symptom, less notifications to be active.		
	Participant 24	Track and monitor asthma symptoms. Record of why users have and have not been active.		
	Participant 25	Track and monitor peak flow.		
	Participant 26	Nothing asthma specific. See effects of physical activity on asthma outcomes. Calendar of symptoms. Prediction based on previous tiggers (e.g., high pollen warning). Peak flow reminders.		
	Participant 27	Colour coded calendar of symptoms.		

4.4.2.3.1. Tracking and Monitoring Asthma Outcomes

From the vignettes and examples, participants thought that the proposed app would not be sufficiently unique from those already available in the app stores and not specific enough for people with asthma. Some participants were uncertain about how the app would benefit their asthma, so they wanted to be able to track and monitor their asthma outcomes and medication usage within the app, so they would be able to see the effects of physical activity on these outcomes. Including these features would also encourage initial engagement, as participants thought they would be more likely to use a single app that contained all the features they wanted.

> *"Because if I had something that I can record, my peak flow my medicines and my symptoms, and the exercise that I'm doing all in one place, I would be much more likely to use it. But if I've got like one app for medications and another for my peak flow and another for my exercise, I'm just less likely to do it. So, if it's kind of joined up, then I think that would be really useful"* [Participant 6 – Female, 40-49, Active, Moderate Uncontrolled Asthma]

It was proposed that notifications could respond to asthma outcomes; for example, if users had a low peak flow or were experiencing asthma symptoms, they would receive fewer notifications to be active. Recording how an activity made them feel was considered useful to review what activities induced asthma symptoms.

4.4.2.3.2. Guidance on Inhaler Techniques and Breathing Exercises

Similar to physical activity suggestions, participants wanted video demonstrations of breathing exercises and inhaler techniques and, if not included, would like to be signposted to credible resources.

> *"So, I've actually recently been given a spacer, but at no point did anyone show me how to use it"* [Participant 6 – Female, 40-49, Active, Moderate Uncontrolled Asthma]

4.4.2.3.3. Weight Management Support

The inclusion of information about what activities burn the most calories was discussed amongst participants as an optional feature. It would allow users to select activities based on how many calories they would burn for those who were struggling with weight gain due to their asthma.

> "I think it would be handy to know-draw what from your activity today you've burnt approximately you know 2,000 calories for example would be great, but I think having the information on if you did tai chi for an hour, if you did swimming-swam for an hour, if you ran for an hour, if you walked for an hour or even just having that on a page would be help too" [Participant 1 – Male, 31-39, Moderately Inactive, Severe Uncontrolled Asthma]

4.4.2.4. Theme Four: Promoting Initial and Sustained Engagement

Table 4.5. *Theme Four: Promoting Initial and Sustained Engagement with a mHealth Physical Activity Intervention*

Theme Four: *Promoting Initial and Sustained Engagement with a mHealth Physical Activity Intervention*				
Focus Group Number	Participant Number	4.1. *Competitions*	4.2. *Achievements and Rewards*	4.3 Accessing the Intervention
Focus Group 1	Participant 1	Short competitions and goals instead of longer ones – Prevent users giving-up.	Record every day to be rewarded a streak and get achievements. Rewards for completing goals (e.g., shields) – Verifications users are going the right thing.	Option to download from app stores. Advertised on websites and social media. Option to be introduced by healthcare providers. Record information between appointments and export data to healthcare providers. Used during appointments to see if improvements have been made. Used to make recommendations to improve asthma.
	Participant 2	Competitions restart weekly. Users can opt in and out of competitions. Competitions against family and friends.	Record every day to be rewarded a streak and get achievements. Gradual achievements to unlock. Rewards for walking a certain distance.	Option for users to download it themselves from the app store. '*Word of Mouth*' recommend app to each other. Allow users to self-manage their asthma themselves without the involvement of healthcare providers. Introduced by an asthma nurse in Primary Care (but also available I the app store for users to recommend). Asthma nurses might recommend something, but they might not have used it themselves. Evidence that users have been active and what has worked/has not worked for them.
	Participant 3			Option to download from the app store. Tool to be used with healthcare providers. Cannot always remember, users can store information within the app. Evidence that users have been active. Feedback

				to healthcare providers about the app and they can recommend to other patients.
Focus Group 2	Participant 4			Healthcare providers need to get better at signposting the best apps to patient. Patients end up trying too many apps and giving up.
	Participant 6			Option for users to download it themselves from the app store. Healthcare providers do not normally recommend apps to help with asthma management. Would be good to have one app they could recommend. Overview page to discuss with healthcare providers and can make recommendations to improve asthma. Healthcare providers are not always supportive of physical activity. But if they could see improvements they might.
Focus Group 3	Participant 13	Reveal results at the end of the week – Prevent users giving-up.	Rewards (e.g., shields) for completing goals and winning competitions. Achievements on other apps are not realistic for people with asthma. Prompt self-reward for completing goals.	Store notes from appointments, so patients do not forget. Download and email data across to healthcare providers. Healthcare providers need to be aware of the app and take it seriously. When patients go to see their healthcare providers, they are either unwell or really well, never see the true picture of asthma. Evidence for biological injections.

	Participant 14	Group competitions, everyone who contributes get a reward no matter how little. Competitions not for everyone.	Rewards (e.g., shields) for completing goals. Rewards as motivational.	Option to email data across to healthcare providers. Only usually see patients on good days/hours and not on their bad days. Lung functioning during appointments might be okay, but patients can keep a log of what it has been like. Not wasting time looking for information, all there in one app.
	Participant 15	Revel results at the end of the competition – Prevent users giving-up.	Prompt self-rewards for completing goals. Rewards (e.g., shield/trophies) make users want to do more.	Overview report can be used to discusses with healthcare providers.
	Participant 16	Competitions not for everyone.		
	Participant 17	Competitions not for everyone. Being bottom of a leader board could be demoralising for users.	Gradual achievements.	
	Participant 18			App should be introduced into nursing schools so they know what they can recommend to patients.
Focus Group 4	Participant 19	Asthma unpredictable, users might not be able to take part every day.		
	Participant 20			Option for users to download it themselves from the app store.
	Participant 22			Option for users to download it themselves from the app store – Easiest way. Spreadsheet overview that can be discussed with healthcare providers. See the

				effects of physical activity on asthma outcomes and they might be more encouraging of physical activity.
	Participant 24	Competitions not for everyone. Not everyone is competitive.		
	Participant 25			Not referred to the app, just available in the app store. Tool to be used with healthcare providers.
	Participant 26	Competitions not for everyone. Some users will not be competitive. Everyone's asthma is different, not everyone can do the same amount of physical activity. Users might not want others to see their results.		Option for users to download it themselves from the app store. Seal of approval if it is recommend by healthcare providers – More trusted.

4.4.2.4.1. Competitions

To keep users engaged, most participants liked the idea of having competitions to take part in. It was suggested that the best format for these would-be short and flexible weekly competitions to prevent users from giving up. It was agreed that this should be something that users could opt in and out of because of the unpredictability of asthma.

> *"I love having the competition aspect as well. But if it's optional, but a lot of the apps are like you, you automatically get put into this competition. And for some people, that really doesn't work for them. But I think being able to kind of go, 'Yeah, actually, I do want to join this competition this week' or whatever"* [Participant 14 - Female, 21-29, Active, Severe Reasonably Well Controlled Asthma]

4.4.2.4.2. Achievements and Rewards

Participants liked the idea of receiving rewards, such as virtual badges or trophies, as it confirmed that they were doing the right thing and believed it would motivate them to continue. They suggested receiving rewards for *making progress* towards goals, achieving goals and winning competitions. The level of achievement required to gain rewards included in other apps was considered unrealistic for people with asthma, which de-motivated them.

> *"The goals on Apple are just unrealistic. I think I've got like two"* [Participant 13– Female, 21-29, Moderately Inactive, Severe Uncontrolled Asthma]

Prompting users to self-reward themselves for completing goals would work for those who are not motivated by intangible rewards.

> *"That's what I'm doing [self-rewarding] with weight loss at the minute. So, when I get to a certain weight, I'll buy myself something"* [Participant 13– Female, 21-29, Moderately Inactive, Severe Uncontrolled Asthma]

4.4.2.4.3. Accessing the Intervention

4.4.2.4.3.1. The Importance of Word of Mouth

Participants wanted the app to be available to download from the app stores. They believed that word of mouth was the best way of recommending an app, as people with asthma are more likely to have used the app and would be the best people to make recommendations. It was suggested that the app could also be advertised on websites and social media to increase awareness.

> *"Word of mouth is often the best way to get something. My nurse might recommend something, but if somebody else that I know who uses it said, 'Oh, I've got this app. It's really good. It does this. It does this. It does this. You really should give it a go'. I'm like, 'Oh yeah, I'll give that ago'"* [Participant 2 – Female, 40-49, Severe Uncontrolled Asthma]

4.4.2.4.3.2. The Value of Professional Signposting

Others wanted the app to be signposted to them by their healthcare providers as it gave it the '*seal of approval*'. They believe if the additional asthma-related features were included, this app would be a good tool to self-manage their asthma: to record information between appointments and have the ability to either export data to their healthcare providers or to be able to access an overview page for discussion during an appointment. Participants mentioned that when they met with their healthcare providers, they were either really well or unwell, and this app could give a true picture of the severity of their asthma. Although healthcare providers did not usually recommend apps, participants thought that it would be good to have one app they could signpost to all their patients.

> *"For me, I think the advantage of being told about it from my nurse or my doctor is it kind of gives it some, like a seal of approval like they've endorsed it. And they agree that the stats and the data and the way it works out and the advice is all correct. I think I'd trust it more"* [Participant 26 – Female, 30-39, Moderately Inactive, Moderate Uncontrolled Asthma]

4.5. Discussion

This study set out to explore preferred content and features for a smartphone app developed to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. We identified four key themes: '*Use of Existing Physical Activity and Health Apps*'; '*Preferred Content and Features for a Physical Activity App*'; '*Integration of Other Aspects of Asthma and Weight Management*'; '*Promoting Initial and Sustain Engagement*'.

Consistent with previous findings, participants found mHealth interventions acceptable (Greenwell et al., 2021; Jacome et al., 2021). However, they thought that the initial ideas presented were not sufficiently different from what is already available. Future apps would need to be more specific for people diagnosed with asthma. Yardley et al (2016) argue that tailoring digital intervention content to users' needs, motivation and personal characteristics enables users to receive guidance that is appropriate, relevant, and safe for them and can increase *'effective engagement'*. They define *'effective engagement'* as sufficient engagement with the intervention to achieve the intended outcomes and required interventions to be perceived as having benefits that outweigh their costs. Participants felt strongly about including other aspects of asthma self-management, such as having the ability to track and monitor asthma outcomes and medication usage, guidance on breathing techniques and breathing exercises, and weight management support.

Multifunctional mHealth platforms that comprise various features to help with all aspects of self-management have been shown to be promising in controlling asthma and improving quality of life (Farzandipour et al., 2017). Highly rated commercial apps have included peak flow readings, asthma symptom monitoring and asthma action plans (Camacho-Rivera et al., 2020). Our participants believed that they would be more likely to initiate and maintain engagement with a smartphone app that would help with all aspects of their asthma self-management, with physical activity being a component of this, which is currently not available. However, incorporating all the preferred content and features would result in a highly complex app. A systematic review has concluded that effectiveness may decline when too many features or techniques are included (Schoeppe et al., 2016). In terms of developing the physical activity component, researchers should consider the preferred content and design highlighted in this current study alongside effective BCTs that could help patients address barriers to physical activity. This would ensure that only essential features to increase efficacy and effective engagement are included.

Most of the participants already used physical activity and/or health apps but where unsure which apps were best for people living with asthma. Participants wanted an app tailored to them; as understandably, additional asthma-related barriers and facilitators to physical activity need to be considered. For example, findings from *Chapter 3: Barriers and Facilitators* suggest that adults diagnosed with asthma believe that they do not have the physical capabilities to be physically active because of their asthma. Deci and Ryan's (2017*) Self-Determination theory* states that *Competence* is one of three innate and universal psychological needs that need to be satisfied for personal well-being. When an individual feels competent, they feel able to interact effectively with their environment, and they have the skills needed for success to ensure that their goals are achieved, and they will be more motivated (Deci & Ryan, 2017). According to the theory, adults diagnosed with asthma believing they do not have the physical capability to be physically active in turn could have a negative effect on their motivation to be active. Therefore, the intervention would need to increase users' competence in being physically active and increase their self-efficacy so that they believe that they can engage in their behaviour change. A meta-analysis has shown that self-efficacy can be increased by setting a specific and detailed plan on when, where and how to perform the behaviour and providing instructions (Williams & French, 2011).

In line with this, participants wanted an app that would guide them to set realistic goals, provide feedback, and prompt them to reflect and be more ambitious when they achieved their goals and made progress. This could be done by incorporating the techniques of *Goal Setting*, *Action Planning* and *Feedback on Behaviour* from the Behaviour Change Techniques Taxonomy v1 (BCTTv1*)* (Michie et al., 2013) when developing future mHealth interventions. Nyenhuis and colleagues (2020) used similar techniques on a group of African American women diagnosed with asthma with significant positive effects on moderate-to-vigorous physical activity. Other BCTs related to *Self-Belief*, such as arguing against self-doubt and telling yourself that you can succeed (*Verbal Persuasion About*

Capabilities) and thinking about or listing previous success (*Focusing on Past Success*), could be encouraged to further increase self-efficacy. In terms of app development, these techniques could be delivered through motivational push notifications, which participants in our study said they would like to receive. Congruent with previous findings, participants in our study also believed that using reminders and push notifications could keep users engaged, but too many notifications could have a negative impact (Perski et al., 2017). Careful consideration would be needed to determine the terminology and wording used in these notifications to ensure they were engaging and not off-putting.

If we consider the Self-Determination theory again, individuals are more motivated when they have *Autonomy*. Autonomy involves being able to make your own decisions and is associated with feelings of independence and enhanced when individuals are given a choice and are able to govern their own behaviour (Deci & Ryan, 2017). Whereas Nyenhuis et al. (2020) focused on walking only, participants in our study wanted to include physical activity suggestions based on the user's interests, asthma status, and physical limitations, including upper body exercises and seated workouts. This way, users could pick an activity they would feel comfortable with and enjoy. This is important as expected and actual enjoyment from PA has been shown to predict adoption and maintenance (Ruby et al., 2011). A major benefit of digitally delivered interventions is the opportunity of offering users a choice, allowing users to self-tailor, selecting what they find most accessible, attractive, and useful, and again helping to increase effective engagement with the intervention (Yardley et al., 2016).

Participants liked the idea of having different levels of intensity to gradually increase their activity and reduce it depending on their asthma, as even people with relatively mild asthma avoid physical activity because of their fears of worsening asthma symptoms (Clarke & Mansur, 2015). The use of *Graded Tasks* (easy-to-perform tasks making them increasingly difficult until recommendations are met) could be incorporated into future interventions, with a systematic review showing that they help improve physical activity in digital interventions (Carraca et al., 2021). However, instead of the still images I presented to participants during the focus groups, they preferred video demonstrations of the activities. Furthermore, some of their anxieties about physical activity could be due to a lack of knowledge on preventing and managing asthma symptoms (Nyenhuis et al., 2019;

Mancuso et al., 2006). Including *Information About the Health Consequences of the Behaviour* and information and guidance on being active safely and managing symptoms, as suggested by our participants, could also help reduce fears around triggering asthma symptoms whilst being active.

Keeping users engaged with smartphone apps long-term or regularly can be challenging, especially if used without human support (Yardley et al., 2016). In terms of the content of the intervention, a systematic review of engagement concluded that social support features positively influence engagement with digital interventions (Perski et al., 2017). Furthermore, these features would address the last component of the Self-Determination theory, *Relatedness*. Relatedness is the ability to feel a sense of both attachment to other people and a sense of belonging amongst other people. It involves feelings of closeness and belonging to a social group (Deci & Ryan, 2017). Without connections, self-determination is harder to achieve because the individual would lack access to both help and support. Our participants wanted to feel like part of a community and have the ability to connect with other people with asthma, whether this was through an online discussion forum or weekly competitions, both of which have been shown to facilitate social support (Perski et al., 2017).

In light of the COVID-19 pandemic, adults diagnosed with asthma have started to take their asthma more seriously and are more motivated than ever to self-manage their disease (Tyson et al., 2021b). As motivation is positively associated with engagement (Perski et al., 2017), we now have a unique opportunity to develop a smartphone app that this patient group might be more likely to engage with and benefit from. Moving forward, the focus should be on developing a multifunctional mHealth platform that meets the needs of its users and helps with all aspects of asthma self-management. Once developed, a feasibility study will be needed to assess the feasibility, acceptability, and potential effectiveness of the intervention in this patient group. Further qualitative research could also be undertaken to determine what other features adults diagnosed with asthma would like to see included on the multifunctional platform to help with asthma self-management, such as peak flow readings, medication and symptom monitoring, asthma action plans, diet and weight management, and environmental updates. Moreover, although we explored why our participants used physical activity and health apps and what made them more likely to be used long-term, we did not explore their initial reasons for downloading them. This could be explored to help us understand when and under what circumstances someone is more likely to engage with an app.

4.5.1. Strengths and Limitations

This study provides valuable evidence on the ideas and preferences of adults diagnosed with asthma for the content and features of an intervention, specifically a smartphone app, to promote physical activity and reduce sedentary behaviour in this population group. How to promote initial and sustained engagement with an mHealth intervention was also identified. Using online video conferencing, allowed me to recruit participants from all over the UK while national lockdown measures were in place. However, there are disadvantages to using online video conferencing, such as technical issues that interfere with the discussions and affect the quality of the recordings, leading to difficulties when transcribing the focus groups, difficulties observing the non-verbal cues of participants, and distraction during the focus groups (Almujlli et al., 2022). During my focus groups, some participants had technical issues that meant they could not engage fully for the duration of the focus group. In addition, although I advised participants to move to a quiet location during the focus group, this was not possible for everyone, particularly those with children. In addition, due to most participants already using health and physical activity apps, and requiring that they have access to the internet, participants may have been a group both more engaged with their asthma and also more accepting of mHealth interventions than the wider population of people diagnosed with asthma. However, it is important to note that this study was conducted during the COVID-19 pandemic when the UK was under restrictions and quarantine. During this time, adults with asthma were more health conscious due to their fear of COVID-19 and were in turn more active and finding new ways of being physical activity (Tyson et al., 2021a). Therefore, it could have been that participants in this study were only using apps as a result of the pandemic and were not actually regular users of health and physical activity apps. Although prior experience using apps meant that participants could discuss the study topic more and got an insight on suggestions on how we can keep users engaged in the long-term.

Furthermore, similar to the study presented in *Chapter 3: Barriers and Facilitators*, there were a high proportion of White British females within the sample, and due to participants registering their own interest in taking part in the study, participants may have been more engaged with their asthma than the average person. Also, participants were required to have access to the internet, so the findings may not be generalisable to the whole population. Research with participants with differing cultural, educational and socioeconomic backgrounds could lead to different findings.

4.5.2. Reflexivity and Personal Reflection

For this study, I had originally submitted an application for REC ethical approval. I wanted to recruit adults diagnosed with asthma and healthcare providers that are directly involved in the care of asthma patients and the delivery of physical activity interventions from Norfolk and Norwich University Hospital. However, whilst waiting for my ethical approval, COVID-19 was declared a pandemic, and the UK was put under national lockdown measures. I knew that I would not be able to recruit or conduct the focus groups as I originally intended. After discussion with my supervisory team, it was decided that we would seek ethical approval from the Faculty of Medicine and Social Sciences at the University of East Anglia and make amendments to the original protocol. Methods are detailed in this chapter but briefly, adults diagnosed with asthma were recruited online instead, using similar methods used in *Chapter 3: Barriers and Facilitators* as they were successful last time, and focus groups would be conducted online using Zoom instead of face-to-face. Due to the demand on healthcare providers during the pandemic, I knew that it would not be possible to have their involvement in the study.

It was also decided with my supervisory team that I would ask additional questions about the effects of COVID-19 on the well-being and physical activity levels of adults diagnosed with asthma. The focus groups were divided into two sections; the first half was spent discussing the effects of COVID-19 and the remaining time was spent discussing user preferences for the smartphone app. Adding this to the protocol worked in my favour as ethics applications that were submitted to collect data on COVID-19 were prioritised, so even though amending the protocol and re-doing the participant facing documents took time, I was able to gain approval for the study quickly. This method worked well, and I was able to collect data for two studies right at the start of the pandemic. The data I collected about the effects of COVID-19 on well-being and physical activity was published in the *Journal of Health Psychology and was* entitled *'Exploring the Effective of COVID-19 on the Wellbeing and Physical Activity Levels of Adults with Asthma'* (Tyson et al., 2021a).

As with *Chapter 3: Barriers and Facilitators*, online recruitment through support groups on Facebook was successful and I had more people registering their interest than I needed for the study. I had intended to advertise the study to Research and Policy Volunteers at Asthma+LungUK, exactly as I had done previously, but this was not needed. This successful recruitment could have been due to people being at home during national lockdown measures. As I had a lot of interest, I was able to be selective and ensure that my participant sample had varying levels of asthma severity and physical activity.

Although I had recently conducted interviews and focus groups as described in *Chapter 3: Barriers and Facilitators*, the focus groups conducted in this study were completely different. There was a lot to consider as they were being conducted online and it was a learning experience. Firstly, when writing the protocol for the study I had intended to recruit 6-8 participants for each focus group. As I had never conducted a focus group online before, I was worried about inviting too many participants and not being able to stay in control and steer the discussion. Therefore, for my first focus group, I only invited six participants, with only three of them actually joining on the day. Although I was disheartened at the start of the focus group, I was really lucky as the three people who did join had a lot to say and were really interested in sharing their experiences and thoughts. One of the participants happened to be an app developer and was able to offer some professional views too. Although the focus group had only three participants, it went really well, and I gather a lot of interesting data for the study. I learnt from this experience and always over invited participants to join the focus group inviting between 8-10 participants to each one. By doing this, I always had enough participants in each focus group and met the recruitment numbers I set out to achieve.

There were also other considerations that I had to think about with conducting the focus groups online. I had to ensure that the Zoom meetings were set up ahead of time and that I emailed the link to join the focus groups to participants the day before. As I could not be sure that everyone had used the programme before, I had to ensure that everyone had instructions on how to join. There were then problems that I encountered that were out of my control. With using technology, participants had problems with their audio, video, and internet connection. In most cases, this could quickly be resolved, but I did have one person who was unable to join using their video and audio. I had to come up with a solution very quickly and I was able to keep the participant engaged by getting them to type in the group chat and reading it out to the group. Lastly, although I asked participants in the Participant Information Sheet and in the joining instructions to try and move to a quiet space in their homes with a blank background, this did not always happen. This was a common problem for participants who were parents, as schools were closed, and their children were at home. This led to a lot of background noise in some cases, and I had to ask participants to turn off their microphones when they were not talking. There were also times when children would walk in front of the cameras, so I gave those participants the option to turn their cameras off if they wished, so it did not show their children. Even with the problems I encountered, I found online focus groups to be a good alternative to face-to-face focus groups and they allowed me to continue collecting data during the pandemic.

4.2. Conclusion

This study shows that participants with asthma found smartphone apps acceptable. Participants wanted an app to guide them to set realistic goals and provide feedback so progress could be made. Physical activity suggestions should be tailored to the user's interests, asthma status, and physical limitations. Providing information about managing symptoms and being active safely with asthma could reduce fears and anxieties about physical activity. Initial engagement with the app could be promoted by making the app more asthma specific by incorporating the ability to track and monitor asthma outcomes and medication usage. Including social support, competitions, and rewards, such as digital badges or trophies, could sustain engagement in the long-term. Although they were happy to download the app from app stores, participants believed that having a healthcare professional signpost them to the app gave it a 'seal of approval'. Future research should focus on developing a multifunctional mHealth platform that meets the needs of its users and helps with all aspects of asthma self-management, with physical activity being a component of this.

In terms of developing the proposed intervention, BCTs highlighted in this current study, such as *Goal Setting, Action Planning, Feedback on Behaviour, Graded Tasks,* and *Information About the Health Consequences of the Behaviour,* as well as techniques relating to *Self-Belief* should be considered for inclusion. User preferences regarding the content and features of the intervention were considered during intervention development. This is presented in *Chapter 5: Intervention Development*.

Chapter 5: Developing a Physical Activity Intervention for Adults Diagnosed with Asthma

Previous chapters have identified the need to develop an evidence-based intervention for promoting physical activity and reducing sedentary behaviour in adults diagnosed with asthma. Chapter 4: User Preferences presented findings from a qualitative study identifying the ideas and preferences of the target end-users for the content and features of the intervention. Overall, they found a smartphone app acceptable and highlighted some important content and features for inclusion. This chapter details the process of developing an intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma based on existing evidence and new primary data presented in this thesis. The rationale for the choice of the theoretical framework and intervention components are discussed, and a programme theory and interactive mock-ups of the smartphone app are presented.

5.1. Background

5.1.1. Developing Behavioural Change Interventions

Intervention development should follow a systematic approach to identify and select appropriate components to change behaviour (Michie, van Stralen & West, 2011). NIHR-MRC guidance divides intervention development into four phases: development or identification of the intervention, feasibility, evaluation, and implementation (Skivington et al., 2021). Each phase has a common set of core elements:

1. ***Consider Context*** – Any feature of the circumstances in which an intervention is conceived, developed, evaluated, and implemented.
2. ***Developing and Refining Programme Theory*** – Describe how an intervention is expected to lead to its effects and under what conditions.
3. ***Engage Stakeholders*** – Those who are targeted by the intervention or policy, involved in its development or delivery, or, more broadly, those whose personal or professional interests are affected.

4. ***Identify Key Uncertainties*** – Identify the key uncertainties that exist, given what is already known and what the programme theory, research team, and stakeholders identify as being most important to discover.
5. ***Refine Intervention*** – The process of fine-tuning and making changes to the intervention once a preliminary version has been developed.
6. ***Economic Considerations*** – Determine the comparative resources and outcome consequences of the interventions for those people and organisations affected.

As discussed in *Chapter 1: Introduction*, although the guidance strongly advocates a theoretical basis and provides a broad outline approach to intervention development, it does not provide detailed guidance on choosing or applying appropriate theories (French et al., 2012; Michie et al., 2005). Even when interventions are said to be guided by theory, they are often not or only minimally used (Michie & Prestwich, 2010). Without theory, interventions might address the unimportant or inappropriate variables or only a proportion of the combination of variables required to have the desired effect (Green, 2000). Using a theoretical framework to aid the intervention development process could offer a potential solution and ensure that interventions are developed using relevant theory.

5.1.2. A Framework for Intervention Development

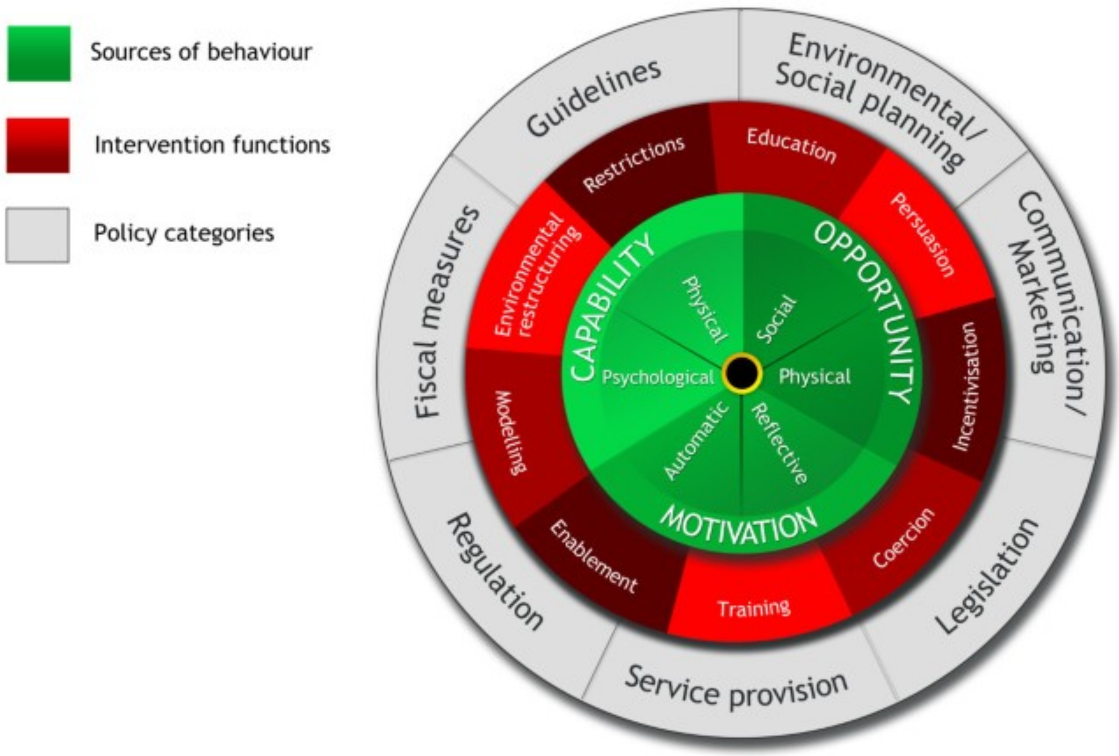
It was important that the development of this intervention was based on appropriate theory. Common behaviour change models used in health interventions include the Health Behaviour Model (Rosenstock, 1966), the Theory of Planned Behaviour (Ajzen, 1991), the Social Cognitive Theory (Bandura, 1986), and the Transtheoretical Model (Prochaska & Velicer, 1997). However, each of these models has its own advantages and disadvantages. For example, the Health Belief Model has been successfully applied to design interventions addressing behaviours that have health consequences, such as physical activity (Orji, Vassileva & Mandryk, 2012). However, a number of variables important in changing behaviour are missing, such as social support and self-efficacy, both of which were identified as barriers and facilitators to physical activity in *Chapter 3: Barriers and Facilitators*. Although models such as the Social Cognitive Theory have a clear link to self-efficacy and behaviour change, there is less emphasis on the role of emotion and motivation. Similarly, the Theory of Planned Behaviour does not account for other variables that factor into intentions and motivations, such as fear or past experiences. The fear of physical activity triggering asthma symptoms, and having previous past experiences of this happening, were again barriers identified in Chapter 3: Barriers and Facilitators, that would need to be addressed in this intervention. Lastly, the Transtheoretical Model states that changing behaviour is not a coincidence but a process, and different people are in different stages of change and readiness (Hashemzadeh et al., 2019), which was true for the participants in *Chapters 3: Barriers and Facilitators and Chapter 4: User Preferences*. However, the model ignores social contexts, such as income. For participants in *Chapter 3: Barriers and Facilitators*, physical activity needed to be affordable, as some had struggled to afford gym memberships, exercise classes or active clothing.

Therefore, instead of a single model, I chose to use the *Behaviour Change Wheel* (BCW), a theoretical framework, to inform the development of this intervention. I chose this framework as it represents the most comprehensive framework available to support intervention development (O'Cathain et al., 2019). Its use is supported by its clear links to other theory-based resources, such as the *Theoretical Domains Framework* (TDF) (Atkins et al., 2013), which is a comprehensive, theory-informed approach to identifying determinants of behaviour, and the *Behaviour Change Techniques Taxonomy v1* (BCTTv1) (Michie et al., 2013). The UK national policy on developing individual-level behaviour change interventions also recommends using this framework (NICE, 2014).

In recognition of the need for a comprehensive framework, Michie and colleagues (Michie, van Stralen & West, 2011) set out to review existing frameworks and assess their usefulness. They identified 19 frameworks covering nine intervention functions (broad categories of means by which an intervention can change behaviour) and seven policy categories (through which an intervention could be implemented to support the delivery of the intervention functions). However, none of the reviewed frameworks covered the full range of intervention functions or policies and only a minority linked to a model of behaviour (Michie, van Stralen & West, 2011).

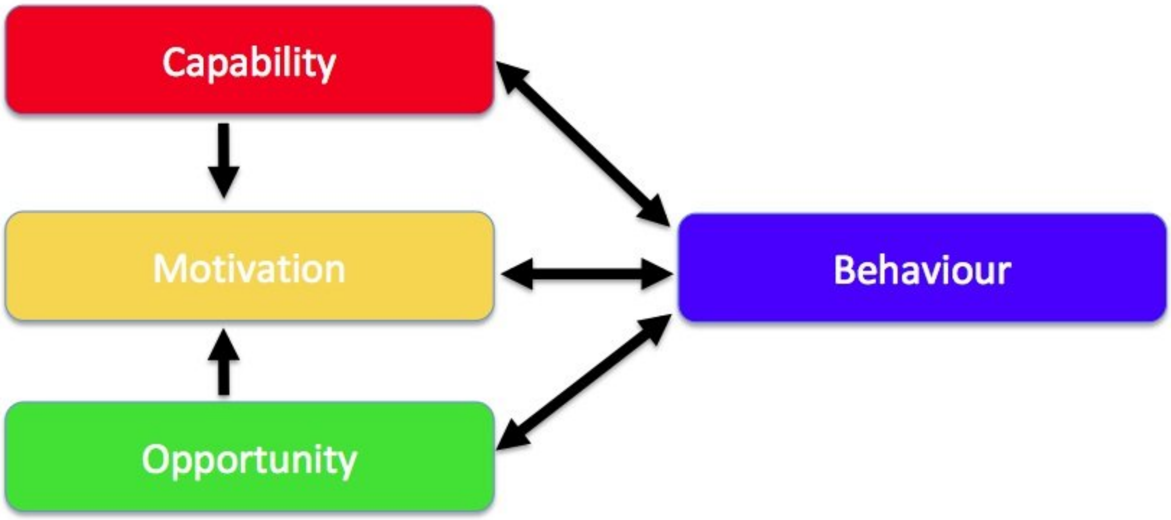
Following the review, a new framework was developed based on the synthesis of the 19 existing frameworks (Michie, van Stralen & West, 2011). The resulting framework is a three-layer model, referred to as the *Behaviour Change Wheel (BCW)* (see *Figure 5.1*). At the core of the wheel is the *Capability, Opportunity, Motivation and Behaviour Model (*COM-B), which helps identify important levers for change necessary for the new behaviour to occur or for a behaviour to be repeated more or less often. The next layer is the nine intervention functions that characterise the type of intervention needed. The outer layer signals seven types of policy categories that can deliver these intervention functions.

Figure 5.1. *The Behaviour Change Wheel (from Michie, van Stralen and West, 2011, open access)*



At the centre of the wheel is the COM-B model (see *Figure 5.2*). Michie and colleagues (2011) proposed that each component of the COM-B is made up of two aspects. *Capability* can be the '*physical'* or '*psychological*' capacity to engage in the activity. *Opportunity* can be the '*physical*' or '*social*' factors that lie outside the individual that make the behaviour possible or promote it. *Motivation* can be the '*reflective*' processes (involves plans and evaluations) or '*automatic*' processes (involves emotional reactions, desires, impulses, inhibitions, drive states and reflex responses) that energise and direct behaviour. Altering an individual's Capability, Opportunity and/or Motivation through an intervention can make them more likely to carry out the behaviour (Michie, van Stralen & West, 2011).

Figure 5.2. *The COM-B Model (from Michie, van Stralen and West, 2011, open access)*



The COM-B model provides a simple starting point for understanding and explaining behaviour and can be further developed using the TDF (Michie et al., 2005). The TDF builds on the systems identified in the COM-B model to further uncover the underlying barriers and facilitators of behaviour change (Cane, O'Connor & Michie, 2012). The TDF contains 14 domains that explain the potential determinants of behaviour based on theoretical constructs identified from 33 behaviour change theories (Michie et al., 2005). The domains include *Knowledge, Skills, Memory, Attention and Decision Process, Behavioural Regulation, Social/Professional Roles and Identity, Beliefs About Capabilities, Optimism, Beliefs About Consequences, Intentions, Goals, Reinforcement, Emotion, Environmental Context and Resources, and Social Influences*. The domains from this framework have been independently mapped onto the COM-B components by three experts in behaviour change, with 100% agreement (see *Table 5.1*) (Cane, O'Connor & Michie, 2012). The COM-B and TDF combined can provide a comprehensive theoretical model to understand behavioural change. I used them as the theoretical basis for developing this intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma.

Table 5.1. *Theoretical Domains Framework and Definitions, Mapped Onto the COM-B Model*

COM-B		Theoretical Domains Framework	Definition*
Capability	Psychological	Knowledge	An awareness of the existence of something.
		Memory, Attention and Decision Processes	The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives.
		Behavioural Regulation	Anything aimed at managing or changing objectively observed or measured actions.
Capability	Physical	Skills	An ability of proficiency acquired through practice.
Motivational	Reflective	Social/Professional Role and Identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting.
		Beliefs about Capabilities	Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use.
		Optimism	The confidence that things will happen for the best or that desired goals will be attained.
		Beliefs about Consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation.
		Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way.
		Goals	Mental representations of outcomes or end states that an individual wants to achieve.
Motivation	Automatic	Reinforcement	Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus.
		Emotion	A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event.
Opportunity	Physical	Environmental Context and Resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour.
Opportunity	Social	Social Influences	Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours.

**as defined by Atkins et al. (2017) p. 4-5*

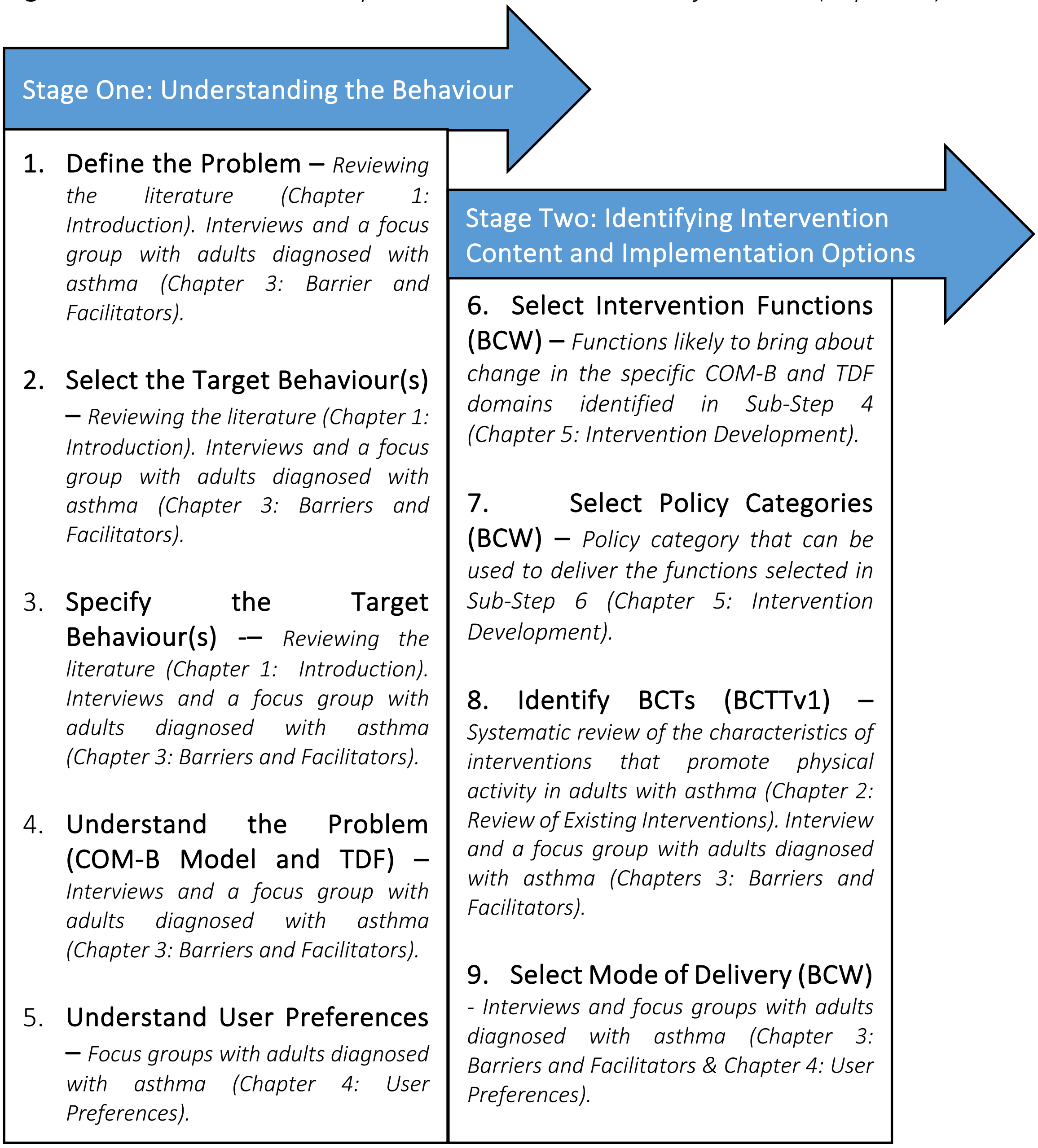
The BCW proposes that in order to change behavioural components, an intervention must perform certain functions represented in the middle layer. These include *Education, Persuasion, Incentivisation, Coercion, Training, Enablement, Modelling, Environmental Restructuring, and Restrictions*. These are the functions of the intervention that change behaviour and can be linked to specific Behaviour Change Techniques (BCTs) using the BCTTv1 (Michie et al., 2013). *The Theory of Techniques Tool* (Carey et al., 2019) was developed to aid researchers in making decisions about which techniques to select based on the process through which they change behaviour (i.e., their mechanism of action. This tool was developed based on a literature synthesis study aimed to identify links between BCTs and mechanisms of action (Carey et al., 2019) and expect consensus (Connell et al., 2019). The triangulation of these two distinct sources of evidence resulted in guidance on how BCTs may affect the mechanisms that change behaviour and is available as an interactive, online tool (Johnston et al., 2020). I used this tool to aid decision making during the development of this intervention. The outer ring of the wheel comprises seven policy categories that can be used to support the delivery of an intervention function and include: *Environmental/Social Planning, Communication/Marketing, Legislation, Service Provision, Regulation, Fiscal Measures and Guidelines* (Michie, van Stralen & West, 2011).

The BCW centred on the COM-B and TDF, offers a comprehensive systematic approach to intervention development based on established behaviour change theory (Michie, van Stralen & West, 2011). Authors acknowledge limitations, including potentially missed frameworks and/or intervention functions and categories, the involvement of personal judgement and potential difficulties for use. To minimise the last concern, the authors produced a step-by-step guide to using the BCW for designing and evaluating interventions (Michie, Atkins & West, 2014). The method for intervention development employed in this chapter has been based on this guide. This chapter describes each stage of the guide in detail and draws together the research presented in the previous chapters to inform the development of this intervention.

5.2. Aim

With the support of my supervisory team, I aimed to develop an intervention that promotes physical activity and reduces sedentary behaviour in adults diagnosed with asthma, using the *Behaviour Change Wheel* in conjunction with other theory-based tools, including the *Theoretical Domains Framework*, *Behaviour Change Techniques Taxonomy v1* and *The Theory of Techniques Tool*. An overview of the intervention development process was presented in *Chapter 1: Introduction* and is presented again in *Figure 5.3.*

Figure 5.3. *Intervention Development Process and Sources of Evidence (Repeated)*



COM-B Model = Capability, Opportunity, Motivation, Behavioural Model; TDF = Theoretical Domains Framework; BCW = Behaviour Change Wheel; BCTTv1 = Behaviour Change Techniques Taxonomy version 1

Using findings from the previous chapters presented in this thesis, behaviour change techniques were selected and translated into intervention features. A programme theory was developed and represented as a Logic Flow Chart, to explain the mechanisms of the intervention and how the intervention features are expected to work, the outputs of the intervention, and the short-term and long-term outcomes. I designed interactive mock-ups of the smartphone app using the wire-framing software *Adobe XD* (*Adobe Inc,* Version: 33.1.12.4) to reflect how the smartphone app would work from the user's point of view. The result of this chapter is a fully specified intervention on paper.

5.3. Methods

5.3.1. Stage 1: Understanding the Behaviour and User Preferences

The first stage comprised five sub-steps to define, specify and analyse the target behaviour using the BCW framework (Michie, Atkins & West, 2014), as shown in *Figure 5.4*. This involved:

1. Defining the Problem in Behavioural Terms
2. Selecting the Target Behaviours
3. Specifying the Target Behaviours
4. Understanding the Problem
5. Understanding User Preferences

Figure 5.4. *Intervention Development Process and Sources of Evidence – Stage One: Understanding the Behaviour*

Stage One: Understanding the Behaviour

1. **Define the Problem** – *Reviewing the literature (Chapter 1: Introduction). Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*
2. **Select the Target Behaviour(s)** – *Reviewing the literature (Chapter 1: Introduction). Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*
3. **Specify the Target Behaviour(s)** -– *Reviewing the literature (Chapter 1: Introduction). Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*
4. **Understand the Problem (COM-B Model and TDF)** – *Interviews and a focus group with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators).*
5. **Understand User Preferences** – *Focus groups with adults diagnosed with asthma (Chapter 4: User Preferences).*

COM-B Model = Capability, Opportunity, Motivation, Behavioural Model; TDF = Theoretical Domains Framework

5.3.1.1. Steps 1, 2 & 3: Defining the Problem and Selecting and Specifying the Target Behaviours

I first defined the problem in behavioural terms, being specific about the target population and the behaviour itself. It was evident from *Chapter 1: Introduction* that the problem is decreased physical activity and increased sedentary behaviour in adults diagnosed with asthma compared to the wider adult population. Once the problem was defined, I identified and selected target behaviours by reviewing the existing literature, presented in *Chapter 1: Introduction,* and analysing qualitative data collected from the interviews and focus group presented in *Chapter 3: Barriers and Facilitators*. From this, I was able to determine which individuals need to engage in the behaviour, what they need to do differently to enable the behaviour change (i.e., increase physical activity and decrease sedentary behaviour), and when, where, how often and with whom they will perform the target behaviours.

5.3.1.2. Step 4: Understanding the Problem

Having defined the problem and specified the target behaviours, the next step was to identify what needed to change for adults diagnosed with asthma to become more physically active and less sedentary. In order to do this, I deductively analysed the transcripts from the interviews and focus group presented in *Chapter 3: Barriers and Facilitators* and coded findings to the COM-B and TDF domains. Codes were arranged under the relevant domains and tabulated. From this, I was able to identify and understand what needs to change in terms of *Capability* (*Physical* and *Psychological*), *Opportunity* (*Physical* and *Social*) and *Motivation* (*Reflective* and *Automatic*) to enable the behaviour change (Michie, Atkins & West, 2014).

5.3.1.3. Step 5: Understanding User Preferences

While the COM-B and TDF were used to identify theoretical domains to elicit change in order for the target behaviours to occur, I used a user-centred approach to explore the ideas and preferences of the target end-users for the content and features of the intervention. Based on the findings from *Chapter 2: Review of Existing Interventions* and *Chapter 3: Barriers and Facilitators*, I developed initial ideas for the intervention through discussions with my supervisory team. As presented in *Chapter 4: User Preferences*, I conducted further focus groups to share these ideas with the target end-users of the intervention. I prompted participants to discuss what they liked, disliked and what they would change. I extracted user preferences from the transcripts and tabulated them with the theoretical domains identified in *Step 4: Understanding the Problem*, to show what content and features would target each domain. I used The *APEASE* criteria for designing and evaluating interventions (Michie, Atkins & West, 2014) to determine which user preferences might be most appropriate for the intervention and would be taken forward to the next stage of the development process. As part of the criteria, I considered: affordability, practicability, effectiveness and cost-effectiveness, acceptability, side effects/safety, and equity.

5.3.2. Stage 2: Identifying Intervention Content and Implementation Options

Stage 2 involved using the results of the behavioural diagnosis carried out in *Stage 1* to guide decisions making regarding the content and delivery of the intervention, as shown *Figure 5.5*. This involved:

6. Selecting Intervention Functions
7. Selecting Policy Categories
8. Identifying Behaviour Change Techniques
9. Selecting Mode of Delivery

Figure 5.5. *Intervention Development Process and Sources of Evidence – Stage Two: Identifying Intervention Content and Implementation Option*

Stage Two: Identifying Intervention Content and Implementation Options

6. **Select Intervention Functions (BCW)** – *Functions likely to bring about change in the specific COM-B and TDF domains identified in Sub-Step 4 (Chapter 5: Intervention Development).*

7. **Select Policy Categories (BCW)** – *Policy category that can be used to deliver the functions selected in Sub-Step 6 (Chapter 5: Intervention Development).*

8. **Identify BCTs (BCTTv1)** – *Systematic review of the characteristics of interventions that promote physical activity in adults with asthma (Chapter 2: Review of Existing Interventions). Interview and a focus group with adults diagnosed with asthma (Chapters 3: Barriers and Facilitators).*

9. **Select Mode of Delivery (BCW)** - *Interviews and focus groups with adults diagnosed with asthma (Chapter 3: Barriers and Facilitators and Chapter 4: User Preferences).*

BCW = Behaviour Change Wheel; BCTTv1 = Behaviour Change Techniques Taxonomy version 1

5.3.2.1. Steps 6 & 7: Identifying Intervention Functions and Policy Categories

I selected intervention functions most suited to target the theoretical domains identified in the behavioural diagnosis carried out in *Stage 1: Understanding the Behaviour,* using the BCW framework guide which provides a table mapping relevant intervention functions likely to bring about change in specific COM-B and TDF domains (Michie, Atkins & West, 2014). Building on the table created in *Stage 1 – Step 4: Understanding the Problem*, selected intervention functions were tabulated with the domains to show which intervention functions would be targeting each domain. Secondly, I identified what policies would best support the delivery of the selected intervention functions, using the BCW framework guide which provides a table mapping the seven policy categories onto relevant intervention functions (Michie, Atkins & West, 2014). Again, the *APEASE* criteria were used to determine which intervention functions and policy categories would be taken forward (Michie, Atkins & West, 2014) and justifications were given for why certain intervention functions and policy categories were not chosen.

5.3.2.2. Step 8: Identifying Behaviour Change Techniques

To guide the identification of all the suitable BCTs, The Theory of Techniques Tool was used to select those most appropriate for each COM-B and TDF domain identified (Carey et al., 2018). Using the online tool, I made a list of possible BCTs for inclusion in the intervention. The list was narrowed down by reviewing the techniques that were deemed effective in *Chapter 2: Review of Existing Interventions* and selecting those that would overcome the perceived barriers and facilitate behaviour change identified in the interviews and focus group presented in *Chapter 3: Barriers and Facilitators*. Building on the table created in *Stage 2 – Step 6: Identifying Intervention Functions*, intervention functions were tabulated with BCTs to show which techniques would be targeting each intervention function. For each identified BCT, suitability and potential efficacy were determined using the *APEASE* criteria to produce a final set of BCTs for inclusion in the intervention.

5.3.2.3. Step 9: Selecting the Mode of Delivery

Lastly, I made decisions about the mode of delivery for the intervention. Although it was already decided the intervention would be delivered via a smartphone app by my supervisory team when the project was developed, Findings from *Chapter 2: Review of Existing Interventions*, *Chapter 3: Barrier and Facilitators and* Chapter 4: User Preferences, were used to decide on the content, provider (who would signpost the app to users), recipients, intensity, duration and fidelity of the intervention. I used the APEASE criteria to assess which modes of delivery would be most suitable.

5.3.3. Intervention Design

The BCTs identified in *Step 8: Identifying Behaviour Change Techniques* were translated into intervention features. User preferences identified in *Stage 1 - Step 5: Understanding User Preferences,* influenced decision-making and what features would be included in the final design. Building on the table created in *Step 8: Identifying Behaviour Change Techniques*, each intervention function was tabulated to show which BCTs it would be targeting. This final table shows how each stage of the intervention development process has come together to decide on the functions included in the intervention. A programme theory was developed, represented as a logic flow chart, to explain the mechanisms of the intervention and how the intervention features are expected to work, the outputs of the intervention, and the short-term and long-term outcomes. Lastly, I developed interactive mock-ups of the intervention using the wire-framing software *Adobe XD*, reflecting how the smartphone app would work from the users' point of view. The software allowed me to export pictures which are presented in this chapter.

5.4. Results

5.4.1. Stage 1: Understanding the Behaviour and User Preferences

5.4.1.1. Step 1: Defining the Problem in Behavioural Terms

The chosen target group for this intervention were adults diagnosed with asthma of any degree of severity. The behavioural problem was decreased physical activity and increased sedentary behaviour, as evidence suggests that adults diagnosed with asthma engage in less physical activity and are more sedentary compared to the wider adult population (Cordova-Rivera et al., 2018).

5.4.1.2. Stage 2: Selecting the Target Behaviours

I decided that users should choose how they will increase their physical activity and decrease their sedentary behaviour. I based this decision on findings presented in *Chapter 3: Barriers and Facilitators* that suggested that choice was an important facilitator to motivation and engagement in physical activity due to the variability of asthma and individual physical limitations. The chapter also showed that It was also important for participants that they played an active role in their asthma self-management and made their own decisions regarding their disease and treatment. A list of some examples of what individuals could do to modify their physical activity and sedentary behaviour is presented in *Table 5.2*. These examples were informed by participants in *Chapters 3: Barriers and Facilitators* and *Chapter 4: User Preferences* and what physical activities they enjoyed or wanted to do.

Table 5.2. *Examples of What Adults Diagnosed with Asthma Could Do to Modify Their Physical Activity Levels and Sedentary Behaviour*

Include activities of daily living as part of regular physical activity (e.g., heavy housework, gardening).
Increase daily step count (e.g., active travel)
Reduce sedentary behaviour (e.g., regular movement/change in position, avoid prolonged sitting/lying).
Choose an enjoyable physical activity (e.g., cycling, swimming, horse riding, dancing).
Increase physical activity already undertaken (e.g., cycling, swimming, horse riding, dancing).
Increase low-intensity physical activity (e.g., stretching and upper body exercises).
Identify NHS programmes available to help increase physical activity (e.g., *Couch to 5K*).
Identify inclusive sports groups to take part in (e.g., walking football).

5.4.1.3. *Step 3: Specifying the Target Behaviours*

As a result of the decisions made in *Step 2: Selecting Target Behaviours*, users will be encouraged to specify themselves how they will increase their physical activity and reduce their sedentary behaviour. The intervention will guide users to specify in terms of what, when, where, how often and with whom they will perform the target behaviours (Michie, Atkins and West, 2014). An example of specifying the target behaviours is presented in *Table 5.3.*

Table 5.3. *Example of Specified Target Behaviours*

Specification Criteria	Choose an Enjoyable Activity	Reducing Sitting Time
Who	Adult diagnosed with asthma	
What	Swimming	Get up from sitting and engage in simple physical activity before sitting again
When	Three Days Per Week	At regular intervals throughout the day
Where	Local Gym	In any location or situation where, prolonged sitting occurs
How Often	Three Days Per Week (e.g., Monday, Wednesday and Friday)	At regular intervals throughout the day (e.g., every hour).
With Whom	Alone or with a Family Member or Friend	Alone

5.4.1.4. *Step 4: Understanding the Problem*

I mapped evidence collected from the qualitative research presented in *Chapter 3: Barriers and Facilitators* onto the COM-B and TDF. This mapping enabled me to identify what might need to change for adults diagnosed with asthma to increase their physical activity and reduce their sedentary behaviour. This analysis and example data are presented in *Table 5.4*.

Table 5.4. *Combined COM-B and Theoretical Domains Framework Analysis*

COM-B	Theoretical Domains Framework	What Needs to Happen for the Target Behaviour to Occur?	Example of Evidence
Psychological Capability	Knowledge	Have an awareness of the benefits of physical activity and develop an understanding of why it might help asthma.	*"…it [physical activity] just mentally makes you feel happy, and you've got something to focus on"* (Participant 4)
		Know options for physical activities that can be done on symptom-free days and days when experiencing asthma symptoms.	*"There isn't really any guidance on sort of, you know if you are feeling this way why not try this. If you are feeling like this, then you can up it to that"* (Participant 3)
		Know where to start when trying to increase physical activity levels.	*"At that level of asthma [uncontrolled], there isn't any advice about exercise. It is 'Get stable. When you're controlled, you can exercise', but they tell uncontrolled asthmatics that they can exercise. But you can't exercise until you're controlled, and you end up sort of going for it and end up in hospital, or don't go for it and be told off for not doing it"* (Participant 9)
		Know how to manage asthma symptoms whilst being active.	*"So, I know it's not going to get any better, you know, but how do you manage something that could trigger off a life-threatening asthma attack anyway"* (Participant 2)
	Memory, Attention and Decision	Prioritise being active.	*"I guess the thing that influences it a lot more Is like you know that you've got something big to do the next day-"* (Participant 1)
	Behavioural Regulation	Set and complete goals to give a sense of achievement.	*"And kind of like go 'I've achieved that now'. That's good"* (Participant 1)

Physical Capability	Physical Skill	Have the physical capabilities to carry out the desired activity.	*"Because you know, regardless of what you say about my asthma symptoms, I don't have the physical fitness at the moment to do that"* (Participant 3)
Motivation	Professional/Social Role and Identity	Know how to be active safely with uncontrolled asthma.	*"At that level of [uncontrolled] asthma, there isn't any advice about exercise. It is 'Get stable. When you're controlled, you can exercise', but they tell uncontrolled asthmatics that they can exercise. But you can't exercise until you're controlled, and you end up sort of going for it and end up in hospital, or don't go for it and be told off for not doing it"* (Participant 9)
Motivation	Professional/Social Role and Identity	Explore acceptance of having asthma and its limitations.	*"You know if you are an asthmatic, you're not going to be able to, you know, do exactly what you want all of the time"* (Participant 6)
Motivation	Beliefs About Capabilities	Identify physical activities that they feel capable of doing.	*"Because I know what my current level is and it's not good. Erm, you know it's-it doesn't take much for me erm, I-I can do, I can walk for an hour, but I'll probably need my inhaler three or four times in that hour"* (Participant 2)
Motivation	Beliefs About Capabilities	Make physical activity flexibly enough to fit in with daily life.	*"But unfortunately, they changed the time of the erm, the erm, actual classes and it suddenly made that I wasn't able to get back from work to go"* (Participant 2)
Motivation	Beliefs About Capabilities	Address confidence with physical activity.	*"So, it's just-it's just having that erm, confidence [to be active) as well"* (Participant 4)
Motivation	Optimism	Address negative attitudes towards physical activity.	*"I want to do the most I can with it. So, I don't want to be inactive"* (Participant 5)
Motivation	Beliefs About Consequences	Address beliefs that consequences do not outweigh the benefits of physical activity.	*"But it just got to the point where I was just feeling I should go, I'm in too much pain I can't go, but I should go"* (Participant 5)

	Reinforcement	Find an enjoyable physical activity.	*"But at least maybe be like, even just like a list of a couple of ideas say like 'If you enjoy swimming, try starting out with this amount' or 'If you enjoy the gym try starting with this'"* (Participant 3)
		Provide positive reinforcement.	*"You know 'Get up you lazy bastard and go for a walk' that kind of thing, people don't like that"* (Participant 6)
	Intentions	Provide tailored support.	*"It's like physically, it's not like they don't want to, we physically can't do as much"* (Participant 4)
	Goals	Set achievable goals.	*"Chunks. Having like smaller milestones"* (Participant 1)
		Changing exercises to make them easier.	*"But I'm spreading it over like a longer time. So, instead of like 8 weeks, I'm going to do it like over 16 weeks"* (Participant 1)
	Emotion	Address negative emotions towards physical activity.	*"Waste of time"* (Participant 2)
		Address worries about being physically active.	*"Just you know exercise to me like I said has always been a bit of a worry"* (Participant 2)
Opportunity	Environment	Make physical activity accessible and affordable.	*"It were £10 a go. Erm, you know you are talking about; you know, a considerable, you know for one hours erm…event sort of thing a week. It was quite [expensive]-"* (Participant 2)
		Encourage adherence to asthma medication.	*"But then when I have to do physical activity, I have to take ten puffs of my inhaler beforehand or there'd be no point because I'll have an attack"* (Participant 4)
		Long wait times for help and support with physical activity.	*"It took an incredibly long time [to get help]"* (Participant 6)

		Barriers to attending existing physical activity programmes.	*"And oh boy. I couldn't go back there. You know, I just I had-I had to be discharged from physio because every time I went there erm, I couldn't-I couldn't go into the actual rooms where they were doing the physio, because I had an asthma attack*" (Participant 5)
		Additional support and guidance after a flare-up.	*"And I can time myself. I actually got to where I could go half an hour dancing straight on one inhaler dose. Erm, but I'll have to work up to that again, obviously once a flare-ups finished because I've had quite a lot of flare-ups this year, which is quite annoying"* (Participant 5)
Opportunity	Social	Social support from peers.	*"Yeah, because we all feel the same. You wouldn't be running with loads of normal people, and they wouldn't understand"* (Participant 4)
		Social support from healthcare providers.	*"When I came out of hospital, I didn't even get any leaflets about doing activity, and I had a three-months wait to see. From coming out of hospital-from somebody who has been in hospital for a month, erm to go under a GP and when I went to see the GP 2-days after I come out of a hospital"* (Participant 2)
		Social support from family and friends.	*"I think I do. I think I do. I mean my husband and my close friends are very supportive of this"* (Participant 5)

The resultant behavioural diagnosis indicated a potential need for change in all components of the COM-B and TDF for adults diagnosed with asthma to increase their physical activity and reduce their sedentary behaviour. The interviews and focus group presented in *Chapter 3: Barrier and Facilitators* revealed a number of findings that are important with respect to intervention development.

Firstly, with regards to *Capability*, findings revealed that participants knew the benefits of physical activity but lacked knowledge regarding preventing and managing their asthma symptoms whilst being active (*Knowledge*). They also did not know where to start when it came to increasing their physical activity or what activities are more suited to someone diagnosed with asthma (*Knowledge*). For participants, it was a complex decision whether to be physically active or not because they did not know if they could do this safely. They knew how easily their asthma symptoms would be triggered and they found it difficult to find a balance between being physically active and triggering their asthma symptoms (*Memory, Attention and Decision Processes*). For those who had negative experiences with being physically active in the past, particularly during their school years, this decision was even more difficult to make (*Memory, Attention and Decision Processes*). Due to their disease and the negative side effects of steroid medication, participants believed they did not have the physical capabilities to be physically active and meet national recommendations (*Physical Capabilities*). They believed that asthma controlled their lives and limited how physically active they could be (*Physical Capabilities*). The additional weight gain from steroid use made being physically active even more difficult (*Physical Capabilities*). Nevertheless, they believed increasing their physical activity levels would give them a sense of achievement and they had the desire to be more physically active (*Behavioural Regulation*).

In terms of *Opportunity*, findings suggest help and support with increasing physical activity needs to be accessible to all. Adults diagnosed with asthma have faced long wait times to be referred to pulmonary rehabilitation (*Environment*). For those who were referred, there were barriers to attending, including problems with travel and transport and not being suitable for those with co-morbidities (*Environment*). It was important for adults diagnosed with asthma to have the support of their friends and family, but what was more important for them was that they had the support of their healthcare providers (*Social Support*).

When they discussed physical activity with their healthcare providers, they did not want to feel like they were being 'punished' for not being physically active but were supported by them to make positive changes (*Social Support*).

Finally, with regard to *Motivation*, the findings suggest that individuals would be at different stages in their journeys to increasing their physical activity, so some would need more support than others (*Intentions*). This was particularly the case for those who had not accepted their disease (*Identity*). Adults diagnosed with asthma had to come to terms with not always being able to do what they wanted as their disease would only allow them to do so much (*Identity*). They had to learn about their own personal limitations and manage their own expectations to avoid disappointment when they were unable to do as much as they would have liked (*Identity*). Participants thought that individuals needed to identify an activity they enjoy as this made it more likely that they would continue to do it (*Reinforcement*). The activity needed to be something that they could fit into their daily lives and that they believed they were capable of doing (*Beliefs About Capabilities*).

Overall, adults diagnosed with asthma had a positive attitude towards physical activity (*Optimism*) but were worried about being physically active and feared triggering their asthma symptoms (*Emotion*). Although they knew the benefits of physical activity, they were uncertain whether the benefits of physical activity outweighed the potential negative consequences to their asthma (*Beliefs about Consequences*). Therefore, they chose to avoid physical activity for fear of triggering their asthma symptoms (*Beliefs about Consequences*). Participants mentioned that they were more motivated when they had a goal to work towards. Due to their physical limitations, it was important that goals were achievable, and that they could work at their own pace to increase their physical activity because of the unpredictability of their asthma (*Goals*). It was important for them that they were given positive reinforcement and gentle encouragement from their healthcare providers (*Reinforcement*).

5.4.1.5. Step 5: Understanding User Preferences

Analysis of focus group discussions presented in *Chapter 4: User Preferences* that explored user preferences for content and features revealed several important intervention components: (1) Tailored Physical Activity Suggestions; (2) Goal Setting; (3) Feedback and Notifications; (4) Information and Guidance; (5) Compatibility with Other Apps and Devices; (6) Social Support; (7) Competitions; (8) Achievements and Rewards. The results from this step are shown in *Table 5.5.*, where user preferences have been mapped to the findings from *Step 4: Understanding the Problem*.

Table 5.5. *User Preferences for Intervention Components*

COM-B (Theoretical Domains Framework)	What Needs to Change for the Target Behaviour to Occur?	User Preferences for Intervention Components	Example of Evidence	Does the User Preferences Meet the APPEASE Criteria?
Psychological Capability (Knowledge)	Have an awareness of the benefits of physical activity and develop an understanding of why it might help asthma.	1) Provide or Signpost to information on the benefits of being physically active with asthma.	*"What about the benefits of like asthma and exercise if you get what I mean? Like I found the more exercise I do, like the more I can do that makes sense? My asthma capacity and lung capacity improved"* (Participant 13)	Yes
	Know options for physical activities that can be done on symptom-free days and days when experiencing asthma symptoms.	1) Provide physical activity suggestions – *Activity suggestions will need to be tailored to users' asthma status and physical limitations.* 2) Provide or Signpost to online video demonstrations of physical activities suitable for people diagnosed with asthma.	*"I think the different levels [of intensity] sound really good as well. Particularly if you were to say-have an exacerbation and you needed to move back a bit to you know, build up your strength and fitness again"* (Participant 7)	Yes
	Know where to start when trying to increase physical activity levels.	1) Provide suggestions of low intensity 'beginner' level physical activities - Activity	*"But you could even do something like a seated workout because I know I, I've got only basically one functional leg at the moment and a lot of the yoga and stuff you can't do if you can't stand on both legs. But if*	Yes

		suggestions will need to be tailored to users' asthma status	*you're having a severe asthma day, standing up and walking around might be too much but actually doing some stretching and simple things is still being active, rather than just sitting there doing nothing"* (Participant 17)	
	Know how to manage asthma symptoms whilst being active.	1) Provide or Signpost to information on what to do in an emergency. 2) Signposting to credible resources. 3) Provide or Signpost to information about asthma action plans.	"I think it's really important to have something in there that says, if you think you're having an attack, call 999 -" (Participant 3)	Yes
Psychological Capability (Memory, Attention and Decision)	Prioritise being active.	1) Provide guidance on scheduling physical activity around daily life – *Goals should be specific including the time/date the activity will be undertaken.*	*"But I do like the idea of having something to schedule my activities and also, it's asking me questions about why I haven't done it. And then that will make me look at my own lifestyle a bit more and how I can rearrange things maybe, to sort of prioritise doing the things that I do actually want to do, but somehow, I'm not getting around to doing so"* (Participant 6)	Yes
Psychological Capability (Behavioural Regulation)	Set and complete goals to give a sense of achievement.	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.*	*"It's quite easy to like set a goal and then just not do it. So, having some accountability and have it written down like reminders, I think maybe you would be more likely to actually do it"* (Participant 19)	Yes

		2) Provide feedback on behaviour. 3) Provide users with digital rewards for completing goals (e.g., badges or trophies).		
Physical Capability (Physical Skill)	Have the physical capabilities to carry out the desired activity.	1) Provide physical activity suggestions with different levels of intensity – *Users need to be able to increase or decrease intensity depending on asthma status.* 2) Provide low impact physical activity suggestions (e.g., seated workouts).	*"I think what I found is, so I've got asthma, but I've also got a physical disability and so many of the apps you can't tailor it to you so half the exercises you sit and look at and go, 'Well, I can't do that'. Whether it's because of your asthma or whether it's because I can't physically do it. And actually, having that kind of flexibility is quite nice"* (Participant 17)	Yes
Motivation (Professional/Social Role and Identity)	Know how to be active safely with uncontrolled asthma.	1) Provide disclaimers on physical activity suggestions – *Users should be encouraged to discuss physical activity with their healthcare providers.* 2) Provide or Signpost to information about asthma and controlling symptoms whilst being active.	*"I mean Asthma UK; I've only looked at their Facebook and their web page and I've only done that recently because of this-the current sort of situation [COVID-19] has made me actually have a look at the page. But I think they do, you know, they give a bunch of information and then-but it also has a speak to your own healthcare provider kind of disclaimer, you must always speak to the doctor"* (Participant 6)	Yes

		3) Signposting to credible resources.		
	Explore acceptance of having asthma and its limitations.	1) Provide or Signpost to information about asthma and controlling symptoms whilst being active. 2) Provide guidance on setting realistic physical activity goals.	*"So, you know, various links to like Asthma UK and NHS website and things like that. So, it's all in one place, and it's all focused on asthma. I don't have anything else. It seems like a simple think, but I don't have any other asthma apps or anything that would collect all those for me."* (Participant 26	Yes
Motivation (Beliefs About Capabilities)	Identify physical activities that they feel capable of doing.	1) Encourage users to continue doing physical activities that they enjoy. 2) Provide guidance on setting realistic physical activity goals. 3) Persuade users that they can progressively increase their physical activity levels – *Motivational push notifications.*	*"Erm…and there's some were I think that's way too much for me. But started being really easy but actually there are others and I think yeah, I can do that one and its quite nice to be able to choose what it is you do"* (Participant 3)	Yes
	Make physical activity flexibly enough to fit in with daily life.	1) Provide guidance on scheduling physical activity around daily life – *Goals*	*"Erm...and finding the time to do the hit workouts and the things that I should be doing for myself, is kind of way down on my list. Whereas if I schedule in into a calendar or a phone that says to me, you know, 'Why*	Yes

		should be specific including the time/date the activity will be undertaken.	*haven't you done it'", that might actually make me prioritise it a bit more"* (Participant 6)	
	Address confidence with physical activity.	1) Provide users with a series of motivational push notifications – *Notifications can include telling them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.*	*"I like the congratulations cos I know when my Fitbit-if I get the little like firework because I've hit the 10,000 steps one day you feel like 'yey!' It doesn't matter how many times you get it; every time you get it you feel like [happy]"* (Participant 2)	Yes
Motivation (Optimism)	Address negative attitudes towards physical activity.	1) Provide users with a series of motivational push notifications – *Notifications can include promoting positive self-talk, advise them to think about or list previous success, telling them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.*	*"And it's a positive way of kind of doing it because I don't know who made the comment, but having to input your weight whatever, that can be quite negative and can lower your mood, but actually having-thinking about success and reflecting on the successes is a good kind of way of motivating yourself"* (Participant 14)	Yes
Motivation (Beliefs About Consequences)	Address beliefs that consequences do not outweigh the benefits of physical activity.	1) Provide or Signpost to information about asthma and controlling symptoms whilst being active.	*"What about the benefits of like asthma and exercise if you get what I mean? Like I found the more exercise I do, like the more I can do that makes sense?* 13)	Yes

		2) Provide or Signpost to information on the benefits of being physically active with asthma.		
Motivation (Reinforcement)	Find an enjoyable physical activity.	1) Encourage users to continue doing physical activities that they enjoy. 2) Provide physical activity suggestions – Activity *suggestions will need to be tailored to users' asthma status and physical limitations.*	*"For example, when you sign-up you could say here are the activities that I tend to do you know, so if it was doing stretchers with a resistance band for example and that's the only activity or exercise you could do and then-then great. Then the suggestions with the output would be tailored to that based on-so, again quite a smart algorithm would be needed to figure that out I suppose, but I think that's a great point"* (Participant 1)	Yes
	Provide positive reinforcement	1) Provide users with a series of motivational push notifications – *Notifications can include telling them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.* 2) Provide feedback on behaviour change.	*"They're not like naggy or making you feel bad, you're wrong. It's more like trying to like motivate you to keep going, which I think is key"* (Participant 19)	Yes
Motivation (Intensions)	Provide tailored support	1) Guide users to set their own realistic goals – *Suggested goals should be given to*	*"But having it so you set your own goals, they don't have to be big goals either"* (Participant 2)	Yes

		users based on their asthma status and current activity levels.		
Motivation (Goals)	Set achievable goals.	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Provide guidance on scheduling physical activity around daily life – *Goals should be specific including the time/date the activity will be undertaken.* 3) Prompt users to review the physical activity levels and goals – *Users should be able to 'tick off' goals when they are completed and visually see progress.* 4) Provide users with digital rewards for completing goals (e.g., badges or trophies). 5) Provide feedback on behaviour change.	*"I think it's pretty good idea. It's quite easy to like set a goal and then just not do it. So, having some accountability and have it written down like reminders, I think maybe you would be more likely to actually do it"* (Participant 19)	Yes

	Changing exercises to make them easier.	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Prompt users to change their goals if they are not being completed.	*"I like the variability within the levels because I don't know about the rest of you guys, but for me personally, there are some days were kind of trying to walk down a corridor can be-can be too much. So, having that easier level It's kind of nice"* (Participant 14)	Yes
Motivation (Emotion)	Address negative emotions towards physical activity.	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Provide or Signpost to information on the benefits of being physically active with asthma.	*"This week I've got a small goal, next week maybe up a little bit. Then next week up it a little bit. Don't feel like you've got to have such a large goal and then you're letting yourself down if you don't make it"* (Participant 2)	Yes
	Address worries about being physically active.	1) Provide or Signpost to information about asthma and controlling symptoms whilst being active. 2) Provide or Signpost to information on the benefits	*"I've had asthma since I was a kid, but arguably still don't really know like, what the best way to exercise with asthma is and I feel like I spend a lot of the time especially when it gets bad just being like, frustrated by it"* (Participant 24)	Yes

		of being physically active with asthma.		
Opportunity (Environment)	Encourage adherence to asthma medication.	1) Provide or Signpost to information about asthma action plans.	*"What you said about having the asthma, about the asthma plan, if that was actually attached in some way, you know, that could be part of the app your-you have a private page with your asthma plan on it"* (Participant 5)	Yes
Opportunity (Social)	Social support from peers.	1) Provide users with a platform to connect with other people diagnosed with asthma. 2) Provide users with competitions to compete with other people diagnosed with asthma.	*"I would say it'd be nice to have a community of people [with asthma] and maybe one way of doing it would be to have a Facebook group for app users"* (Participant 1)	Safety concerns regarding the false information that could be circulated if a discussion forum or something similar were to be included. It would not be affordable or practical to monitor. Competitions against other users could be included, as long as them are implemented correctly and will not discourage those would are 'not

				winning' or 'not doing well'.

One of the main features participants wanted to see included in the intervention was physical activity suggestions tailored to the user's interests, asthma status, and physical limitations, including low-intensity and seated workouts. In addition, they wanted support and guidance to set realistic goals and feedback so progress could be made. It was also thought that providing information about preventing and managing symptoms and being active safely with asthma could help to reduce fears and anxieties about physical activity. Participants thought that it was important to include social support, competitions, and rewards, such as digital badges or trophies, to sustain engagement with the intervention in the long-term.

Having identified user preferences for content and features, the APEASE criteria were used to determine the most appropriate user preferences. All targets were considered appropriate, except the ideas around social support and the inclusion of discussion forums. Participants in *Chapter 5: User Preferences* suggested that there could be safety issues with the circulation of false medical advice. This could make monitoring these forums costly and impractical. Instead, they suggested that competitions could be included to help social support. The best format for these would-be short competitions that re-start weekly to ensure that users do not lose motivation if they fall behind others.

5.4.2. Stage 2: Identifying Intervention Content and Implementation Options

5.4.2.1. Step 6: Selecting Intervention Functions

The BCW framework provides a table mapping relevant intervention functions likely to bring about change in specific COM-B and TDF domains. The activity identified seven key intervention functions: *Education, Persuasion, Incentivisation, Training, Environmental Restructuring, Modelling, and Enablement, to target the domains identified in Stage 1 – Step 4: Understanding the problem*. The results from this step are shown in *Table 5.6*, where the intervention functions have been mapped to the findings from *Stage 1 – Step 4: Understanding the Problem*. Examples of how intervention functions can be implemented within the context of supporting adults diagnosed with asthma to become more physically active and less sedentary have been included.

Table 5.6. *COM-B, Theoretical Domains, and Intervention Functions Mapping Table*

Stage 1 (Steps 1-5)		Stage 2 (Steps 6-8)	
COM-B (Theoretical Domains Framework)	**What Needs to Change for the Target Behaviour to Occur?**	**Intervention Function(s)**	**Example**
Psychological Capability (Knowledge)	Have an awareness of the benefits of physical activity and develop an understanding of why it might help asthma.	Education	Provide or signpost to information on the benefits of being physically active with asthma.
	Know options for physical activities that can be done on symptom-free days and days when experiencing asthma symptoms.	Education	Provide activity suggestions with different levels of intensity - *Activity suggestions will need to be tailored to the users' asthma status, current activity levels and interests.*
	Know where to start when trying to increase physical activity levels.	Education	Provide Suggestions of low intensity, 'beginner' activities that can be used to progressively increase activity levels - *Activity suggestions will need to be tailored to the users' asthma status, current activity levels and interests.*
	Know how to manage asthma symptoms whilst being active.	Education	Provide or signpost to information on how to be active safely with asthma.

Psychological Capability (Memory, Attention and Decision)	Prioritise being active.	Training, Environmental Restructuring and Enablement	Support patients to increase their physical activity and reduce their sedentary behaviour by helping patients to build activity into their daily routines. Prompts will be given to patients to aid with this - *Tailored prompts to be delivered to patients at times of the day when patient are more sedentary.*
Psychological Capability (Behavioural Regulation)	Set and complete goals to give a sense of achievement.	Education and Training	Encourage patients to set their own achievable goals. Patients will review goals and attention will be drawn to discrepancies between the patient's current behaviour and their goals - *Suggested goals will be given to patients based on their asthma status and current activity levels.*
Physical Capability (Physical Skill)	Have the physical capabilities to carry out the desired activity.	Training	Provide activity suggestions and demonstrations at varying levels of difficult and intensity. Beginner activities can act as a starting point, to increase physical fitness and muscle strength. Difficulty and intensity can be increased until recommendations are met - *Activity suggestions will need to be tailored to the users' asthma status, current activity levels and interests.*

Motivation (Professional/Social Role and Identity)	Know how to be active safely with uncontrolled asthma.	Education, Persuasion and Modelling	Provide information on how to be active safely with asthma.
	Explore acceptance of having asthma and its limitations.	Education, Persuasion and Modelling	Include testimonials from others who have benefited from being more active or Include testimonials from athletes who have asthma.
Motivation (Beliefs About Capabilities)	Identify physical activities that they feel capable of doing.	Education	Provide activity suggestions to gradually build-up activity levels - *Activity suggestions will need to be tailored to the users' asthma status, current activity levels and interests.*
	Make physical activity flexibly enough to fit in with daily life.	Persuasion	Provide patients with help and support to overcome barriers, increase their physical activity and reduce their sedentary behaviour.
	Address confidence with physical activity.	Education, Persuasion and Modelling	Tell them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.
Motivation (Optimism)	Address negative attitudes towards physical activity.	Education, Persuasion and Modelling	Tell them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.
Motivation (Beliefs About Consequences)	Address beliefs that consequences do not outweigh the benefits of physical activity.	Education, Persuasion and Modelling	Give them the opportunity to list and compare the pros and cons of physical activity.

Motivation (Reinforcement)	Find an enjoyable physical activity.	Training and Incentivisation	Encourage to continue doing activities that they enjoy.
	Provide positive reinforcement to be active.	Training and Incentivisation	Give rewards, such as virtual badges or trophies, for using the app, making progress towards goals, achieving goals and winning competitions.
Motivation (Intensions)	Provide tailored support.	Education and Persuasion.	Guide them to set their own realistic goals - Suggested goals should be given to patients based on their asthma status and current activity levels.
Motivation (Goals)	Set achievable goals.	Education, Persuasion and Incentivisation	Guide to set their own realistic goals - *Suggested goals will be given to patients based on their asthma status and current activity levels.*
	Changing exercises to make them easier.	Education, Persuasion and Incentivisation	Review goals and draw attention to discrepancies between current behaviour and their goals.
Motivation (Emotion)	Address negative emotions towards physical activity.	Persuasion and Modelling	To provide patients with activity suggestions to help them build up their physical activity levels and reduce negative emotions.
	Address worries about being physically active	Persuasion and Modelling	Provide information on how to be active safely with asthma
Opportunity	Make physical activity accessible and affordable.	Environmental Restructuring and Enablement	Patients will be given an app to download to provide them with help and support to

(Environmental Context and Resources)			increase their physical activity and reduce their sedentary behaviour.
	Encourage adherence to asthma medication.	Environmental Restructuring and Enablement	Advise patients to adhere to their medication regime to help facilitate changes to physical activity - *General advice can be given, so patients should be advised to speak to a healthcare professional if they have any questions.*
	Long wait times for help and support with physical activity.	Environmental Restructuring and Enablement	Patient will be given an app to download to provide them with help and support to reduce the time they spent sedentary and increase their physical activity levels.
	Barriers to attending existing physical activity programmes.	Environmental Restructuring and Enablement	Patient will be given an app to download to provide them with help and support to reduce the time they spent sedentary and increase their physical activity levels.
	Additional support and guidance after a flare-up.	Training and Environmental Restructuring	To prompt patients to consider what they could do in this situation.
Opportunity (Social)	Social support from healthcare providers.	Enablement	Encourage to seek help and guidance from healthcare providers if they have any questions.
	Social support from family and friends.	Enablement	Advise people to seek support from family and friends.

Following the *APEASE* criteria (*Table 5.7*), the following two intervention functions were not selected at this stage: Coercion and Restriction. I did not select these functions because it was important for participants in *Chapter 4: User Preferences* that they did not feel like they were being forced into being active or punished for not being physically active but instead played an active role in the self-management of their asthma, as detailed in *Chapter 3: Barriers and Facilitators*.

Table 5.7. *APEASE Analysis of Intervention Functions*

Intervention Functions	**Does the Intervention Function Meet the APEASE Criteria?**
Education	Yes
Persuasion	Yes
Incentivisation	Yes
Coercion	Not selected because it was important for participants that they did not feel like they were being forced into being active or punished for not being active (*Chapter 4: User Preferences*), but instead play an active role in the self-management of their asthma (*Chapter 3: Barriers and Facilitators*).
Training	Yes
Restriction	Not selected because it was important for participants that they did not feel like they were being forced into being active or punished for not being active (*Chapter 4: User Preferences*), but instead play an active role in the self-management of their asthma (*Chapter 3: Barriers and Facilitators*).
Environmental Restructuring	Yes
Modelling	Yes
Enablement	Yes
Selected Intervention Functions	Education, Persuasion, Incentivisation, Training, Environmental Restructuring, Modelling an Enablement

5.4.2.2. Step 7: Selecting Policy Categories

Similarly, to *Step 6: Selecting Intervention Functions*, the BCW framework provides a table linking intervention functions with policy categories. Using this and considering the APEASE criteria, I identified *Service Provision* as the most appropriate policy category to help support and enact the intervention (*Table 5.8.*). *Service Provision* can be used to deliver the intervention functions selected during *Step 6: Selecting Intervention Functions: Education, Persuasion, Incentivisation, Coercion, Training, Modelling and Enablement*. However, participants in *Chapter 3: Barriers and Facilitators*, suggested that asthma specific physical activity *Guidelines* are needed, specifically for people with severe symptoms. Furthermore, participants from the focus groups conducted in *Chapter 3: Barriers and Facilitators* and *Chapter 4: User Preferences* believed that more was needed to communicate how life-threatening asthma can be and the importance of staying physically active in the media, which is something else that could be explored using *Communication/Marketing* in the future.

Table 5.8. *APEASE Analysis of Policy Categories*

Intervention Functions	**Does the Policy Category Meet the APEASE Criteria?**
Communication/Marketing	No – Possible in the long-term to increase awareness of asthma and the benefits of physical activity (*Chapter 3: Barriers and Facilitators* and *Chapter 4: User Preferences*).
Guidelines	No – Might be possible in the long-term to specify physical activity guidelines to help with asthma self-management, but this could be difficult due to the variability of asthma and personal limitations (*Chapter 3: Barriers and Facilitators*).
Fiscal Measures	No – Not Relevant for this current intervention.
Regulation	No – Not Relevant for this current intervention.
Legislation	No – Not Relevant for this current intervention.
Environmental/Social Planning	No – Not Relevant for this current intervention.
Service Provision	Yes

5.4.2.3. Step 8: Identifying Behaviour Change Techniques

Mapping BCTs to intervention functions involved two steps. Firstly, I used The Theory and Techniques Tool (Carey et al., 2018) to select BCTs that had a link to the intervention functions selected in *Step 6: Selecting Intervention Functions* to provide a list of BCTs for this intervention. Secondly, to help narrow down the list of results, the findings from *Chapter 2: Review of Existing Interventions* was used to identify effective BCTs for inclusion. The most commonly used BCTs in effective interventions were: '*Action Planning*' (100%); '*Goal Setting*' (100%); '*Instruction on how to Perform the Behaviour*' (89%); '*Demonstration of Behaviour*' (89%); and '*Behavioural Practice/Rehearsal*' (89%). Although the review could not identify specific BCTs that showed promise of effectiveness due to the similarities of the BCTs used across all intervention groups, they are well evidenced in the literature (Howlett et al., 2018; Samdal et al., 2017).

For example, the behavioural analysis in *Stage 1*, informed by the results presented in *Chapters 3: Barriers and Facilitators and Chapter 4: User Preferences*, revealed *Beliefs about Capabilities* as a barrier to physical activity. Using the Theory of Techniques Tool, *Beliefs about Capabilities* has been linked to the BCTs: *1.2. Problem Solving, 4.1. Instructions on How to Perform Behaviour, 6.1. Demonstration of Behaviour, 8.1. Behavioural Practice/Rehearsal, 8.7. Graded Tasks, 15.1. Verbal Persuasion About Capability, 15.3. Focus on Past Success*, and *15.4 Self-Talk (Figure 5.6.).* Techniques from this list that were commonly used in effective interventions were highlighted as important for inclusion in the intervention. *Table 5.9* presents the final BCTs selected from this process, their corresponding COM-B, TDF and Intervention Functions, and the APEASE criteria analysis.

Figure 5.6. *Example of Selecting Behaviour Change Techniques Using the Theory of Techniques Tool (Carey et al., 2018).* ***Emboldened*** *text indicates BCTs identified in Chapter 2: Review of Existing Interventions and Important for Inclusion*

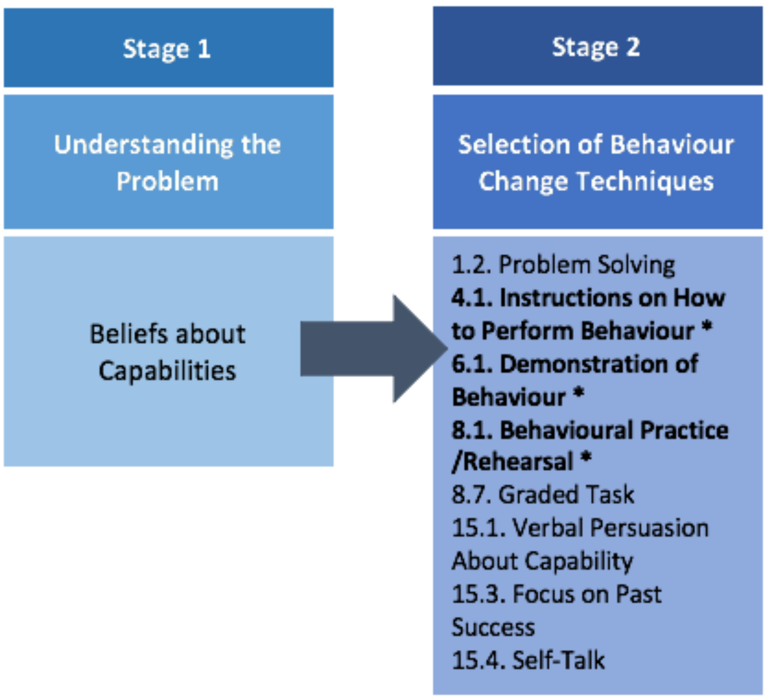


Table 5.9. *COM-B, Theoretical Domains, Intervention Functions and Behaviour Change Techniques Mapping Table*

Stage 1 (Steps 1-5)		Stage 2 (Steps 6-8)		
COM-B (Theoretical Domains Framework)	**What Needs to Change for the Target Behaviour to Occur?**	**Intervention Function(s)**	**Behaviour Change Technique(s)**	**Does the BCT Meet the APEASE Criteria?**
Psychological Capability (Knowledge)	Have an awareness of the benefits of physical activity and develop an understanding of why it might help asthma.	Education	5.1. Information About Health Consequences	Yes
	Know options for physical activities that can be done on symptom-free days and days when experiencing asthma symptoms.	Education	4.1. **Instruction on How to Perform Behaviour**	Yes
	Know where to start when trying to increase physical activity levels.	Education	4.1. **Instruction on How to Perform Behaviour**	Yes
	Know how to manage asthma symptoms whilst being active.	Education	4.1. **Instruction on How to Perform Behaviour** 5.1. Information About Health Consequences	Yes
Psychological Capability (Memory, Attention and Decision)	Prioritise being active.	Training, Environmental Restructuring and Enablement	1.2. Problem Solving 4.1. **Instructions on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour** 8.7. Graded Tasks	Yes

			15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4. Self-Talk	
Psychological Capability (Behavioural Regulation)	Set and complete goals to give a sense of achievement.	Education and Training	1.1. **Goal Setting (Behaviour)** 1.4. **Action Planning** 2.4. Self-Monitoring of Outcomes of Behaviour	Yes
Physical Capability (Physical Skill)	Have the physical capabilities to carry out the desired activity.	Training	4.1. **Instruction on How to Perform the Behaviour** 8.1. **Behavioural Practice/Rehearsal** 8.7. Graded Tasks	Yes
Motivation (Professional/Social Role and Identity)	Know how to be active safely with uncontrolled asthma.	Education, Persuasion and Modelling	4.1. **Instruction on How to Perform Behaviour** 5.1. Information About Health Consequences 9.1. Credible Source 6.2. Social Comparison	Yes
	Explore acceptance of having asthma and its limitations.	Education, Persuasion and Modelling	9.1. Credible Source 6.2. Social Comparison	Yes
Motivation (Beliefs About Capabilities)	Identify physical activities that they feel capable of doing.	Education	1.2. Problem Solving 4.1. **Instructions on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour** 8.1. **Behavioural Practice/Rehearsal** 8.7. Graded Tasks	Yes

			15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4 Self-Talk	
	Make physical activity flexibly enough to fit in with daily life.	Persuasion	1.2. Problem Solving	Yes
	Address confidence with physical activity.	Education, Persuasion and Modelling	1.2. Problem Solving 4.1. **Instructions on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour** 8.7. Graded Tasks 15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4 Self-Talk 10.4. Social Reward	Yes
Motivation (Optimism)	Address negative attitudes towards physical activity.	Education, Persuasion and Modelling	5.1. Information About Health Consequences	Yes
Motivation (Beliefs About Consequences)	Address beliefs that consequences do not outweigh the benefits of physical activity.	Education, Persuasion and Modelling	5.1. Information About Health Consequences 92. Pros and Cons	Yes
Motivation (Reinforcement)	Find an enjoyable physical activity.	Training and Incentivisation	5.1. Information About Health Consequences	Yes
	Provide positive reinforcement to be active.	Training and Incentivisation	2.2. Feedback on Behaviour 10.4. Social Reward 10.6. Non-Specific Reward 10.9. Self-Reward	Yes

Motivation (Intensions)	Provide tailored support.	Education and Persuasion.	5.1. Information About Health Consequences	Yes
Motivation (Goals)	Set achievable goals.	Education, Persuasion and Incentivisation	1.1. **Goal Setting (Behaviour)** 1.4. **Action Planning** 1.5. Review Behaviour Goal(s) 1.6. Discrepancy Between Current Behaviour and Goal	Yes
	Changing exercises to make them easier	Education, Persuasion and Incentivisation	1.1. **Goal Setting (Behaviour)** 1.4. **Action Planning** 1.5. Review Behaviour Goal(s) 1.6. Discrepancy Between Current Behaviour and Goal 8.7. Graded Tasks	Yes
Motivation (Emotion)	Address negative emotions towards physical activity.	Persuasion and Modelling	9.2. Pros and Cons	Yes
	Address worries about being active.	Persuasion and Modelling	9.2. Pros and Cons 15.4. Self-Talk	Yes
Opportunity (Environmental Context and Resources)	Make physical activity accessible and affordable.	Environmental Restructuring and Enablement	12.5. Adding Objects to the Environment	Yes
	Encourage adherence to asthma medication.	Environmental Restructuring and Enablement	11.1. Pharmacological Support	Yes
	Long wait times for help and support with physical activity.	Environmental Restructuring and Enablement	12.5. Adding Objects to the Environment	Yes
	Barriers to attending existing physical activity programmes.	Environmental Restructuring and Enablement	12.5. Adding Objects to the Environment	Yes

	Additional support and guidance after a flare-up.	Training and Environmental Restructuring	1.2. Problem Solving 4.1. **Instructions on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour** 8.1. **Behavioural Practice/Rehearsal** 8.7. Graded Tasks 15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4. Self-Talk	Yes
Opportunity (Social)	Social support from healthcare providers.	Enablement	3.2. Social Support (Practical) 3.3. Social Support (Emotional)	Yes
	Social support from family and friends.	Enablement	3.2. Social Support (Practical) 3.3. Social Support (Emotional)	Yes
Emboldened text indicates BCTs identified in from the systematic review presented in *Chapter 2: Review of Existing Interventions*.				

5.4.2.4. Step 9: Selecting Mode of Delivery

In line with the long-term goal of the NHS (2019) to expand the use of technology for healthcare services and Asthma UK's (2016) recommendations for technology-based solutions to asthma management, the original concept for this intervention was distance delivery in the form of an mHealth intervention; specifically, a smartphone app. As explained in *Chapter 1: Introduction*, mHealth could be used as a potential solution to the barriers of attending traditional face-to-face medical interventions such as pulmonary rehabilitation and can increase the number of individuals who can receive the help and support, they need to increase their physical activity and reduce their sedentary behaviour. The chosen mode of delivery met the APEASE criteria. Distance delivery via a smartphone app was accepted by participants in *Chapter 4: User Preferences* who wanted the app to be available to download in the app stores and awareness to be spread using social media. However, it was important for them that the app had the approval of their healthcare providers. Therefore, if the intervention was efficacious and cost-effective, healthcare providers could signpost patients to it. I also decided that a person-centred delivery approach should be utilised, as it was frequently discussed during the interviews and focus group in *Chapter 3: Barriers and Facilitators* that a one-size-fits-all approach would not work, and a tailored approach would be needed. The intensity of the activity and the duration of the intervention would be up to the user. However, tailored suggestions would be given based on the users' current activity levels and asthma control. Although some participants in *Chapter 4: User Preferences* could see themselves continuously using the app to track their activity levels, others saw the app as something they would use until they had met their goals and come back to if they had a flare-up in their asthma and had to build up their activity levels again.

5.4.3. Intervention Design

5.4.3.1. Translating BCTs Into Intervention Features

Once I had identified potentially effective BCTs in *Step 8: Identifying Behaviour Change Techniques*, I translated them into smartphone app features. Findings on user preferences identified in *Step 5: Understanding User Preferences* influenced decision-making during this process. For example, to deliver the BCTs linked to *Beliefs about Capabilities*, users will be encouraged to continue doing physical activities that they enjoy doing. However, for those who do not know where to start, users will be provided with activity suggestions tailored to their asthma status and physical limitations. Suggestions will initially be generated by completing a short questionnaire during sign-up but can be updated. As suggested by participants in *Chapter 4: User Preferences,* users will be provided with or signposted to online video demonstrations of the suggested activities suitable for people diagnosed with asthma instead of still images (Figure 5.7). *Table 5.10* provides an overview of the included BCTs and corresponding intervention features.

Figure 5.7. *Example of Translating Behaviour Change Techniques into Intervention Functions*

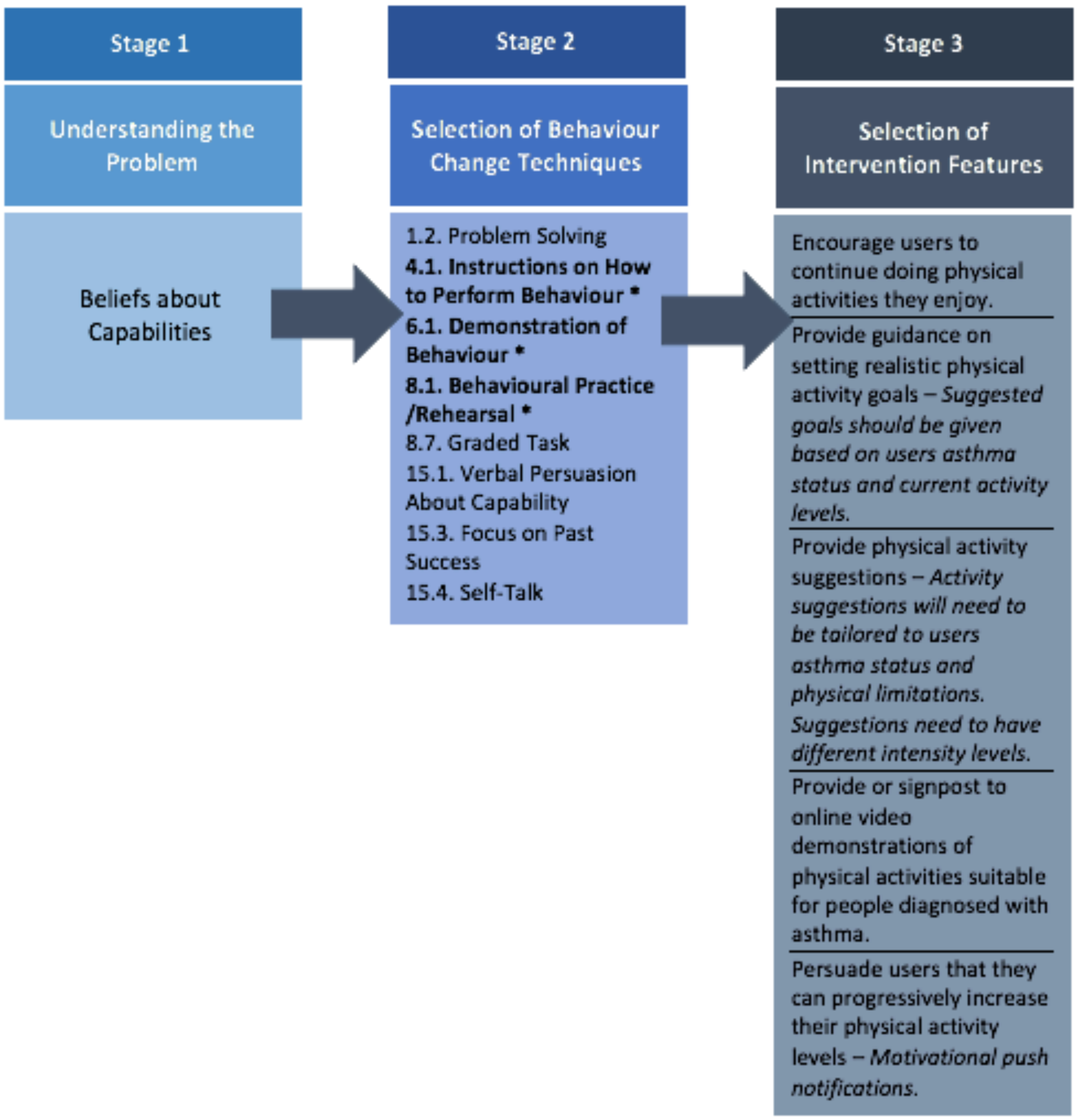


Table 5.10. *Translating Behaviour Change Techniques into Intervention Features*

Stage 1 (Steps 1-5)		Stage 2 (Steps 6-8)		Stage 3
COM-B (Theoretical Domains Framework)	**What Needs to Change for the Target Behaviour to Occur?**	**Intervention Function(s)**	**Behaviour Change Technique(s)**	**Intervention Features**
Psychological Capability (Knowledge)	Have an awareness of the benefits of physical activity and develop an understanding of why it might help asthma.	Education	5.1. Information About Health Consequences	1) Provide or signpost to information on the benefits of being physically active with asthma. 2) Signpost to credible resources.
	Know options for physical activities that can be done on symptom-free days and days when experiencing asthma symptoms.	Education	4.1. Instruction on How to Perform Behaviour 6.1. Demonstration of the Behaviour	1) Provide physical activity suggestions – Activity *suggestions will need to be tailored to users' asthma status and physical limitations.* 2) Provide or signpost to online video demonstrations of physical activities suitable for

				people diagnosed with asthma.
	Know where to start when trying to increase physical activity levels.	Education	4.1. **Instruction on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour**	1) Provide suggestions of low intensity 'beginner' level physical activities - Activity *suggestions will need to be tailored to users' asthma status* 2) Provide or signpost to online video demonstrations of physical activities suitable for people diagnosed with asthma.
	Know how to manage asthma symptoms whilst being active.	Education	5.1. Information About Health Consequences	1) Provide or signpost to information on what to do in an emergency. 2) Signpost to credible resources. 3) Provide or signpost to information about asthma action plans.
Psychological Capability	Prioritise being active.	Training, Environmental Restructuring and Enablement	1.4. Problem Solving	1) Provide guidance on scheduling physical activity around daily life – *Goals*

(Memory, Attention and Decision)				*should be specific including the time/date the activity will be undertaken.*
Psychological Capability (Behavioural Regulation)	Set and complete goals to give a sense of achievement.	Education and Training	1.2. **Goal Setting (Behaviour)** 1.4. **Action Planning** 2.2. Feedback on Behaviour 2.4. Self-Monitoring of Outcomes of Behaviour	1) Provide guidance on setting realistic physical activity goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Track and monitor physical activity. 3) Provide feedback on behaviour – *Weekly progress reports and push notifications.* 4) Provide users with digital rewards for completing goals (e.g., badges or trophies).
Physical Capability (Physical Skill)	Have the physical capabilities to carry out the desired activity.	Training	4.1. **Instruction on How to Perform the Behaviour** 6.1. **Demonstration of the Behaviour** 8.1. **Behavioural Practice/Rehearsal** 8.7. Graded Tasks	1) Provide physical activity suggestions with different levels of intensity – *Users need to be able to increase or decrease intensity*

				depending on asthma status. 2) Provide low impact physical activity suggestions (e.g., seated workouts). 3) Provide or signpost to online video demonstrations of physical activities suitable for people diagnosed with asthma.
Motivation (Professional/Social Role and Identity)	Know how to be active safely with uncontrolled asthma.	Education, Persuasion and Modelling	4.1. **Instruction on How to Perform Behaviour** 5.1. Information About Health Consequences 9.1. Credible Source	1) Provide disclaimers on physical activity suggestions – *Users should be encouraged to discuss physical activity with their healthcare providers.* 2) Provide or signpost to information about asthma and controlling symptoms whilst being active. 3) Signpost to credible resources.

	Explore acceptance of having asthma and its limitations.	Education, Persuasion and Modelling	9.1. Credible Source 6.2. Social Comparison	1) Provide or signpost to information about asthma and controlling symptoms whilst being active. 2) Signpost to credible resources. 3) Provided testimonies from other people diagnosed with asthma who are physically active. 4) Provide guidance on setting realistic physical activity goals – *Suggested goals should be given to users based on their asthma status and current activity levels.*
Motivation (Beliefs About Capabilities)	Identify physical activities that they feel capable of doing.	Education	1.2. Problem Solving 4.1. **Instructions on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour** 8.1. **Behavioural Practice/Rehearsal** 8.7. Graded Tasks 15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success	1) Encourage users to continue doing physical activities that they enjoy. 2) Provide guidance on setting realistic physical activity goals – *Suggested goals should be given to users based on their asthma*

			15.4Self-Talk	*status and current activity levels.* 3) Provide physical activity suggestions – Activity *suggestions will need to be tailored to users asthma status and physical limitations.* 4) Provide or signpost to online video demonstrations of physical activities suitable for people diagnosed with asthma. 5) Persuade users that they can progressively increase their physical activity levels – *Motivational push notifications.*
	Make physical activity flexibly enough to fit in with daily life.	Persuasion	1.2. Problem Solving	1) Provide guidance on scheduling physical activity around daily life – *Goals should be specific including the time/date the activity will be undertaken.*

	Address confidence with physical activity.	Education, Persuasion and Modelling	15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4 Self-Talk 10.4. Social Reward	1) Provide users with a series of motivational push notifications – *Notifications can include telling them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.*
Motivation (Optimism)	Address negative attitudes towards physical activity.	Education, Persuasion and Modelling	5.1. Information About Health Consequences 15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4 Self-Talk 10.4. Social Reward	1) Provide or signpost to information on the benefits of being physically active with asthma. 2) Provide users with a series of motivational push notifications – *Notifications can include promoting positive self-talk, advise them to think about or list previous success, telling them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.*

Motivation (Beliefs About Consequences)	Address beliefs that consequences do not outweigh the benefits of physical activity.	Education, Persuasion and Modelling	5.1. Information About Health Consequences 9.2. Pros and Cons	3) Provide or signpost to information about asthma and controlling symptoms whilst being active. 4) Provide or signpost to information on the benefits of being physically active with asthma.
Motivation (Reinforcement)	Find an enjoyable physical activity.	Training and Incentivisation	5.1. Information About Health Consequences	1) Encourage users to continue doing physical activities that they enjoy
	Provide positive reinforcement to be active.	Training and Incentivisation	2.2. Feedback on Behaviour 10.4. Social Reward 10.6. Non-Specific Reward 10.9. Self-Reward	1) Provide users with a series of motivational push notifications – *Notifications can include telling them that they can successfully perform the activity, arguing against self-doubts and asserting that they will succeed.* 2) Provide feedback on behaviour – *Weekly progress reports and push notifications.*
Motivation	Provide tailored support.	Education and Persuasion.	5.1. Information About Health Consequences	1) Provide physical activity suggestions with different

(Intensions)				levels of intensity – *Users need to be able to increase or decrease intensity depending on asthma status.* 2) Provide low impact physical activity suggestions (e.g., seated workouts). 3) Provide or signpost to online video demonstrations of physical activities suitable for people diagnosed with asthma.
Motivation (Goals)	Set achievable goals.	Education, Persuasion and Incentivisation	1.2. **Goal Setting (Behaviour)** 1.4. **Action Planning** 1.5. Review Behaviour Goal(s) 1.6. Discrepancy Between Current Behaviour and Goal 2.2. Feedback on Behaviour	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Provide guidance on scheduling physical activity around daily life – *Goals should be specific including*

				the time/date the activity will be undertaken. 3) Prompt users to review the physical activity levels and goals – *Users should be able to 'tick off' goals when they are completed and visually see progress.* 4) Provide users with digital rewards for completing goals (e.g., badges or trophies). 5) Provide feedback on behaviour – *Weekly progress reports and push notifications.*
	Changing exercises to make them easier	Education, Persuasion and Incentivisation	1.2. **Goal Setting (Behaviour)** 1.4. **Action Planning** 1.5. Review Behaviour Goal(s) 1.6. Discrepancy Between Current Behaviour and Goal	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Prompt users to review the physical activity levels and goals – *Users should be able to 'tick off' goals when they*

				are completed and visually see progress. 3) Prompt users to change their goals if they are not being completed.
Motivation (Emotion)	Address negative emotions towards physical activity.	Persuasion and Modelling	5.1. Information About Health Consequences	1) Provide or signpost to information on the benefits of being physically active with asthma.
	Address worries about being active.	Persuasion and Modelling	9.2. Pros and Cons 15.4. Self-Talk	1) Provide or signpost to information about asthma and controlling symptoms whilst being active. 2) Provide or signpost to information on the benefits of being physically active with asthma.
Opportunity (Environmental Context and Resources)	Make physical activity accessible and affordable.	Environmental Restructuring and Enablement	12.5. Adding Objects to the Environment	1) Provide or signpost to information about asthma action plans.
	Encourage adherence to asthma medication.	Environmental Restructuring and Enablement	11.1. Pharmacological Support	1) Provide users with a platform to connect with other people diagnosed with asthma.

				2) Provide users with competitions to compete with other people diagnosed with asthma.
	Long wait times for help and support with physical activity.	Environmental Restructuring and Enablement	12.5. Adding Objects to the Environment	1) Guide users to set their own realistic goals – *Suggested goals should be given to users based on their asthma status and current activity levels.* 2) Provide feedback on behaviour. 3) Provide users with digital rewards for completing goals (e.g., badges or trophies).
	Barriers to attending existing physical activity programmes.	Environmental Restructuring and Enablement	12.5. Adding Objects to the Environment	1) Provide physical activity suggestions with different levels of intensity – *Users need to be able to increase or decrease intensity depending on asthma status.* 2) Provide low impact physical activity

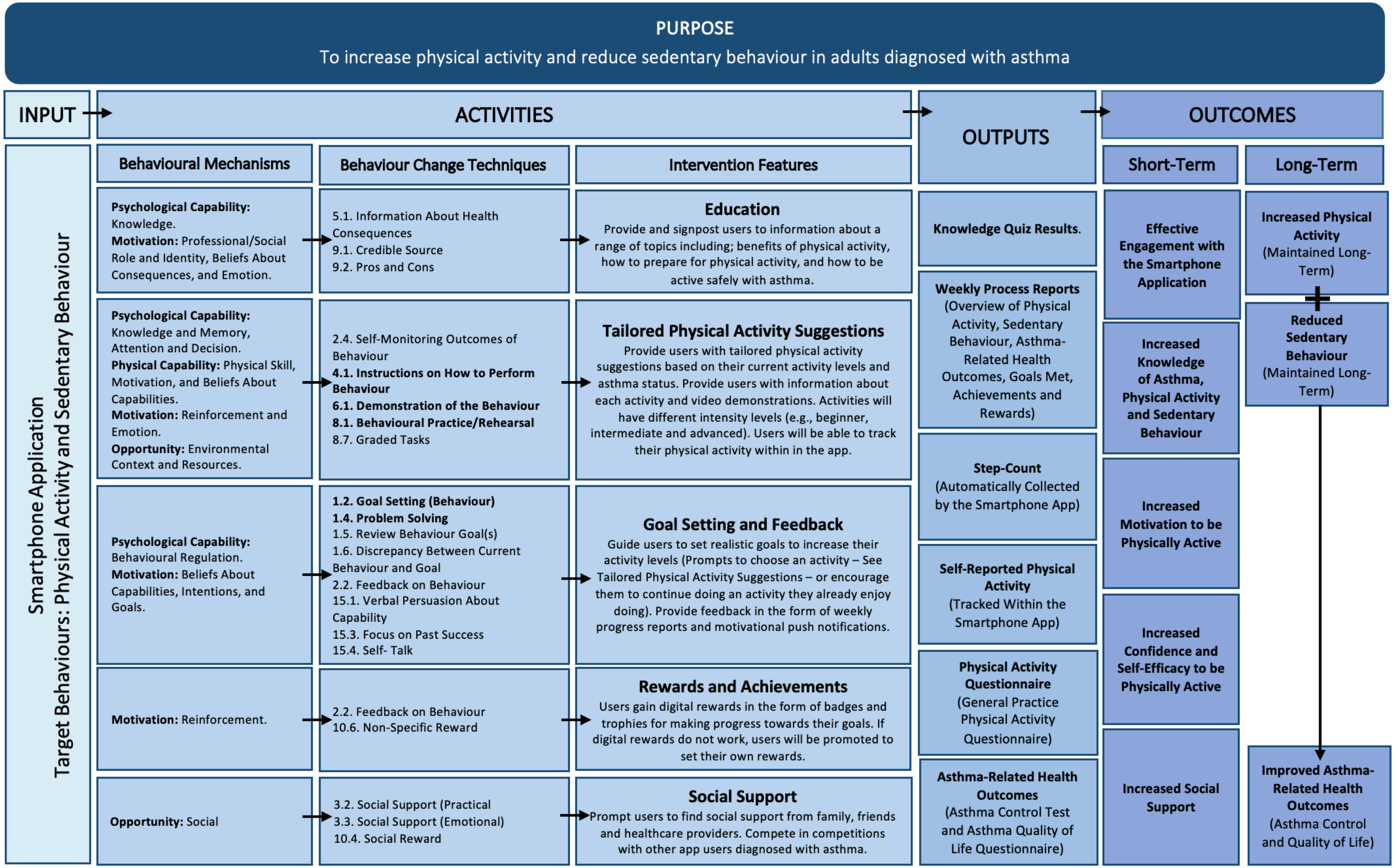
				suggestions (e.g., seated workouts).
	Additional support and guidance after a flare-up.	Training and Environmental Restructuring	1.2. Problem Solving 4.1. **Instructions on How to Perform Behaviour** 6.1. **Demonstration of the Behaviour** 8.1. **Behavioural Practice/Rehearsal** 8.7. Graded Tasks 15.1. Verbal Persuasion About Capability 15.3. Focus on Past Success 15.4. Self-Talk	1) Provide disclaimers on physical activity suggestions – *Users should be encouraged to discuss physical activity with their healthcare providers.* 2) Provide or signpost to information about asthma and controlling symptoms whilst being active. 3) Signposting to credible resources.
Opportunity (Social)	Social support from healthcare providers.	Enablement	3.2. Social Support (Practical) 3.3. Social Support (Emotional)	1) Provide or signpost to information about asthma and controlling symptoms whilst being active. 2) Provide guidance on setting realistic physical activity goals.
	Social support from family and friends.	Enablement	3.2. Social Support (Practical) 3.3. Social Support (Emotional)	1) Encourage users to continue doing physical activities that they enjoy.

				2) Provide guidance on setting realistic physical activity goals. 3) Persuade users that they can progressively increase their physical activity levels – *Motivational push notifications.*
Emboldened text indicated BCTs identified in from the systematic review presented in *Chapter 2 – Review of Existing Interventions.*				

5.4.3.2. *Programme Theory and Interactive Mock-Ups*

All intervention features were selected with the long-term goal of increasing physical activity and reducing sedentary behaviour in adults diagnosed with asthma. With these improvements, we would hope to see a positive effect on asthma-related health outcomes, such as asthma control and quality of life. Users will be encouraged to seek support from their friends, family, and healthcare providers, so how they respond could impact how the user engages with the intervention. The programme theory is represented in the logic flow chart (*Figure 5.8*) to explain the mechanisms of the intervention and how the intervention features are expected to work, the outputs of the intervention, and the short-term and long-term outcomes. I developed interactive mock-ups using *Adobe XD*. Icons and images can be clicked on to move to another area of the design to reflect how the app would work in practice. Each intervention feature included in the programme theory is detailed below, along with figures exported from the interactive mock-ups.

Figure 5.8. *Programme Theory Represented as a Logic Flow Chart*



5.4.3.3. *Creating a Profile*

When first downloading the app, the user will be prompted to register and make an account. The app will collect general information about the user, such as their name and age, as well as their current activity levels using the *General Practice Physical Activity Questionnaire* (Department of Health and Social Care, 2013), their perceived level of asthma control using the *Asthma Control Test* (Nathan et al., 2004) and quality of life using the *Asthma Quality of Life Questionnaire* (Juniper et al., 1999). Information about the physical activities they already do and activities they would be interested in doing will also be collected. This information will be used to tailor the app to the user, providing them with activity and goal suggestions (see 6*.4.3.5. Goal Setting and Feedback* and *6.4.3.6. Tailored Physical Activity Suggestions for more detail*). Questionnaires will be re-taken weekly to update suggestions and collect data from users that can be used in the evaluation of the intervention. Furthermore, as suggested by participants in *Chapter 4: User Preferences*, users will be able to customise their profile by editing their homepage and changing the colour scheme in the settings menu.

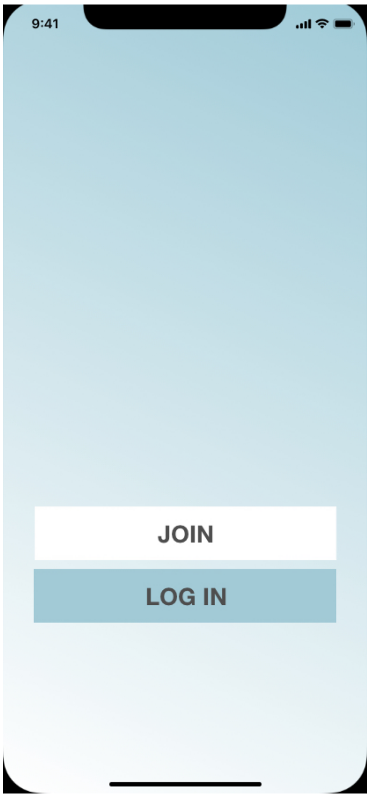


Figure 5.9. *Log-In Screen*

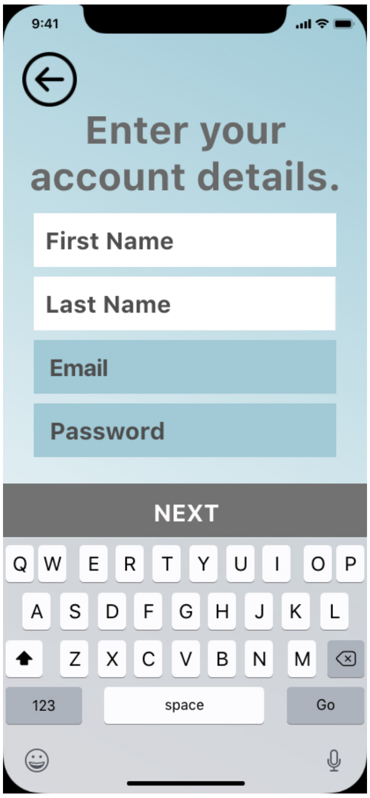


Figure 5.10. *Creating a Profile – Account Information*

Figure 5.11. *Creating a Profile – Demographic Information*

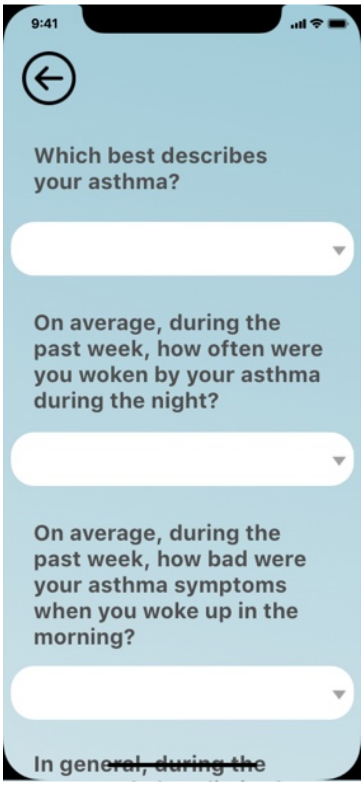


Figure 5.12. Creating a Profile - *Tailoring Questions 1*

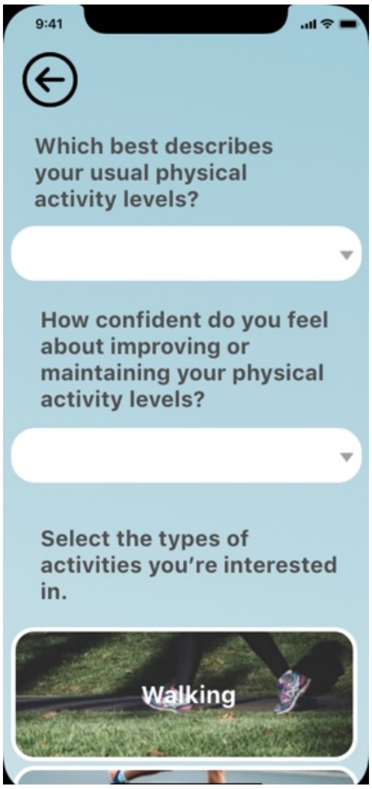


Figure 5.13. Creating a Profile - *Tailoring Questions 2*

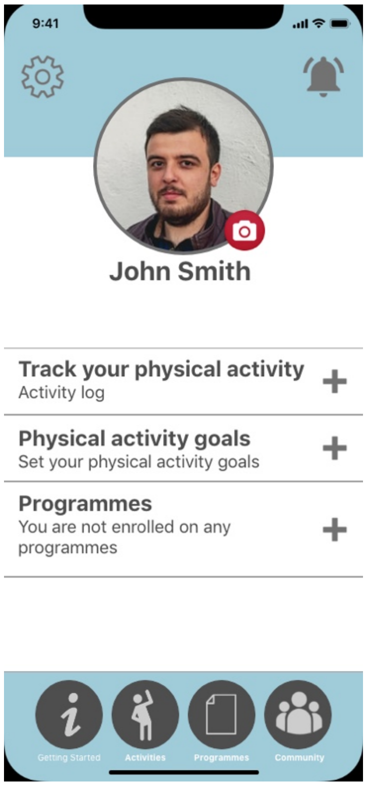


Figure 5.14. *Main Homepage*

5.4.3.4. Education

In the short-term, educational features will be used to increase users' motivation and self-efficacy in being active by knowing how to safely participate in physical activity and encouraging them to look at physical activity more positively to achieve the long-term goal. From the interviews and the focus group conducted in *Chapter 3: Barriers and Facilitators*, participants had a negative view of physical activity. They believed that the benefits did not outweigh the potential negative consequences to their asthma. It is hoped that the educational features will help users to feel less worried about being physically active as they will know how to prepare properly for physical activity and how to prevent and manage their asthma symptoms whilst being active. To make this more interactive, users will be given a quiz to determine the most appropriate information and guidance for them. For example, if the quiz determines that the user does not know the benefits of physical activity for asthma, the app will suggest they read '*Is physical activity good for my asthma?*'. Again, this data could also be used in the evaluation of the intervention. Chosen topics were based on findings from *Chapter 4: User Preferences*, which highlighted several essential topics to cover. Some of the topics covered will include the benefits of physical activity, how to prepare for physical activity, how to be active safely with asthma and what to do in an asthma-related emergency. Users will also be signposted to other credible resources to explore these topics further, for example, NHS websites and Asthma+Lung UK.

Figure 5.15. *Education - Homepage*

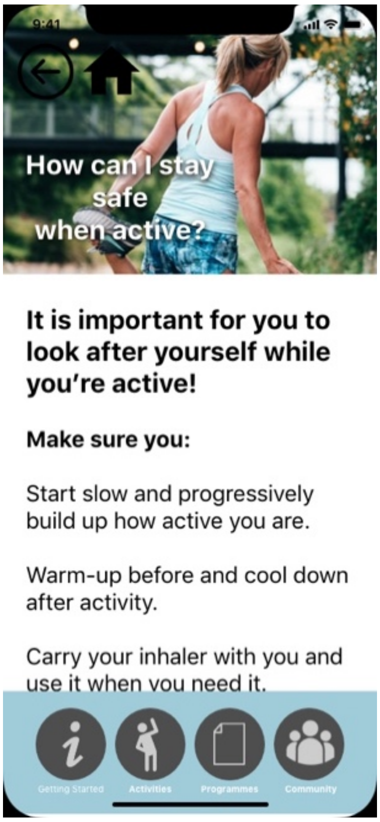


Figure 5.16. Education - *Information on 'How Can I Stay Safe When Active?'*

Figure 5.17. Education - *Information on 'Is Physical Activity Good for my Asthma?"*

5.4.3.5. Goal Setting and Feedback

Results from Chapter 2: Review of Existing Interventions, identified Goal Setting (Behaviour) and *Problem Solving* as effective BCTs to include in the intervention. Therefore, the app will guide users to set realistic activity goals, being specific about when, where, how often and with whom (optional) they will take part in the activity. The app will prompt users to select an activity from the activity suggestions (see *5.3.2.4. Tailored Physical Activity Suggestions*) or encourage them to continue doing or increase an activity they already enjoy. Results presented in *Chapter 4: User Preferences* showed that participants believed they would be more likely to complete a goal they had set themselves as they knew what they were capable of but initially would like some guidance on setting goals. This initial guidance is important, as participants in *Chapter 3: Barriers and Facilitators* discussed how they did not know where to start when it came to increasing their physical activity levels. Therefore, goal suggestions will be initially generated based on the sign-up questionnaire and updated based on users' activity levels during the previous week and updated *Asthma Control Test* (Nathan et al., 2004) and Asthma Quality of Life Questionnaire (Juniper et al., 1999) results. Users can set up activity reminders through push notifications to support goal achievement.

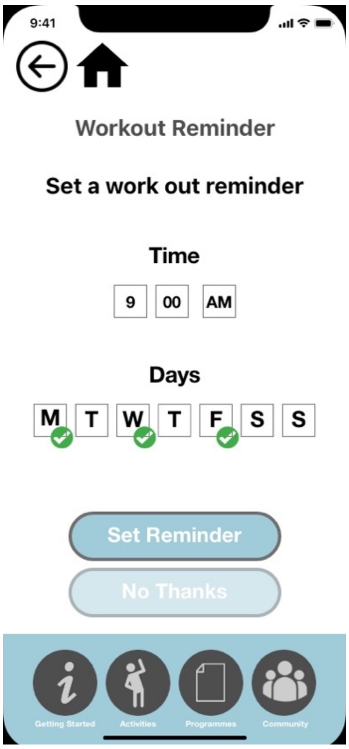


Figure 5.18. *Setting Reminders*

It was important for participants in Chapter 4: User Preferences that they received regular feedback on their behaviours so progress could be made. The app will provide users with weekly progress reports showing how active they have been and the goals they have achieved compared to the previous week. If goals are not being met or are being met too easily, users will be encouraged to change their goals. Progress reports can also be used in the evaluation of the intervention. Furthermore, they will receive motivational push notifications to provide feedback, not only when the user is doing well and should increase their goals but also if they are not meeting their goals. It was important for participants in Chapter 4: User Preferences that they were held accountable for not making progress. Users will be able to tailor the push notifications they receive in the settings menu (e.g., type of notification and frequency of notification), as suggested by participants in *Chapter 4: User Preferences*. See *Table 5.11* for some examples of motivational push notifications.

Table 5.11. *Example Motivational Push Notifications*

'**Congratulations!** You have completed your goal. Well done. Consider setting a new goal'
'**Congratulations!** You have done more steps than last week. Keep up the good work'
'**Remember**. Think about all the success you had last week. Can you do that again this week?'
'**Remember**. Remember the benefits you have been feeling from being active to keep you motivated for the week ahead'

Again, in the short-term, these features will help users to feel more motivated to increase their physical activity and reduce their sedentary behaviour by setting realistic goals they feel capable of achieving and gradually increasing them until the long-term goal is met. Completing goals and receiving positive feedback will also increase users' confidence in being physically active and reduce negative emotions toward physical activity.

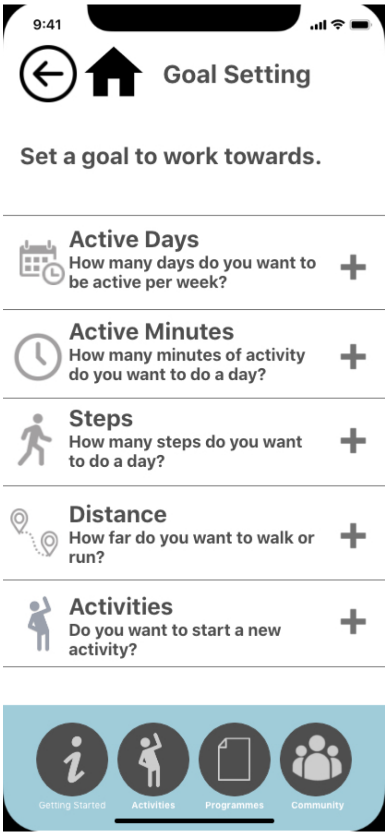


Figure 5.19. *Setting a Goal – Homepage*

Figure 5.20. *Setting a Goal - Step Count*

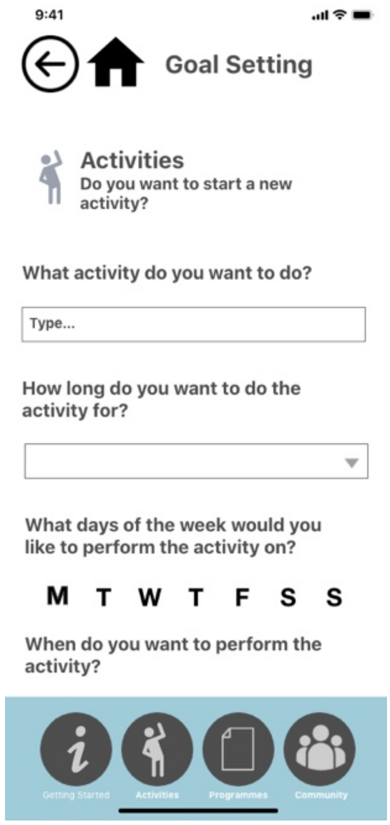


Figure 5.21. *Setting a Goal - Specific Activity*

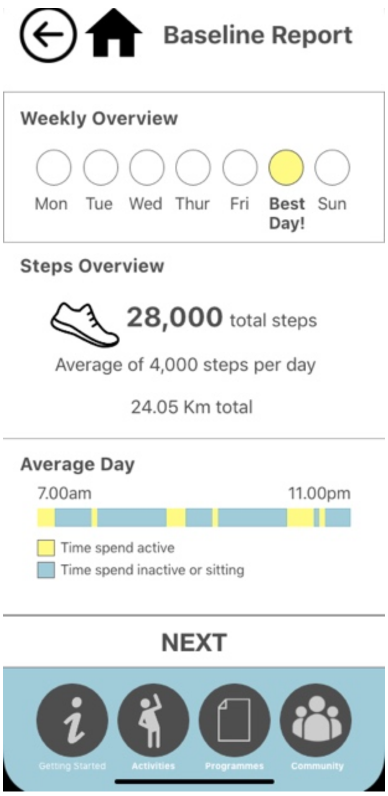


Figure 5.22. *Weekly Progress Report*

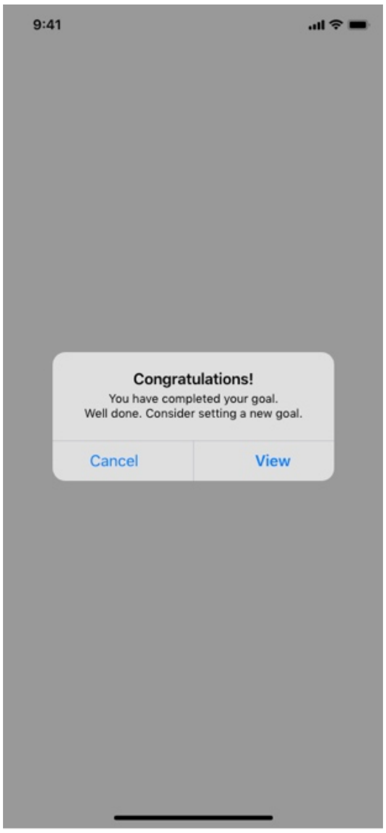


Figure 5.23. *Examples of Push Notifications - Congratulations*

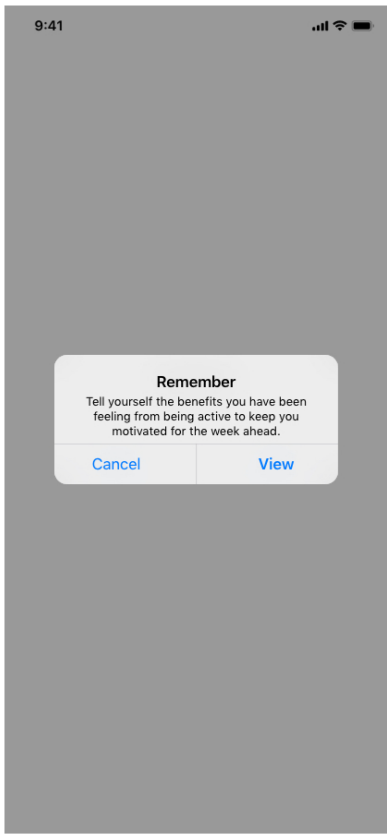


Figure 5.24. *Examples of Push Notifications - Remember*

5.4.3.6. Tailored Physical Activity

The app will encourage users to continue doing activities they enjoy, as highlighted in the sign-up questionnaire. Results presented in *Chapter 3: Barriers and Facilitators* suggested that participants did not know where to start when it came to increasing their physical activity and reducing their sedentary behaviour. Therefore, the app will give users suggestions based on their current activity levels, perceived asthma control and quality of life. Results presented in *Chapter 4: User Preferences* highlighted that having a choice was important for participants, so users will be able to choose from a number of different activity suggestions. The app will provide users with information about each activity and video demonstrations, as *Instructions on How to Perform the Behaviour* and *Demonstration of the Behaviour* were identified as effective BCTs in *Chapter 2: Review of Existing Interventions*. Activities will have different intensity levels (e.g., beginner, intermediate and advanced), so progress can be made but also allow users to move down a level if they are experiencing an asthma flare-up, as suggested by participants in *Chapter 4: User Preferences*. Users will be able to self-monitor their physical activity by logging the activities they have completed within the app. Step count will automatically be tracked using the smartphone's built-in pedometer, which users will be able to view in the app. The short-term goal would be for users to feel more confident and motivated to increase their physical activity by finding an activity that they enjoy and can gradually increase until the long-term goal is met.

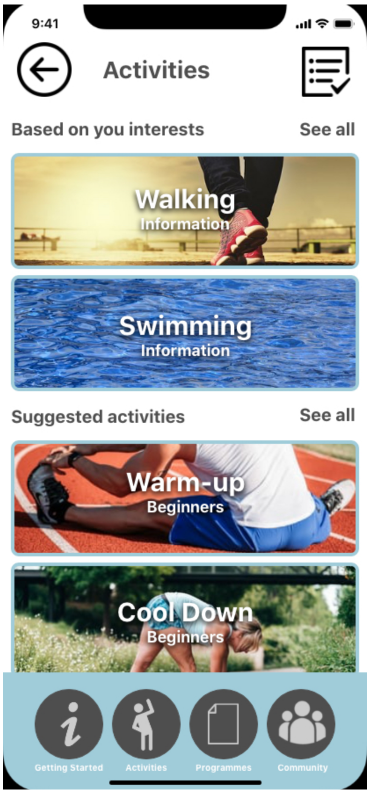


Figure 5.25. *Activities - Homepage*

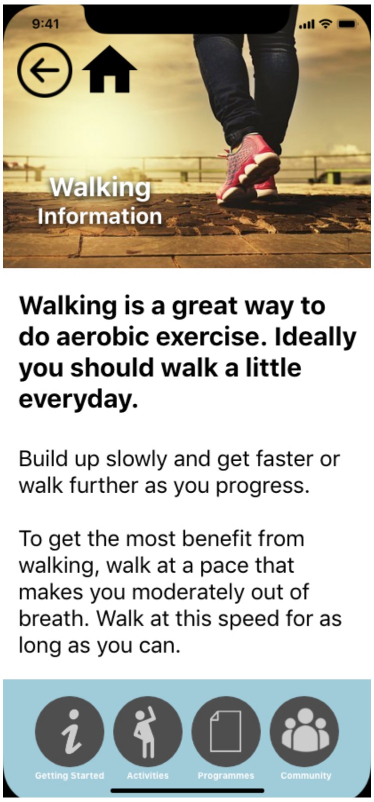


Figure 5.26. Activities - Information on Walking

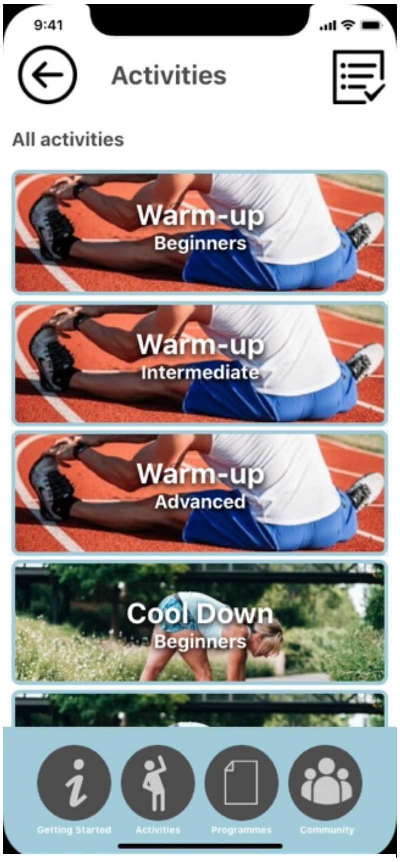


Figure 5.26. Activities - *Activity Suggestions with Different Levels of Intensity*

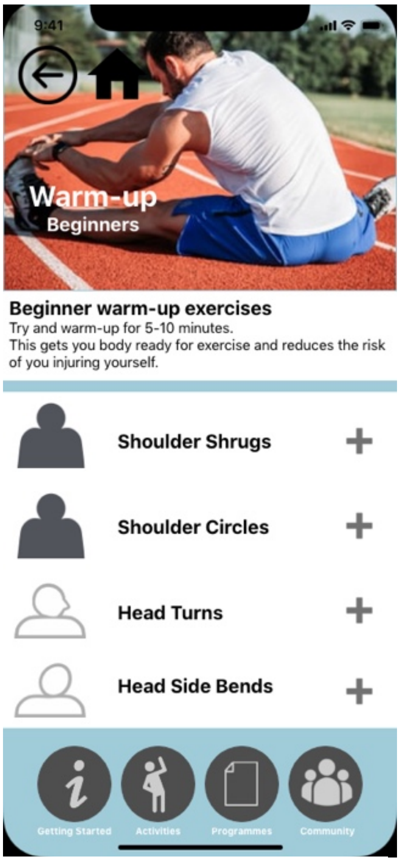


Figure 5.27. Activities - *Activity Suggestions with Examples*

5.4.3.7. *Social Support*

Social support features were included with the aim of ensuring that users were supported to increase their physical activity and meet the long-term goal. While setting goals, the app will prompt users to choose someone (optional) with whom they will perform the activities. By doing this, the aim is to ensure that users are supported to make these changes and deal with any setbacks. In the education sections, users will be encouraged to discuss physical activity with their friends, family, and healthcare providers. Participants highlighted these people as important sources of social support in *Chapter 4: User Preferences*. Users will also be able to opt into competitions with other app users. Based on user preferences presented in *Chapter 4: User Preferences*, these will be short competitions that re-start weekly to prevent loss of motivation if falling behind. Competitions will include number of active days, number of steps, and total active minutes. Users will be grouped based on their current asthma status and physical activity levels to ensure that they compete against others with similar abilities and limitations. The idea is to create a community where users feel they are not alone and that there are other people diagnosed with asthma who are trying to increase their physical activity levels, as social support from other people diagnosed with asthma was considered a facilitator by participants In *Chapter 3: Barriers and Facilitators*.

5.4.3.8. *Rewards and Achievements*

Users will gain digital rewards (e.g., badges and trophies) for engaging with the app, making progress, completing goals, and participating in competitions. Participants from *Chapter 4: User Preferences* acknowledged that this was important as it gave them a sense of achievement and confirmed that they were doing the right thing. Gamification has also been shown to keep users engaged with digital interventions in the long-term (Perski et al., 2017). For users where digital rewards are not motivating, they will be encouraged to set their own rewards, such as buying a new pair of shoes or an outfit, as suggested by participants in *Chapter 4: User Preferences*. In the short-term, these features will help change users' outlook on physical activity and help them view it more positively, being able to look back on the badges and trophies they have collected. Seeing themselves progress will encourage them to continue making positive changes until the long-term goal is met.

5.5. Discussion

This chapter has described the step-by-step process of developing an intervention, specifically a smartphone app, to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma using the BCW. Intervention development was based on findings from *Chapter 2: Review of Existing Interventions*, which was a systematic review exploring the effectiveness and characteristics of interventions developed to promote physical activity in adults diagnosed with asthma and qualitative interviews and focus groups presented in *Chapter 3: Barriers and Facilitators* and *Chapter 4: User Preferences*. The process resulted in the development of a programme theory explaining how each identified feature is expected to work, including the short-term and long-term goals. I also developed interactive mock-ups to show how the app would work from the user's point of view.

Users will be at different stages in their journey to increasing their physical activity and reducing their sedentary behaviour, so some would need more support and guidance than others. Therefore, instead of going through the components of the app sequentially, users can use the most appropriate features. The long-term goal of the intervention would be for users to become regularly active, less sedentary and meet physical activity recommendations. It would be hoped that this behaviour change would then have a positive effect on their asthma-related health outcomes, such as asthma control and quality of life. Therefore, the hope would be that users would continue to use the app until the long-term goal is met. Due to the variability of asthma and the *'vicious cycle'* of inactivity described in more detail in the qualitative analysis presented in *Chapter 3: Barriers and Facilitators*, users could come back to the app following a flare-up of asthma symptoms if they need to build their physical activity levels back up again.

Although there is evidence that mHealth technology can be effective, as mentioned previously, maintaining engagement can be especially difficult when used without human support, typically leading to high levels of dropout and non-usage attrition (Yardley et al., 2016). Participants in *Chapter 4: User Preferences* suggested several features that have been included to improve initial and sustained engagement with the intervention. When setting goals, users can set reminders in the form of push notifications for when they have said they would like to be active. Push notifications will also be used to send motivational messages and feedback, especially when users have stopped engaging with the app. A systematic review conducted by Fry and Neff (2009) investigated the effectiveness of periodic prompts and reminders, which were found to be effective at promoting engagement. However, care must be taken not to overuse notifications as too many can have a negative effect (Perski et al., 2017). This is why users will have the option to customise the type and frequency of notifications they receive. Users will also be provided with personalised feedback in the form of weekly progress reports, summarising how active they have been and the goals they have completed. A scoping review of engagement strategies used in digital interventions for mental health found that personalised support and feedback during an intervention can promote engagement (Saleem et al., 2021).

Social support features have also been shown to positively influence engagement with digital interventions (Perski et al., 2017). Users will be able to participate in short competitions that restart weekly. I chose this format because participants suggested in *Chapter 4: User Preferences* that users might give up if they fell behind others. Competitions will be an optional feature, as suggested by participants in *Chapter 4: User Preferences*, so users can decide to take part depending on their asthma status. Users will be grouped based on their current asthma status and physical activity levels to ensure that they compete against others with similar abilities and limitations. Furthermore, users will be given rewards in the form of virtual badges and trophies for engagement with the app, making progress towards goals, achieving goals and winning competitions. These rewards needed to be achievable as participants in *Chapter 4: User Preferences* believed that those included in other smartphone apps were not.

It is important that the application of mHealth interventions to support health, such as the smartphone app developed in this thesis, does not inadvertently widen health inequalities. Health inequalities are avoidable and unfair differences in health status between groups or communities (Public Health England, 2018) and equality issues require further exploration (McAuley, 2014). Issues to consider include (1) do certain groups of individuals have unequal access to the intervention, and (2) do certain groups of individuals have unequal use of the intervention (e.g., do they lack the understanding to use the intervention and to effectively engage with it). For the first issue, the rate of smartphone ownership is lower in older age groups and lower-income households. While 95% of 16-24-year-olds in the UK reported having a smartphone, only 57% of those over 75 years old had one (Ofcom, 2021). Likewise, 87% of households in the AB economic group (higher and intermediate managerial, administrative, professional occupations) had smartphones compared to 66% of the DE households (semi-skilled and unskilled manual occupations, unemployed and lowest grade occupations) in the UK (Ofcom, 2021). Therefore, an intervention delivered via a smartphone app could be less accessible to older individuals and those of lower socioeconomic status. That being said, ownership was on a step increase in the preceding years, suggesting that smartphone use may continue to grow (Ofcom, 2021).

For the second issue, simply giving an individual an intervention does not guarantee effective engagement that leads to behaviour change (Yardley et al., 2016). A systematic review of digital behaviour change interventions aimed at increasing physical activity showed that they were effective for people of high socioeconomic status but were not observed to be beneficial for people of low socioeconomic status (Western et al., 2021). A reason for this could be due to poor health and digital literacy. Digital literacy is an individual's ability to find and evaluate information on digital platforms and is associated with levels of use and engagement with digital technology and the internet (Honeyman et al., 2020). Those who are less digitally literate come disproportionally from population groups with lower socioeconomic status, and education and are older, putting them at the greatest risk of exclusion (Good Things Foundation, 2016). It is not just digital literacy that could be a problem, but general reading literacy too. Findings from the National Literacy Trust (2017) show that 16.4% of adults in England, or 7.1 million people, can be described as having ‘very poor literacy’. Poor literacy could affect an individual’s ability to engage with a digital intervention, affecting their ability to navigate the technological device themselves, understand the information derived from the educational components and appropriately apply the self-regulatory BCTs that are advocated (Wester et al., 2021).

Understanding and addressing the factors contributing to lower levels of access, use and engagement are crucial to ensure that mHealth technologies to support health do not inadvertently widen inequalities. To reduce inequalities and improve effectiveness, future development of mHealth interventions aimed at improving physical activity must make more effort to meet the needs of certain groups such as those of low socioeconomic status (Western et al., 2021). Refining the intervention with older people and those of lower socioeconomic status could help to ensure that the intervention is simple enough to use and engage with effectively.

To date, only Nyenhuis and colleagues' (2020) have developed a walking intervention for African American women diagnosed with asthma supplemented by mHealth technology. The intervention developed during this project differs considerably from their intervention. Firstly, their intervention is only supplemented by mHealth tools (e.g., a wearable activity device and one-way text messages). In contrast, all components of the intervention I have developed are delivered via a smartphone app. Again, this was in line with the long-term goal of the NHS (2019) to increase the use of technology in healthcare services and Asthma UK's (2016) recommendation for technology-based solutions to asthma care. Nyenhuis and colleagues (2020) also focused on walking, whereas the proposed intervention allows users to choose an activity they enjoy. I made this decision as having a choice was important for participants in *Chapter 3: Barriers and Facilitators* and *Chapter 4: User Preferences*. They did not want to be told what to do but to pick an activity they enjoyed and felt they could do based on their physical limitations. However, the motivational push notifications included in my intervention cover similar topics to the one-way text messages received by participants in Nyenhuis and colleagues (2020) study. Their participants accepted these messages and found the content appropriate.

Similar interventions have been developed for other respiratory diseases. Bentley and colleagues (2020) developed a mobile app with an activity tracker for patients with COPD to encourage physical activity through goal setting, self-monitoring and feedback. They developed this app to be used in conjunction with pulmonary rehabilitation and following the short-term programme. The intervention showed increased exercise capacity and improved quality of life and depression scores. However, there were high drop-out rates, with half of the participants dropping out. Their reasoning for this was that technology was daunting and overwhelming. As previously mentioned in *Chapter 4: User Preferences*, a systematic review concluded that effectiveness may decline when too many features or techniques are included (Schoeppe et al., 2016). Whilst developing this intervention, I have tried to only include essential components and those that were preferred by the target end-users in *Chapter 4: User Preferences*.

This chapter follows the first stage in the intervention development process outlined by the NIHR-MRC guidance (Skivington et al., 2021). Using an iterative approach, further intervention refinement would be needed as the intervention developed was not validated with the target end-users. This could be done by using co-design workshops with the target end-users of the intervention and think-aloud interviews. It would be important to ensure that there was diversity within the same to ensure that the intervention does not widen health inequalities and get the views of older people and those of lower socioeconomic status. During think-aloud interviews, participants would be asked to comment on every aspect of the intervention. This is useful to reveal information relating to the content that needs to be modified (Yardley et al., 2011). The interviews could also be used to get feedback on how the actual content of the intervention is written, including the educational information and push notification messages, to ensure that they are understandable and accessible to the target end-users. This process can be continued until there are no new suggestions for change. This will be an important next step before developing the first prototype of the smartphone app.

Once the prototype has been developed, some early-user testing should be conducted, by getting the target end-users to use the smartphone app. Retrospective semi-structured interviews could then be conducted to evaluate user experiences and identify any further problems when using the intervention (Bradbury et al., 2014). Once the intervention has been refined, the next stage would be to conduct a feasibility study to assess the feasibility and acceptability of the intervention and evaluate the design before progressing to a large-scale study. Such designs are extremely useful for highlighting any problems with the feasibility of using the intervention in the context that it will eventually be implemented (Arain et al., 2010).

5.5.1. Strengths and Limitations

The main strength of this intervention development process is that it used a vigorous systematic approach that drew together theory and evidence. Using the COM-B model, TDF provided a comprehensive theoretical basis for intervention development. Developing an intervention guided by theory makes it more likely that the intervention addresses the appropriate variables to achieve the desired effect (Green, 2000). The BCW offered a theoretical framework derived from consensus work that identified overlapping theoretical constructs and domains from several theories rather than using one 'named' theory (Michie, Stralen & West, 2011). Furthermore, the development process can be linked to the NIHR-MRC guidelines for developing interventions to improve health (Skivington et al., 2021). Lastly, development was supported by my supervisory team, who have expertise and experience in developing behaviour change interventions.

However, although I developed the intervention using a systematic approach, there still remains a significant element of subjectivity in the choice of intervention content and delivery options (French et al., 2011). For example, there is a wide range of BCTs available. Although the ones selected in this current intervention were chosen based on the evidence, decisions had to be made that relied primarily on myself and my supervisory team's judgment. Similarly, the BCW does not provide a guide on how to translate BCTs into intervention features. Therefore, translating BCTs into intervention features relied again on myself and my supervisory team's expertise and creativity. Going forward, the target end-users of the intervention will play a critical role in refining the intervention to ensure that the intervention is acceptable. Nonetheless, the BCW is the most comprehensive, well-researched framework for developing interventions at the time of writing.

Lastly, the NIHR-MRC guidance encourages those developing behaviour change interventions to engage with all relevant stakeholders (Skivington et al., 2021). Even though I conducted two phases of qualitative work with the target end-users of the intervention, adults diagnosed with asthma, other stakeholders (e.g., healthcare providers involved in the care of asthma patients) were not involved. Their views could have potentially been useful during the development process, particularly regarding implementing the intervention into healthcare services. Although I initially planned to involve other stakeholders, the COVID-19 pandemic meant that this was not possible. Going forward and during the refinement stage, further qualitative work could be conducted to get the opinions of other stakeholders.

5.6. Conclusion

This chapter has presented a systematic process for developing an intervention, specifically a smartphone app, to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. This process used a theoretical framework, the BCW, combined with existing evidence and qualitative data collected throughout the project. In line with NIHR-MRC guidelines, this is consistent with the first phase of developing an intervention (Skivington et al., 2021). Using an iterative approach, further refinement and early-user testing of the first prototype of the smartphone app will be needed before a feasibility study can be conducted.

Chapter 6: Summary and Discussion of Research Findings and Implications for Research and Clinical Practice

The preceding Chapters 2-5 have presented the studies and development process undertaken to develop an intervention to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. This chapter summarises the main findings from these studies and discusses their implications for future research and clinical practice. The overall strengths and weaknesses of the process are presented, as well as my personal reflection.

6.1. Thesis Aims and Objectives

The overall aim of this thesis was to develop an intervention, specifically a smartphone app, to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma. The thesis objectives were:

1) Examine the effectiveness of existing interventions that promote physical activity on behavioural and health outcomes in adults diagnosed with asthma (*Chapter 2: Review of Existing Interventions*).
2) Identify the behaviour change techniques and other intervention components, such as intensity, intervention provider, delivery focus and mode of delivery used within existing physical activity interventions (*Chapter 2: Review of Existing Interventions*).
3) Explore the perceived barriers and facilitators to physical activity among adults living with asthma (*Chapter 3: Barriers and Facilitators*).
4) Identify user preferences for the content and features of an intervention to promote physical activity in adults diagnosed with asthma (*Chapter 4: User Preferences*).
5) Develop a theory-based intervention that promotes increased physical activity and reduced sedentary behaviour in adults diagnosed with asthma (*Chapter 5: Intervention Development*).

The development process was conducted via a series of studies, including a systematic review (*Chapter 2: Review of Existing Interventions*) and qualitative interviews and focus groups (*Chapters 3: Barriers and Facilitators and Chapter 4: User Preferences*). Using a systematic approach, the findings were drawn together with existing theory to develop the intervention (*Chapter 5: Intervention Development*).

6.2. Contributions to Knowledge

The studies presented in this thesis contribute to knowledge in various ways. These will be discussed in more detail but can be summarised as follows:

1. There is support from existing evidence for the short-term benefits of interventions developed to promote physical activity in adults diagnosed with asthma. However, there is limited evidence of the long-term effectiveness of these interventions. Evidence supports the development of a new intervention based on theory and evidence that considers barriers to attending traditional medical interventions such as pulmonary rehabilitation.
2. To my knowledge, this is the first study in the UK to use interviews and a focus group to explore the perceived barriers and facilitators of physical activity among adults diagnosed with asthma. A unique barrier identified was embarrassment about experiencing asthma symptoms and taking inhalers in public, resulting in the avoidance of group-based activities.
3. Adults diagnosed with asthma found mHealth interventions acceptable. They shared ideas and preferences to inform the development of an intervention, including tailored physical activity suggestions, goal setting, feedback and notifications, social support, competitions, and achievements and rewards.

6.2.1. Support for the Development of Physical Activity Interventions for Adults Diagnosed with Asthma

The benefits of pulmonary rehabilitation for asthma patients are already well established. However, no systematic reviews to date have explored the effectiveness of other interventions developed to promote physical activity in this patient group. In *Chapter 2: Review of Existing Interventions*, I found that alternative interventions have significant benefits: increasing physical activity, decreasing sedentary behaviour, and improving quality of life and asthma symptoms. However, although there was an increase in physical activity during the intervention period, the only intervention to follow-up participants beyond the intervention showed that the increase in physical activity was not maintained (Coelho et al., 2018). Behaviour change maintenance is also an issue for pulmonary rehabilitation programmes that have only shown improvements in the short-term (Egan et al., 2012). A reason for this could be the notably absent behaviour change techniques (BCTs) that help to self-regulate behaviour and sustain motivation. Future interventions should consider including BCTs such as '*Problem Solving*', '*Reviewing Behavioural Goals*', '*Prompts/Cues*', '*Habit Formation*', and '*Self-Reward*', which are associated with behaviour change maintenance (Howlett et al., 2019; Samdal et al., 2017).

Components, including the BCTs used, were similar across all interventions regardless of effectiveness. Therefore, I could not identify *'promising'* or effective components and could only make recommendations for what to include in future interventions based on the literature. However, it shows that the interventions that have been developed are only *'reinventing the wheel'* by including the same components instead of using theory and identifying the most effective components for this patient group.

Furthermore, even though the included interventions were not pulmonary rehabilitation, most still would not have overcome major barriers to the uptake and completion reported by patients with COPD. These include travelling to attend sessions, disrupting routines, inconvenient timings (Jones et al., 2017), and not being suitable or accessible to those with co-morbidities (Keating et al., 2011). When developing future interventions, these barriers must be thought through, and alternative delivery methods must be considered.

67.2.2. Barriers and Facilitators to Physical Activity for Adults Diagnosed with Asthma in the UK

Interviews and focus groups were used to explore the perceived barriers and facilitators of physical activity among adults predominantly living with severe asthma. I chose this participant group because Mancuso et al. (2006) argued that this group is more likely to believe that physical activity worsens their asthma and experience additional barriers to participation. They are also likely to benefit most from an intervention that promotes physical activity and reduced sedentary behaviour (Panagiotou, Koulouris & Rovina, 2020).

Understanding the perceived barriers and facilitators to physical activity is critical in developing behaviour change interventions that include the most appropriate BCTs to overcome barriers and facilitate behaviour change. Barriers identified in this study are concurrent with previous findings from Mancuso et al. (2006) and Nyenhuis et al. (2020), such as beliefs about the negative consequences of physical activity on asthma and beliefs about limited physical capabilities to be active. A unique barrier identified in this study was participants' embarrassment about experiencing asthma symptoms and taking inhalers in public, resulting in the avoidance of group-based activities. Although De Simoni and colleagues (2016) have explored these ideas in teenage populations, this study would suggest that stigma is a problem among adults diagnosed with asthma too.

I identified social support, particularly from healthcare providers, and the desire to be healthy as facilitators of physical activity. Contrary to Nyenhuis et al. (2020), participants in my study were aware of the physical and psychological benefits of physical activity. However, for them, the benefits did not outweigh the potential negative consequences to their asthma. Differences in findings could be due to participant characteristics; Nyenhuis and colleagues’ (2020) sample was made up of only African American females, whereas mine were mostly White British females.

6.2.3. The Acceptance of mHealth interventions and User Preferences for Content and Features

The study presented in *Chapter 4: User Preferences* found that adults diagnosed with asthma found mHealth interventions acceptable, with most participants already using physical activity and/or health apps. Conducting focus groups allowed me to explore participants' ideas and preferences for the content and features of the intervention. I needed to identify user preferences as maintaining engagement with mHealth interventions can be difficult, typically leading to high drop-out and non-usage attrition (Yardley et al., 2016). My findings showed that participants wanted an app to help them set realistic goals and provide feedback so that they could make progress. They wanted access to physical activity suggestions tailored to their interests, asthma status, and physical limitations. Participants suggested that providing information about managing symptoms and how to be active safely with asthma could reduce fears and anxieties about physical activity.

Participants in my study suggested that initial engagement with the intervention could be promoted by making the app more asthma specific by incorporating the ability to track and monitor asthma outcomes and medication. Including social support, competitions, and rewards, such as digital badges or trophies, could sustain engagement in the long-term. However, participants proposed that a physical activity intervention alone would not work but instead should be a component of a multifunctional platform that helps with all aspects of asthma self-management (see *7.3.2.2. Development of a Self-Management Intervention for Adults Diagnosed with Asthma* for more detail).

6.3. Implications for Research

6.3.1. Methodology

6.3.1.1. Use of the Behaviour Change Wheel for Intervention Development

A key strength of the intervention developed in this thesis is its systematic approach informed by an underpinning theory of behaviour change. As mentioned in *Chapter 5: Intervention Development*, NIHR-MRC guidance (Skivington et al., 2021) strongly advocates a theoretical basis and provides a broad outline approach to intervention development. However, it does not provide detailed guidance on choosing or applying appropriate theories (French et al., 2012; Michie et al., 2005). Without theory, interventions might address the wrong or inappropriate variables or only a proportion of the combination of variables required to have the desired effect (Green, 2000).

The Behaviour Change Wheel (*BCW)* offered a comprehensive framework for intervention development based on the theoretical constructs of behaviour change (Michie, van Stralen & West, 2011). The accompanying step-by-step guide on using the framework was easy to follow and made the development process uncomplicated. Mapping the perceived barriers and facilitators of physical activity among adults diagnosed with asthma onto the framework gave me a detailed understanding of possible mechanisms for changing physical activity and sedentary behaviour in this patient group. This thesis is an exemplar of how researchers can use the *BCW* theoretical framework combined with other related tools such as the Theoretical Domains Framework (TDF), Behaviour Change Techniques Taxonomy v1 (BCTTv1*)* and *Theory of Techniques Tool* as a comprehensive systematic approach to developing an intervention.

However, literature on the development of mHealth interventions emphasises user-centred design and the consideration of the target end-users at every stage of the development process (McCurdie et al., 2012). Although I added an additional step to the framework and incorporated the ideas and preferences of the target end-users, the mapping processes of the BCW relied primarily on myself and my supervisory teams' judgement. This means that the developed intervention has not been validated with the target end-ends, and in hindsight, more could have been done during the development process to involve them. As a result, the developed intervention will need further refinement and early-user testing (see *7.3.2.1. Refinement and Early-User Testing for more detail*).

6.3.1.2. Use of Technology to Recruit and Conduct Online Interviews and Focus Groups

The COVID-19 pandemic promoted the uptake of remote data collection methods (Keen, Lomeli-Rodriguez & Joffe, 2022). I conducted the study presented in *Chapter 4: User Preferences*. Due to the restrictions to stop the spread of the virus, conducting my focus groups face-to-face was not possible. Instead, I conducted my focus groups online using the video-conferencing application *Zoom* (*Zoom Video Communications Inc*, Version: 5.0.3). Not only did conducting my focus groups online allow me to continue my research during the pandemic, but it also widened geographical access to participants, and I could reach individuals I would normally not have asked to participate. Although we are no longer under restrictions, researchers can still use these methods to recruit and engage more people to participate in research. The ease of video calls vs travelling is also likely to be a substantial incentive and can be more flexible for participants (Keen, Lomeli-Rodriguez & Joffe, 2022). Collecting demographic information and consent was also highly feasible online. The feasibility of virtual alternatives to gaining consent while preserving data confidentiality has previously been discussed (Roberts, Pavlakis & Richards, 2021; Sy et al., 2020). I was able to get participants to complete online versions of demographic questionnaires and e-sign consent forms and provide them with a link to an online version of the participant information sheet.

It has been argued that using technology to conduct qualitative research should not be considered an adaptive compromise within pandemic restrictions but more of an opportunity for long-term methodological progress (Keen, Lomeli-Rodriguez & Joffe, 2022). The chapter presented in this thesis and the detailed methods sections exemplify how researchers can use technology to recruit participants and conduct high-quality, rigorous, ethical qualitative research remotely.

6.3.2. Further Developments of the Current Intervention

6.3.2.1. Refinement and Early-User Testing

This thesis follows the first step in the intervention development process outlined by the NIHR-MRC guidance (Skivington et al., 2021). However, further refinement would be needed as the developed intervention was not validated with the target end-users to establish their acceptability and satisfaction with the intervention (Yardley et al., 2010). As mentioned in *Chapter 5: Intervention Development*, this could be done by conducting co-design workshops with the target end-users and think-aloud interviews to get feedback on every aspect of the intervention. These workshops can then be repeated until no new changes are suggested. Furthermore, the guidance encourages engagement with all relevant stakeholders (Skivington et al., 2021). Although I conducted two phases of qualitative research with the target end-users of the intervention, other stakeholders (e.g., healthcare providers involved in the care of asthma patients) were not involved. I initially planned to involve other stakeholders, but the COVID-19 pandemic meant that this was not possible due to the demand on healthcare providers. Moving forward and during the refinement stage, further qualitative work could be conducted to get the opinions of other stakeholders and gain a better understanding of how the intervention could be implemented into healthcare services. Once the intervention has been refined, and a prototype of the smartphone app has been developed, some early-user testing could be done by getting the target end-used to use the intervention and evaluate their experiences. Early-user testing would identify any further problems with the intervention before progressing to a feasibility study.

6.3.2.2. Development of a Self-Management Intervention for Adults Diagnosed with Asthma

It was clear from the interviews and focus groups conducted as part of this project that participants believed it was not enough to look at physical activity alone and that a holistic approach would be needed. Participants in *Chapter 4: User Preferences* believed that they would be more likely to engage in a smartphone app that would help with all aspects of their asthma and self-management, with physical activity a component of this. Although this was beyond this project's scope, participants suggested that the intervention developed during this project should be a component of a multifunctional platform to help with all aspects of asthma self-management. Multifunctional mHealth platforms comprising various components to help with all aspects of self-management have shown to be promising in controlling asthma symptoms and improving quality of life compared to traditional interventions (Farzandipour et al., 2017). A systematic review by Hui et al. (2017) concluded that the most successful smartphone apps for self-managing asthma had multiple functionalities. Despite this, participants in *Chapter 4: User Preferences* discussed not being able to find a smartphone app available in the app stores that helped them with all aspects of their asthma self-management.

The future focus should be on developing a multifunctional mHealth platform that meets the needs of its users and helps with all aspects of asthma self-management, with physical activity being a component of it. Further qualitative research could be undertaken to determine what other components adults diagnosed with asthma would like to see included on the multifunctional health platform, such as peak flow readings, medication and symptoms monitoring, asthma action plans, diet and weight management, and environmental updates.

6.4 Implications for Clinical Practice

The research presented in this thesis confirms that there is a need to improve the help and support provided to patients to increase their physical activity levels and reduce their sedentary behaviour.

6.4.1. Open Conversations with Patients

Participants in *Chapters 3: Barriers and Facilitators* and *Chapter 4: User Preferences* believed that healthcare providers should play a crucial role in promoting physical activity by providing information, motivation, and advice about what patients can do. They mentioned feeling let down by their healthcare providers because even though they had asked for help to be more active, they had not received the help and support they needed. Participants acknowledged that physical activity could not always be a priority if something more important needed their attention. However, they wanted healthcare providers to make more effort to discuss physical activity with their patients. They suggested that the best times to discuss physical activity would be during routine appointments in primary care and following a hospital admission when patients could have been sedentary for a long period of time. Participants who discussed physical activity with their healthcare providers felt they were being 'punished' for not being active. Instead, healthcare providers should give patients positive reinforcement and gentle encouragement to increase their activity levels. However, it will not be enough just to tell patients to be active; healthcare providers need to speak to patients about the benefits of physical activity and the risks of inactivity and signpost them to information or services if necessary. To support healthcare providers in discussing physical activity with patients, appropriate education, training, and access to resources are essential (Cunningham & O'Sullivan, 2021). Efforts are already being made with the national programme '*Moving Healthcare Professionals', which was initiated in 2017* to provide evidence-based physical activity training and support resources for healthcare providers (Sport England, 2021). The programme was developed to increase healthcare providers' knowledge and skills and incorporate physical activity within routine care to support quality improvement and better patient outcomes.

6.4.2. Improving Access to Help and Support

Some participants in *Chapter 3: Barriers and Facilitators* discussed the long wait times they had faced for places to become available on pulmonary rehabilitation programmes to help them increase their physical activity, which is only likely to get worse following the COVID-19 pandemic and the significant suspension of face-to-face support. While waiting, participants did not know where to start or how to increase their activity levels safely. With insufficient facilities and funding to deliver PR programmes to patients, alternative services need to be considered to increase the number of patients who can access help and support to increase their activity levels. As discussed in *7.4.1. Open Conversations with Patients*, healthcare providers should be informed of what resources and services are available so they can be signposted to patients. For example, participants in *Chapter 4: User Preferences* knew that there were smartphone apps available to help increase their physical activity levels, but they did not know what apps were best suited to people diagnosed with asthma. Also, following the pandemic, more online resources have become available that patients could continue to use post-pandemic; they just need to be made aware and signposted to them. However, implementing evidence-basic practice and interventions can be challenging given the lack of time away from the clinical areas healthcare providers have to keep up with research (Kerr & Rainey, 2021).

6.5. Strengths and Limitations

The strengths and limitations of individual studies are discussed in the preceding chapters. Overall strengths and limitations are summarised below.

A major strength of this project is that, unlike most interventions that have been developed to promote physical activity and reduce sedentary behaviour in adults diagnosed with asthma, I developed this intervention with a theoretical underpinning and evidence. Using the BCW as a theoretical framework allowed me to comprehensively develop and analyse physical activity and sedentary behaviour in this patient group and understand the potential mechanism of behaviour change. By conducting in-depth qualitative interviews and focus groups, I gained an understanding of the perceived barriers and facilitators of physical activity and what needs to change for the behaviour to occur. Adding an additional step to the framework and incorporating the ideas and preferences of the target end-users has hopefully resulted in an intervention that is more likely to be accepted and sustain engagement in the long-term. Additionally, the standardised terminology used in the BCW, and the other tools used in developing this intervention, such as the BCTTv1 and Theory of Techniques Tool, can facilitate comparison with other interventions and aid the reproducibility of the intervention development process.

However, similarly to other psychological models and health behaviour change frameworks, the BCW does not provide a guide on how to translate BCTs into intervention features. As noted by Orji and Mandryn (2014), using a mapping process for intervention development can be subject to interpretation. There is a wide range of BCTs available, and although the choice of techniques was guided by the findings from the systematic review (*Chapter 2: Review of Existing Interventions*) and qualitative studies (*Chapters 3: Barriers and Facilitators* and *Chapter 4: User Preferences*), I had to make decisions that relied primarily on myself and my supervisory team's judgement. As previously mentioned in 7*.3.2.1. Refinement and Early-User Testing*, because the target end-users were not involved throughout the development process and did not validate the developed intervention, further refinement will be needed to ensure that the choices we made are accepted by the target end-users. Nonetheless, the BCW is the most comprehensive, well-researched framework for developing interventions at the time of writing.

Limitations of the research predominately relate to issues with recruitment and participant characteristics. As a result, other researchers must interpret the findings from these studies with caution, as recruitment biases may have restricted the range of opinions represented. For example, within all the studies presented in this project, females were over-represented, and samples were not ethnically diverse. Therefore, the perceived barriers and facilitators to physical activity and the ideas and preferences for the content and features of the intervention might be less representative of males and other ethnicities. During the recruitment of these studies, more could have been done to diversify the samples. For example, when recruiting for the interviews and focus groups, additional questions could have been asked in the eligibility questionnaires, allowing me to be more selective of those I invited to participate. Thus, making the sample more diverse. Care must be taken when recruiting for future evaluation studies to ensure that the views of all potential end-users are considered. This includes not only a balance of gender but also ethnicity. Exploring the views of other ethnic groups is especially important as there are significantly higher rates of asthma incidences in black and minority ethnic groups (Asthma UK, 2018), and the barriers to physical activity are not well understood (Nyenhuis et al., 2019).

Furthermore, when recruiting participants, they were aware that I was conducting the studies to inform the development of an intervention to promote physical activity in adults diagnosed with asthma. Therefore, participants included in the presented studies might have been more accepting of physical activity. Although most participants were deemed Moderately Inactive, they had sedentary jobs and did less than 1 hour of exercise per week (Department of Health and Social Care, 2013); they could have been more open to increasing their physical levels compared to the more general asthma population. They could have also been more accepting of digital interventions, such as smartphone apps. This is likely because the majority of participants included in Chapter 4: User Preferences had used or were using physical activity and/or health apps. However, prior experience using smartphone apps meant that participants could discuss the topic more.

Lastly, there is a chance that mHealth interventions to support health might inadvertently widen health inequalities instead of narrowing them and equality issues require further exploration (McAuley, 2014). Issues to consider include; (1) do certain groups of individuals have unequal access to the intervention, and (2) do certain groups of individuals have unequal use of the intervention (e.g., do they lack the understanding to use the intervention and to effectively engage with it). Groups most at risk of health inequalities include older adults and those of low socioeconomic status. Understanding and addressing the factors contributing to lower levels of access, use and engagement are crucial to ensure that mHealth technologies to support health do not inadvertently widen inequalities. In the studies conducted in *Chapter 3: Barriers and Facilitators* and *Chapter 4: User Preferences*, the majority of the participants were middle-aged, and data was not collected on their socioeconomic status. Refining the intervention with older people and those of lower socioeconomic status could help to ensure that the intervention is simple enough to use and engage with effectively.

6.6. Personal Reflection

Undertaking this research project and writing this thesis has been hugely challenging yet rewarding. I would be lying if I said that I never doubted that I would finish this project, so I am genuinely proud to be writing this, the final chapter of my thesis. If you ask anyone who knows me, they will probably describe me as a 'perfectionist' and, with that, a 'people-pleaser'. Being overly concerned about pleasing others and earning their approval has always been a problem for me, and I think that is where those doubts came from. Coming into the project, I felt I had to prove myself to my supervisory team and assure them they had selected the right candidate. Because of this, I let them guide the project and did what I thought they wanted me to do. I know now that this was the wrong thing to do; instead, I should have taken control and made the project my own. I then began to feel as though my supervisors doubted me and started to doubt myself. I think these doubts have stayed with me throughout this process, but I would like to think that I have become more confident in my thoughts and feelings and began to take more control. Moving forward in my career as a researcher, I will not make the same mistakes.

I think things took a turn when the COVID-19 pandemic was announced, and everyone had to start working from home. I think that being away from the academic setting made me feel more independent and in control of my project. Although I had to make changes because of the pandemic, when I reflect on the situation, I like to think I took advantage of it and turned it into something positive. It showed that I was adaptable and could quickly turn around work and make decisions. The pandemic also allowed me to conduct and publish additional research exploring the effects of social distancing and self-isolation (Tyson et al., 2021b), which I would not have done otherwise. My COVID-19 research was also the first piece of work that I had published, which was a significant achievement for me. This is also the research that I have had the most positive feedback on, as it has a positive conclusion about individuals taking their disease more seriously and increasing their physical activity levels to improve their health. Showing something positive that has come out of a difficult situation.

However, this did come with new challenges, and because I was working from home, I did struggle to gain a good work-life balance. I would say that there was a point when my PhD controlled my life. There were times when I would feel guilty when I was not working because there was always something I could be doing. I knew this was not healthy, and although it was hard at first, I started to take a step back and do some of the things I used to enjoy instead of spending all my time working on my project. I knew this was important because I began to lose interest in what I was doing and forget why I wanted to do a PhD in the first place.

As part of the project, I knew that I would conduct some qualitative research; however, I did not expect to enjoy it as much as I have. I had some experience in using these research methods before. As for my master's dissertation, I conducted a qualitative study looking into children's and adolescent's perceptions' of asthma. At first, the thought of it was daunting, and looking back, I knew the first interview I conducted could have gone better, but I finished knowing what I did wrong, and I knew how I could improve. Instead of focusing on the next question I was going to ask, I needed to listen more and make it more conversational and not so structured. I also wanted to give myself a short introduction at the start of each interview and focus group, so participants knew more about me and understood why I was conducting the research. From then on, I kept notes on how I could improve after each interview and focus group. I think doing this reflection exercise helped me to improve and made me a better qualitative researcher.

I truly feel honoured that others have taken the time to speak to me. I hope that I have helped to tell their stories of living with asthma and their struggles. Speaking to my participants has been the highlight of my PhD. Coming away from my interviews and focus groups knowing that I have found something interesting or unique, is a really satisfying feeling. I have learnt so much from my participants about a disease I thought I knew a lot about. Although I have personal experiences with asthma, hearing from other people, I have learnt that everyone's experiences are different and so unique to them. Hearing about how they have struggled not only with their disease but with the healthcare system has only made me want to continue to work in this field even more.

To recruit participants for the qualitative studies presented in this project, I joined a number of asthma support groups on social media. Although I initially only did this for recruitment purposes, I am still a member of these groups and regularly engaging with other people diagnosed with asthma. I have also become more involved in asthma research as a participant. I am currently a research and policy volunteer for Asthma+LungUK taking part in other research studies. This way, I get to see what other research is being conducted in the field that I am interested in and also help other researchers that are conducting research like me, as I know recruitment can be difficult.

One of my biggest achievements during my PhD process has been presenting my research at seminars and conferences. Although I had previously presented my work, it was always to small groups, which was even a worry for me. When I look back at how far I have come, I feel really proud as it is something that I could never see myself doing, and even now, when I tell my family and friends, they find it hard to believe. Although a part of me still dreads it, I try to think of the positives because I know every time I present and get feedback from others, I feel optimistic and motivated to continue with my work. I also had the opportunity to be interviewed by *BBC World Service* for their podcast *Health Check* about the systematic review I published, presented in *Chapter 2: Review of Existing Interventions*. Again, this is something completely out of my comfort zone and something I would never have seen myself doing, but I actually really enjoyed it. All these experiences have helped me to improve in confidence, and I know that I am much better at presenting and communicating my research to different audiences than I was at the start of my PhD.

Undertaking this research project has enabled me to develop professionally as a researcher and personally. I have learnt so much about the field I am interested in from the literature I have read and the participants I have spoken to, but I have also learnt so much about myself. I have become much more confident, trusting my thoughts and feelings, and I hope it stands me in good stead to continue growing and developing as a researcher.

6.7. Thesis Summary

Despite the benefits, adults diagnosed with asthma are less active and more sedentary than those without asthma. Interventions developed to promote physical activity in this population group do not overcome patient-reported barriers to attending traditional medically supervised programmes and lack theoretical underpinning. My research found that adults diagnosed with asthma supported the development of an intervention to promote physical activity and reduce sedentary behaviour. They were accepting of it being delivered using mHealth, specifically a smartphone app. An intervention was developed based on existing evidence, combined with the ideas and preferences of the target end-users and informed by a theoretical framework for behaviour change. In conclusion, it is recommended that further refinement and early-user testing of the intervention is done to validate the developed intervention with the target end-user before a feasibility study can be conducted. In addition to this, more work needs to be done to develop a multifunctional platform that helps with all aspects of asthma self-management, including physical activity as a component.

Appendices

Appendix A. *Systematic Review of the Characteristics of Interventions that Promote Physical Activity in Adults with Asthma. Journal of Health Psychology (Tyson et al., 2021a)*

JHP

Review

Journal of Health Psychology
1–20

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A systematic review of the characteristics of interventions that promote physical activity in adults with asthma

Leanne Tyson[1], Wendy Hardeman[1], Malcolm Marquette[2], Joanna Semlyen[1], Gareth Stratton[3] and Andrew M Wilson[1]

Abstract

Physical activity is promoted in the asthma population through pulmonary rehabilitation, but limited funding and facilities are available. This review aimed to examine the effectiveness of interventions that promote physical activity and identify the behaviour change techniques (BCTs) and other intervention components used. Five databases were searched, and 25 studies met the inclusion criteria. Interventions had a significant positive effect on physical activity, sedentary behaviour, quality of life and asthma symptoms. BCTs used across intervention and control groups were similar in studies that showed effects and those that did not. Future interventions should employ techniques that help to maintain behaviour change.

Keywords

asthma, physical activity, exercise, intervention, systematic review

Background

Physical activity is widely recommended in national and international guidelines for asthma management (British Thoracic Society, 2019; Global Initiative for Asthma, 2018). Engaging in regular physical activity (⩾150 minutes/week of moderate-vigorous physical activity) has shown to have extensive benefits for people living with asthma. Recent reviews have shown that increased physical activity is positively associated with improved lung function, asthma control, health status, and healthcare utilisation (Cordova-Rivera et al., 2018; Hansen et al., 2020). However, despite the guidelines, population-based studies have shown that people living with asthma engage in less physical activity and are more sedentary than people without asthma (van 't Hul et al., 2016).

Pulmonary Rehabilitation (PR) is a comprehensive intervention designed to promote physical activity in patients with respiratory diseases and is defined as 'patient-tailored therapies that

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Appendix B. *The Effects of Social Distancing and Self-Isolation During the COVID-19 Pandemic on Adults Diagnosed with Asthma: A Qualitative Study. Journal of Health Psychology (Tyson et al., 2021)*

Article

JHP

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The effects of social distancing and self-isolation during the COVID-19 pandemic on adults diagnosed with asthma: A qualitative study

Leanne Tyson[1], Wendy Hardeman[1], Gareth Stratton[2], Andrew M Wilson[1] and Joanna Semlyen[1]

Abstract

This study aimed to explore how social distancing and self-isolation measures, aimed at protecting vulnerable groups from COVID-19, affected the wellbeing and physical activity levels among adults diagnosed with asthma. Twenty-seven participants took part across four online focus groups. Transcripts were analysed using thematic analysis. Participants reported becoming more health conscious due to being labelled as vulnerable. Their relationship with the severity of their asthma was altered and they reported making positive changes to increase their physical activity levels. Findings suggest there is a window of opportunity to engage with people diagnosed with asthma to promote beneficial lifestyle changes and self-management.

Keywords

asthma, COVID-19, health behaviour, physical activity, qualitative methods

Introduction

Coronavirus disease (COVID-19), caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SAR-CoV-2), was declared a pandemic by the World Health Organization in March 2020 (World Health Organization, 2020a). The virus primarily targets the respiratory system, resulting in symptoms including fever, coughing and anosmia/hyposmia and is transmitted from person to person, spread mostly via respiratory droplets or contact with contaminated surfaces (Rothan and Byrareddy, 2020). To reduce transmission, governments all over the world have advised the public on both hand hygiene and social distancing as preventative steps (World Health Organization, 2020b).

Evidence regarding the impact of COVID-19 on individuals with underlying health conditions is limited. As a result, the World Health

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Appendix C. *Preferred Reporting for Systematic Reviews and Meta-Analysis (PRISMA) Checklist*

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Page 1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Pages 3-4
Informatio n sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 4
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Page 4 and *Supplementa ry File 2*
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Pagess 4-5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Pages 4-5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Pages 4-5

Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 5
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	N/A
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	N/A
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Pages 5-6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Pages 5-6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 6 and *Supplementary File 3*

	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	*Supplementary File 3*
Study characteristics	17	Cite each included study and present its characteristics.	Pages 6-7 and *Table 1*
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	*Page 7, Supplemental Material 4* and *5.*
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	*Tables 2* and *3.*
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	N/A
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Pages 13-15
	23b	Discuss any limitations of the evidence included in the review.	Page 16
	23c	Discuss any limitations of the review processes used.	Page 16
	23d	Discuss implications of the results for practice, policy, and future research.	Pages 13-15

OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 3
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 17
Competing interests	26	Declare any competing interests of review authors.	Page 17

Section and Topic	Item #	Checklist item	Location where item is reported
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix D. *MEDLINE Search Strategy*

exp Asthma/ or exp Asthma, Exercise-Induced/ or exp Respiratory Hypersensitivity/ or exp Bronchial Spasm/

AND

exp Exercise/ or Physical activity.tw. or exp Running/ or exp Walking/ or exp Physical Fitness/ or exp Swimming/ or exp Cardiorespiratory Fitness/ or ((Moderat* or Vigorous*) adj Activ*).tw. or (Led Walk* or Health Walk*).tw. or (Physical adj5 (Fit* or Train* or Activ*)).tw. or (Exercis* adj5 (Fit* or Train* or Activ*)).tw. or exp Sedentary Lifestyle/ or (Sedentary adj (Lifestyle* or Time* or Behaviour*)).tw. or Sitting Time.tw. or Inactiv*.tw.

AND

Intervention*.tw. or Interventional Stud*.tw. or exp Randomized Controlled Trials/ or Randomi?ed Controlled Trial*.tw. or (Randomi?ed adj3 (Stud* or Trial* or Design*)).tw. or RCT.tw. or exp Random Allocation/ or exp Double-Blind Method/ or exp Single-Blind Method/ or (Non-Randomi?ed adj3 (Stud* or Trial* or Design*)).tw. or (Quasi-Experiment* adj3 (Stud* or Trial* or Design*)).tw. or (Before adj3 After) adj3 (Stud* or Trial* or Design*).tw. or exp Feasibility Studies/ or exp Pilot Projects/ or Study.tw.

Appendix E. *Reasons for Exclusion*

Author (Year)	Article Title	Reasons for Exclusion
Ahmed (2016)	The Effectiveness of Web-Based Asthma Self-Management System, My Asthma Portal (MAP): A Pilot Randomized Controlled Trial	Not a Physical Activity Intervention
Arandelovic (2007)	Swimming and Persons with Mild Persistent Asthma	Outcomes Assessed
Bacon (2015)	Impact of a 12-Week Supervised Aerobic Exercise Program on Asthma Control in Adult Patients with Asthma: Preliminary Results from the EX-ASTHMA Behavioural RCT	Abstract Only
Boyd (2011)	The Effects of Aerobic Exercise on Asthma Related Responses in Adults	Abstract Only
Carvalho (2014)	Aerobic Training Decrease Bronchial Hyperresponsiveness and Systematic Inflammation in Patients with Moderate or Severe Asthma: A Randomized Controlled Trial	Abstract Only
Coelho (2015)	Effects of an Unsupervised Pedometer-Based Physical Activity Program on Adults with Moderate to Severe Asthma	Abstract Only
Da Silva (2017)	High Intensity Interval Training Increases Aerobic Fitness, Health related Quality of Life and Clinical Control in Patients from moderate to Severe Asthma	Abstract Only
Develi (2017)	Effects of Core Stabilization Exercise on Patients with Asthma	Abstract Only

Dogra (2011)	Regular Physical Activity is Associated with Better Asthma Control in Adults	Abstract Only
Emtner (1996)	High-Intensity Physical Training in Adults with Asthma	Pulmonary Rehabilitation Intervention
Emtner (1998)	A 3-Year Follow-Up of Asthmatic Patients Participating in a 10-Week Rehabilitation Program with Emphasis on Physical Training	Pulmonary Rehabilitation Intervention
Emtner (1998)	High-Intensity Physical Training in Adults with Asthma. A Comparison Between Training on Land and in Water	Pulmonary Rehabilitation Intervention
Evaristo (2017)	Effects of Aerobic and Breathing Exercises on Clinical Control and Airway Inflammation in Persistent Asthma	Abstract Only
Farid (2005)	Effect of Aerobic Exercise Training on Pulmonary Function and Tolerance of Activity in Asthmatic Patients	Outcomes Assessed
Franca-Pinto (2015)	Aerobic Training Decrease bronchial Hyperresponsiveness and Systemic Inflammation in Patients with Moderate or Severe Asthma: A Randomised Controlled Trial	Pulmonary Rehabilitation Intervention
Freeman (2018)	High Intensity Intermittent Exercise Training in Poorly Controlled Asthma: Preliminary Clinical Trial Results	Conference Abstract
Freeman (2019)	Effects of Interval Exercise Training on Asthma Symptoms and Inflammation	Conference Abstract
Freeman (2019)	Interval Exercise Training in Poorly Controlled Asthma: Preliminary Clinical Trial Results	Conference Abstract

Freitas (2019)	Effects of a Behaviour Change Intervention Aimed at Increasing Physical Activity on Clinical Control of Adults with Asthma: An RCT	Conference Abstract
Jaakkola (2017)	Regular Exercise and Asthma Control in Adults: A Randomized Controlled Trial	Abstract Only
Jalbert (2018)	Effects of Aerobic Exercise on Asthma Control in Eosinophilic Asthma Patients: A Randomized Controlled Trial	Conference Abstract
Khusial (2019)	Myaircoach: mHealth Assisted Self-Management in Patients with Uncontrolled Asthma, A Randomized Control Trial	Conference Abstract
Khusial (2020)	Effectiveness of myAirCoach: A mHealth Self-Management System in Asthma	Physical Activity Intervention
Lowe (2018)	Home-Based Exercise Intervention Versus Remote Asthma Care Guidance Via Telephone Text Message in Obese Asthmatics: A Pilot Randomized Controlled Trial	Abstract Only
Lowe (2018)	Feasibility of a Home-Based Exercise Intervention with Remote Guidance for Obese Asthmatics	Abstract Only
Ma (2010)	The Breathe Easier Through Weight Loss Lifestyle (BE WELL) Intervention: A Randomised Controlled Trial	Not a Physical Activity Intervention
Mendes (2018)	Seasonal Changes Influence the Improvement in Asthma Symptoms by Exercise Training in Subjects with Asthma	Pulmonary Rehabilitation Intervention
Merlini (2019)	Improved Sprint Performance with Inhaled Long-Acting B2-Agonists Combined with Resistance Exercise	Diagnosis of Asthma

Meyer (2015)	A 12-Month, Moderate-Intensity Exercise Training Program Improves Fitness and Quality of Life in Adults with Asthma: A Controlled Trial	Pulmonary Rehabilitation Intervention
Nyenhuis (2018)	The Feasibility and Acceptability of a Tailored Physical Activity Intervention for Sedentary African American Women with Asthma	Abstract Only
Nyenhuis (2020)	Daily Physical Activity of Urban African American Women with Asthma	Conference Abstract
Olenich (2018)	Flexibility and Strength Training in Asthma: A Pilot Study	Not a Physical Activity Intervention
O'Neill (2020)	Reducing Anxiety and Anxiety Sensitivity with High-Intensity Interval Training in Adults with Asthma	Outcomes Assessed
Paul (2013)	The Effect of Regular Bris Walking on Quality of Life and Lung Function in Partially Controlled Adult Asthmatics	Abstract Only
Peper & Tibbetts (1992)	Fifteen-Month Follow-up with Asthmatics Utilizing EMG/Incentive Inspirometer Feedback	Not a Physical Activity Intervention
Peric (2018)	Feasibility of Individualized Aerobic Threshold-Based Exercise on Ventilatory Efficiency in Sedentary Adult Asthma Patients	Pulmonary Rehabilitation Intervention
Pushpa (2018)	Yoga as a Complementary Therapy Improves Pulmonary Functions in Patients of Bronchial Asthma: A Randomized Controlled Trial	Outcomes Assessed

Rasulnia (2018)	Assessing the Impact of a Remote Digital Coaching Engagement Program on Patient-Reported Outcomes in Asthma	Not a Physical Activity Intervention
Razavi (2011)	The Effect of an Exercise Programme and Consumption of Vitamin D on Performance and Respiratory Indicators in Patients with Asthma	Not Written in English
Refaat & Gawish (2015)	Effect of Physical Training on Health-Related Quality of Life in Patients with Moderate and Severe Asthma	Pulmonary Rehabilitation Intervention
Renolleau (2014)	Home-Based Respiratory Rehabilitation in Adult Patients with Moderate or Severe Persistent Asthma	Pulmonary Rehabilitation Intervention
Rodrigues (2020)	Are the Effects of High-Intensity Exercise Training Different in Patients with COPD Versus COPD + Asthma Overlap?	No Asthma Diagnosis
Saccomani (2013)	Comparison Between the effects of Aerobic and Breathing Exercises in the Clinical Psychosocial Factors in Asthmatic Patients	Abstract Only
Sano (2018)	Pedometer Intervention to Improve Daily Physical Activity and QOL in Patients with Stable COPD Including those with ACO	Conference Abstract
Sano (2019)	Pedometer Intervention to Improve Daily Physical Activity and QOL in Patients with Stable COPD. Additional Analysis on ACO	Conference Abstract
Scichilone (2012)	Effects of Exercise Training on Airway Closure in Asthmatics	Outcomes Assessed
Shaw (2011)	Pulmonary Function and Abdominal and Thoracic Kinematic Changes Following Aerobic and Inspiratory Resistive	Outcomes Assessed

	Diaphragmatic Breathing Training in Asthmatics	
Shaw (2010)	Role of Diaphragmatic Breathing and Aerobic Exercise in Improving Pulmonary Function and Maximal Oxygen Consumption in Asthmatics	Outcomes Assessed
Sodhi (2014)	Assessment of the Quality of Life in Patients with Bronchial Asthma, Before and After Yoga: A Randomised Trial	Participants Under 18-Years
Tartibian (2018)	High-Intensity Interval Training/Resistance Exercise Lead to Greater Lung Function: Improvement of FEV1/FVC% and FEF25-75%	Poster Presentation Abstract Only
Toennesen (2017)	Exercise and Diet Improve Asthma Control in Non-Obese Asthma Patients – A Randomised Controlled Trial	Abstract Only
Toennesen (2018)	Feasibility of High-Intensity Training in Asthma	Outcomes Assessed
Tousman (2010)	A Pilot Study Assessing the Impact of a Learner-Centred Adult Asthma Self-Management Program on Psychological Outcomes	Not a Physical Activity Intervention
Turk (2017)	Effect of a High Intensity Lifestyle Program on Asthma Control in Obese Patients with Asthma	Abstract Only
Turner (2011)	Improvements in Symptoms and Quality of Life Following Exercise Training in Older Adults with Moderate/Severe Persistent Asthma	Pulmonary Rehabilitation Intervention

Unal (2018)	Effect of Mild/Moderate Lower or Upper Extremity Resistance Exercises on Lung Function in Asthmatic Patients	Abstract Only
Villanueva (2018)	The Effectiveness of Combining Inspiratory Muscle Training with Manual Therapy and A Therapeutic Exercise Program on Maximum Inspiratory Pressure in Adults with Asthma: A Randomized Clinical Trial	Outcomes Assessed
10 Clinical Trials		Abstract Only

Appendix F. *Barriers and Facilitators - Ethical Approval*

Faculty of Medicine and Health Sciences Research Ethics Committee

University of East Angli

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Norwich Research Par
Norwich, NR4 7T

Email: fmh.ethics@uea.ac.u

Web: www.uea.ac.uk/researchandenterpris

Leanne Tyson
MED

19 August 2019

Dear Leanne

Title: Exploring the views of adults living with asthma to inform the development of a physical activity intervention

Reference: 2018/19 - 147

Thank you for your response to the recommendations of the FMH Ethics Committee to your proposal. I have considered your amendments and I can now confirm that your proposal has been approved.

Please can you ensure that any further amendments to either the protocol or documents submitted are notified to us in advance, and also that any adverse events which occur during your project are reported to the Committee.

Approval by the FMH Research Committee should not be taken as evidence that your study is compliant with GDPR and the Data Protection Act 2018. If you need guidance on how to make your study GDPR compliant, please contact your institution's Data Protection Officer.

Please can you also arrange to send us a report once your project is completed.

Yours sincerely

Prof Alastair Forbes
Chair
FMH Research Ethics Committee

Appendix G. *Barrier and Facilitators - Social Media and Internet Recruitment Text*

Exploring the Views of Adults Living with Asthma to Inform the Development of a Physical Activity Intervention

Researcher Leanne Tyson from the University of East Anglia is inviting adults with asthma to take part in a 1-hour interview or focus group. The research is designed to find out more about the views of people with asthma, and the things that encourage or discourage physical activity.

Face-to-face focus groups or interviews will be held at the University of East Anglia, Norwich. If you cannot attend face-to-face, we can arrange an individual interview to be done over the phone or via a service like Skype or Facetime, at a time convenient to you. During the interview or focus group, you will be asked to discuss your views on physical activity and asthma. We will use this information to design a physical activity programme for people with asthma.

You will get £20 shopping vouchers as a thank you for your time.

To find out more and register your interest in taking part, please contact Leanne Tyson by email: leanne.tyson@uea.ac.uk.

Appendix H. *Barrier and Facilitators - Recruitment Poster*

Appendix I. *Barriers and Facilitators - Participant Information Sheet*

Exploring the Views of Adults Living with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Information Sheet Version 0.3 10/07/2019
Researcher: Leanne Tyson University of East Anglia

You are being invited to take part in a research study. This Participant Information Sheet tells you about the research. Knowing what is involved will help you decide if you want to take part. **Please take time to read the following information sheet carefully and decide whether you want to take part, or not.** Ask us if there is anything that is not clear, or if you would like more information.

Taking part in this research study is voluntary. By giving consent to take part in this study, you are telling us that you;

- ✓ Understand what you have read;
- ✓ Agree to take part in the research study as outlined below;
- ✓ Agree to the use of your personal information as described.

Why is this research needed?

Asthma is a long-term condition that affects your airways. In the UK alone, approximately 8 million people have been diagnosed with asthma. It usually causes symptoms such as coughing, wheezing, and breathlessness. People with asthma may have times when their asthma is worse, and sometimes they have attacks requiring additional treatment.

It is important that people with asthma remain or become more physically active (e.g., walking, cycling, swimming, etc.). This can improve symptoms, and how people feel about their life, and also reduce visits to the doctor or hospital. However, previous research has shown that adults with asthma do less physical activity than people who do not have asthma. This study is designed to find out more about the views of people with asthma, about the things that encourage or discourage physical activity. We will use this information to develop an intervention to help people with asthma become more physically active.

Who is running the study?

The study is being carried out by the research student, who is conducting this research as part of her PhD project at the University of East Anglia. The project will take place under the supervision of Professor Andrew Wilson (Principal Investigator), Dr Wendy Hardeman, and Dr Joanna Semlyen.

Why have I been invited?

You have been invited to take part because you are older than 18 and have a diagnosis of asthma.

What will I be asked to do if I take part?

You will be invited to take part in a group discussion (focus group) or an individual interview with the research student (Leanne Tyson). Focus groups will take place at the University of East Anglia. There will be up to 4 to 5 other people like yourself in the group. If you are unable to attend the university for a focus group, you will have the option to take part in an interview. This can be done over the phone or via a service like Skype or Facetime – whichever you prefer. Before the focus group or interview starts, you will be asked to read and sign a consent form. During the focus group or interview, you will be asked about your views on physical activity and asthma, and the things that encourage or discourage you from being physically active.

You can say as much or as little as you want, and there are no right or wrong answers. This will last for about an hour. We will ask your permission for the focus group or interview to be recorded on a secure recording device. We need to do this so we have an accurate record of what you say during the focus group or interview so we can analyse it later.

Do I have to take part?

No, taking part is voluntary. You do not have to take part if you do not want to. If you decide not to take part, you do not have to give a reason.

If you decide to take part, we will ask you to sign a consent form. We will also ask you to complete a short questionnaire for us to collect some information about you (e.g., age, gender, ethnicity, and employment status), your asthma, and levels of physical activity.

What are the potential risks and benefits of taking part?

The research involves taking part in either a focus group or interview. Therefore, we do not anticipate there being any risks involved in taking part or that what you will be discussing with the researcher will be sensitive or distressing. However, if you do feel upset, you will be able to leave the discussion at any time. When ready, you will be able to re-join the focus group or continue with the interview. If during or following the focus group or interview you become concerned about your health or would like any addition support please contact your general practitioner (GP), the researcher leading the focus group or interview will be unable to recommend any treatment or medication.

There will be no direct benefit to your asthma from taking part in this research study. However, your involvement will allow you to have your say about your experiences of physical activity and asthma and will inform the development of an intervention to increase physical activity which may benefit other people living with asthma. As a token of thanks for taking the time to participate, we will offer you a £20 shopping voucher.

What if I wish to withdraw at a later stage?

You are free to withdraw at any time. Just tell us you want to withdraw from the research – you do not need to give a reason. You can also decline to answer any of the questions asked.

If you are taking part in a focus group, it will not be possible to remove your comments from our records once the session has started, as it is a group discussion.

If you are taking part in an interview, unless you indicate otherwise, any recordings will be erased, and the information provided will not be included in the study.

Will my taking part in this study be kept confidential?

Yes. Any information that you give us will be treated in confidence. When you agree to take part in the research, you will be assigned a personal code name. This code will be used rather than any personal details, in order to make sure your identity cannot be known.

To allow us to set up the focus group, we will need you to provide us with your name and contact details. **This information will be accessible only to the research student and Professor Andrew Wilson (Principal Investigator)**. Your contact details will be stored securely, in password-protected files on password protected computers. They will not be passed to the sponsor of the study or any third party. They will be kept securely for up to 12 months after the study has completed, so that we can forward the results to you if you wish, then destroyed.

We will ask you to sign two copies of the consent form before the start of the group session. We will give you one copy of this form, and the research team will keep one copy. During the study, our copy of your consent form will be stored in a locked filing cabinet accessible only to the researchers. Certain individuals from the University of East Anglia who are responsible for research regulation may look at your research records to check the accuracy of the research study.

The audio-recordings of the group discussion will be written up in full. The writing up (also called 'transcription') will be undertaken either by the researcher who conducted the session or by a trusted company. While being stored, transcriptions will be kept in password-protected files on password protected computers, accessible only to the researcher team and the transcription company. When the discussion is transcribed, all information that would allow you to be identified (such as names, locations, or specific descriptions) will be replaced with personal code names or a generalised summary; this is called 'anonymisation.' Therefore, anything you say will not be able to be linked to you in any reports or publications. Reports from the study will include quotations from the discussion, but names will not be used.

After anonymisation (a process where the information you provide are no longer linked to you), information collected during the session will be shared within the research team for data analysis. The information collected during the session will be stored at the university running the research, in a locked filing cabinet and/or password-protected computers accessible only to the researcher team. It will be stored up to 5 years after the study has ended, then it will be destroyed.

What will happen to the results of the research study?

The results from the research will inform the development of a smartphone application to promote physical activity in people with asthma. The results will be written up as part of a PhD thesis and shared with others via research papers in academic journals and conference presentations.

What if I would like further information about the study?

When you have read this information sheet, Leanne Tyson will be available to discuss it with you further and answer any question you may have. If you would like to know more at any stage during this study, please feel free to contact her [leanne.tyson@uea.ac.uk].

What do I do if I have a complaint?

If you have any complaints about the study, then you can contact Mercedes Mills, the Research & Innovation Services Project Office at the University of East Anglia on 01603591574 or rin.reception@uea.ac.uk.

Will I be told the results of the study?

Yes. You can tell us that you wish to receive feedback by ticking the relevant box on the consent form. The feedback will be in the form of a one-page lay summary. You will receive this feedback after the research is finished.

What do I do now?

Thank you for considering taking part in this research study. You will be contacted by Leanne Tyson (PhD Student) in a few days. You can ask any questions you have and let her know your final decision. If you decide to take part, a focus group will be scheduled.

This information sheet is for you to keep.

Appendix J. *Barriers and Facilitators - Interview Consent Form*

University of East Anglia

Faculty of Medicine and Health Sciences
Norwich Medical School

University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Web: www.uea.ac.uk

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Consent Form – Interview Version 0.3 09/07/2019

Researcher: Leanne Tyson University of East Anglia

Please Initial Boxes

1. I confirm that I have read and understood the information sheet dated, 10/07/2019 (version 0.3) for the above research 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 a reason. ☐
3. I understand that if I do withdraw, information collected on or about me as part of this research can only be removed up until the point where data analysis starts. ☐
4. I give permission for my contact details to be kept confidentially and securely. I agree that members of the research team can use these details to make contact with me for the duration of the study, solely for the purpose of activities connected with the research. ☐
5. I agree to take part in one interview of approximately 60 minutes in duration. ☐

1. I agree for the interview to be audio-recorded and written out in full (transcribed) by the research team or by an approved transcription service provider. ☐

2. I agree to my direct quotes from the interview being used when the results of the research are made public. I understand that my name will not be used in these and that the team will ensure neither I nor someone to whom I refer during my interview will be identifiable in such quotes. ☐

3. I understand that personal information and research data collected from me will be stored in accordance with University policy. ☐

4. I understand that my research data may be looked at by responsible individuals from the research team, the university involved in the research and research regulatory bodies ☐

5. I agree to take part in the research. ☐

Optional

6. I would like to receive a summary of the main results of the research. ☐

Name of Participant (Print Name):	**Date:**	**Signature:**
____________________________	_______________	_______________________

For Researcher to Complete:

Name of Person Taking Consent:	**Date:**	**Signature:**
____________________________	_______________	_______________________

Original: Investigator Site File. Copy: Participant.

Appendix K. *Barriers and Facilitators – Focus Group Consent Form*

University of East Anglia

Faculty of Medicine and Health Sciences
Norwich Medical School

University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Web: www.uea.ac.uk

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Consent Form – Focus Group Version 0.3 09/07/2019

Researcher: Leanne Tyson University of East Anglia

Please Initial Boxes

1. I confirm that I have read and understood the information sheet dated, 10/07/2019 (version 0.3) for the above research 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 a reason. ☐
3. I understand that if I do withdraw, it will not be possible to withdraw my comments once the focus group has stared at it is a group discussion. ☐
4. I give permission for my contact details to be kept confidentially and securely. I agree that members of the research team can use these details to make contact with me for the duration of the study, solely for the purpose of activities connected with the research. ☐
5. I agree to take part in one focus group of approximately 60 minutes in duration. ☐

1. I agree for the focus group to be audio-recorded and written out in full (transcribed) by the research team or by an approved transcription service provider.

2. I agree to my direct quotes from the focus group being used when the results of the research are made public. I understand that my name will not be used in these and that the team will ensure neither I nor someone to whom I refer during my interview will be identifiable in such quotes.

3. I understand that personal information and research data collected from me will be stored in accordance with University policy.

4. I understand that my research data may be looked at by responsible individuals from the research team, the university involves in the research and research regulatory bodies.

5. I agree to take part in the research.

Optional

6. I would like to receive a summary of the main results of the research.

Name of Participant (Print Name):	**Date:**	**Signature:**
______________________________	________________	_________________________

For Researcher to Complete:

Name of Person Taking Consent:	**Date:**	**Signature:**
______________________________	________________	_________________________

Original: Investigator Site File. Copy: Participant.

Appendix L. *Barriers and Facilitators - Participant Invite*

Exploring the Views of Adults Living with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Invite Version 0.2 10/07/2019

Researcher: Leanne Tyson University of East Anglia

Date:

Dear Sir or Madam,

Thank you for registering your interest in taking part in this research study.

This study has been designed to find out more about the views of people with asthma, about the things that encourage or discourage physical activity. We will use this information to develop an intervention (programme) to help people with asthma become more physically active.

As someone who is over the age of 18 and has a diagnosis of asthma, your views and experiences will be very helpful to us. However, you do not have to take part in the research if you don't want to.

If you participate in this research, you will be asked to take part in one focus group or interview with a researcher which will last for about one hour. The focus group will take place at the University of East Anglia. If you are unable to attend face-to-face, an interview can be done over the phone or via a service such as Skype or Facetime –

whichever you prefer. With your permission, the focus group or interview will be audio-recorded. Any information that you give us will be treated in confidence.

There will be no direct benefit to your asthma from taking part in this research study. However, your involvement will allow you to have your say about your experiences of physical activity and asthma and will inform the development of an intervention (programme) to increase physical activity in people with asthma. As a token of thanks for taking the time to participate, we will offer you a £20 shopping voucher.

The accompanying information sheet tells you more about the research. Please read this carefully before making your decision regarding whether to take part or not. If you have any questions about the research, contact the researcher – their contact details can be found on the information sheet. You will be contacted by the researcher in a few days, and you can let them know your final decision.

Thank you for taking the time to read the information sheet and for considering taking part in our research.

Kind Regards,

Leanne Tyson, Researcher.

Appendix M. *Barrier and Facilitators - Demographic Questionnaire*

University of East Anglia

Faculty of Medicine and Health Sciences
Norwich Medical School

University of East Anglia
Norwich Research Park
Norwich NR4 7TJ
United Kingdom

Web: www.uea.ac.uk

Exploring the Views of Adults Living with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Questionnaire Version 0.3 16/08/2019

Researcher: Leanne Tyson University of East Anglia

Background Information

1. **Age (please tick):**

   18-24 ☐ **25-45** ☐ **46-55** ☐ **Over 55** ☐

2. **Gender (please tick):**

   Male ☐ **Female** ☐ **Other** ☐ **Prefer not to say** ☐

3. **Ethnicity:**

4. **Employment Status:**

   Full Time ☐ **Part Time** ☐ **Student** ☐ **Unemployed** ☐ **Retired** ☐

   Other (please specify):___________________________________

Participant Questionnaire V0.2 10/07/2019
Leanne Tyson. Submitted: 11/07/2019

Asthma Status

1. **Approximately how long have you had asthma? -**

2. **What inhalers and tablets do you currently take? -**

3. **Do you experience asthma symptoms during/after physical activity?**

Every time 1	**Most of the time** 2	**Only sometimes** 3	**Not at all** 4

4. **During the past 4 weeks, how often did your asthma prevent you from getting as much done at work, school or home? (please circle)?**

All of the time 1	**Most of the time** 2	**Some of the time** 3	**A little of the time** 4	**None of the time** 5

5. **During the past 4 weeks, how often have you had shortness of breath (please circle)?**

More than once a day 1	**Once a day** 2	**3 – 6 Times a week** 3	**1 -2 Times a Week** 4	**Not at all** 5

6. **During the past 4 weeks, how often did your asthma symptoms (wheezing, coughing, shortness of breath, chest tightness, or pain) wake you up earlier than usual in the morning (please circle)?**

4 or more times a week 1	**2 – 3 Nights a week** 2	**Once a week** 3	**Once or twice** 4	**Not at all** 5

1. **During the past 4 weeks, how often have you used your rescue inhaler (usually blue) (please circle)?**

3 or more times a day 1	**1 – 2 Times a day** 2	**2 – 3 Times a week** 3	**Once a week or less** 4	**Not at all** 5

2. **How would you rate your asthma control during the past 4 weeks (please circle)?**

Not Controlled 1	**Poorly Controlled** 2	**Somewhat Controlled** 3	**Well Controlled** 4	**Completely Controlled** 5

Physical Activity Level

1. **Please tell us the type and amount of physical activity involved in your work.**

		Please Mark One Box Only
A	I am not in employment (e.g., retired, retired for health reasons, unemployed, full-time carer etc.)	
B	I spend most of my time at work sitting (such as in an office)	
C	I spend most of my time at work standing or walking. However, my work does not require much intense physical effort (e.g., shop assistant, hairdresser, security guard, childminder, etc.)	
D	My work involves definite physical effort including handling of heavy objects and use of tools (e.g., plumber, electrician, carpenter, cleaner, hospital nurse, gardener, postal delivery worker, etc.)	
E	My work involves vigorous physical activity including handling of very heavy objects (e.g., scaffolder, construction worker, refuse collector, etc.)	

2. **During the last week, how many hours did you spend on each of the following activities?**

		None	Some but less than 1 hour	1 – 2 hours	3 hours or more
A	Physical exercise such as swimming, jogging, aerobics, football tennis, gym workout, etc.				
B	Cycling, including cycling to work and during leisure time.				

C	**Walking, including walking to work, shopping, for pleasure, etc.**				
D	**Housework/Childcare**				
E	**Gardening/DIY**				

1. **How would you describe your usual walking pace? (Please mark one box only)**

Slow Pace (i.e. less than 3mph)		**Steady Average Pace**	
Brisk Pace		**Fast Pace (i.e. over 4mph)**	

Appendix N. *Barriers and Facilitators - Standardised Topic Guide*

Exploring the Views of Adults Living with Asthma to Inform the Development of a Physical Activity Intervention

Topic Guide Version 0.2 10/07/2019

Researcher: Leanne Tyson University of East Anglia

Introduction

The purpose of this *[focus group or interview]* is to find out more about the views of people with asthma about the things that encourage or discourage physical activity. We will then use this information to develop an intervention (programme) to help people with asthma be more physically active.

Does anyone have any questions?

- Introduce digital recorder
- Stress confidentiality
- Set ground rules

Explain: Physical activity – Any bodily movement produced by muscles that require energy – including activities undertaken while working, playing, carrying out household chores, travelling, and engaging in recreational activates.

Capability – 'Physical' and 'Psychological'

What do you think the recommendations say about physical activity for adults with asthma? [Knowledge]

How do you think these differ from the recommendations for non-asthmatics?

How do you currently keep active? [Skills]

Are there any activities that you find difficult to do because of your asthma?

How do you keep track of how physically active you are? [Behaviour Regulation]

What do you think are the biggest challenges to improving or maintaining physical activity in people with asthma? [Knowledge/Skills]

Do you think people with more severe asthma have additional challenges? If so, what might these challenges be?

How could we overcome these challenges?

Opportunity

What might stop you from being physically active? [Environmental Context and Resources]

Could you tell me if you know any resources available to help improve or maintain physical activity? [Environmental Context and Resources]

Do you have somewhere to be physically active? [Environmental Context and Resources]

Do you know whom you would talk to if you had concerns about your physical activity for support and encouragement? [Social Influences]

Whom would you prefer to talk to about physical activity (e.g. family, friends, someone else with asthma, healthcare professional)?

Do you prefer to be active alone or with a partner? (e.g., family, friends, someone else with asthma?). [Social Influences]

Motivation

How confident do you feel in being able to make changes to improve your physical activity? [Beliefs about Capabilities]

To what extent do you think physical activity is important? [Beliefs about Consequences]

e.g., In general, and to your asthma management.

What do you think are the advantages and disadvantages of increasing or maintaining your physical activity? [Belief about Consequences].

What are your main worries about the consequences of not being regularly active? (e.g., being overweight, other health consequences, etc.) [Beliefs about Consequences]

What are your main concerns about becoming regularly active? [Beliefs about Consequences]

Are there any fears you have relating to physical activity? [Emotions]

What kind of things encourage you to be more active or maintain your physical activity? [Reinforcement]

Other

Is there anything else that encourages you to be active or maintain your physical activity we have not discussed?

Is there anything else that discourages you from being active or maintaining your physical activity we have not discussed?

Appendix O. *User Preferences - Ethical Approval*

Faculty of Medicine and Health Sciences Research Ethics Committee

University of East Anglia

NORWICH MEDICAL SCHOOL
Bob Champion Research & Educational Building
James Watson Road
University of East Anglia
Norwich Research Park
Norwich NR4 7UQ

Email: fmh.ethics@uea.ac.uk
www.med.uea.ac.uk

Leanne Tyson
Norwich Medical School
Bob Champion Research & Educational Building
University of East Anglia
Norwich Research Park
NR4 7UQ

17th April 2020

Dear Leanne

Project Title: Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention.

Reference: 2019/20-100

The submission of your application has been considered by a Sub-Committee of the Faculty Research Ethics Committee and I can confirm that your proposal has been approved.

Please could you ensure that any amendments to either the protocol or documents submitted are notified to us in advance, and that any adverse events which occur during your project are reported to the Committee. Please could you also arrange to send us a report once your project is completed.

Approval by the FMH Research Ethics Committee should not be taken as evidence that your study is compliant with GDPR and the Data Protection Act 2018. If you need guidance on how to make your study GDPR compliant, please contact your institution's Data Protection Officer.

I would like to wish you good luck with your project.

Yours sincerely

Prof Alastair Forbes
Chair
FMH Ethics Committee

COVID-19: *The FMH Research Ethics Committee procedures remain as normal. Please note that our decisions as to the ethics of your application take no account of Government measures and UEA guidelines relating to the coronavirus pandemic and all approvals granted are, of course, subject to these. If your research is COVID-19 related it will naturally be expedited. If the current situation means that you will have to alter your study, please submit an application for an amendment in the usual way.*

Appendix P. *User Preferences - Social Media and Internet Recruitment Text*

<u>Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention</u>

Researcher Leanne Tyson from the University of East Anglia is inviting adults diagnosed with asthma to take part in an online group discussion (focus group) about a physical activity smartphone application (app) to improve physical activity among people living with asthma. During the focus group, we would like to share our initial ideas for the app with you, to get your views on what key features to include. We would also like to ask you about the current coronavirus (COVID-19) outbreak and how it has influenced your physical activity levels.

The online focus groups will be conducted using an online video app called *Zoom* - which is free to download. Focus groups will last between 60-90 minutes. You will get a £20 shopping voucher as a thank you for your time.

If you are interested in taking part in our study, please complete this online questionnaire to check your eligibility: https://forms.office.com/Pages/ResponsePage.aspx?id=lYdfxj26UUOKBwhl5djwkOJMRzCFJCdLujNOSbJk3DdUMDlIQUNIWUo2QUdEQ1MwUk9RUDFPVzZOTS4u.

If you have any questions about the research or would like to know more, please contact Leanne Tyson by email: Leanne.Tyson@uea.ac.uk.

Appendix Q. *User Preferences - Participant Eligibility Questionnaire*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention

Participant Eligibility Questionnaire Version 0.2 15/04/2020

Researcher: Leanne Tyson, University of East Anglia

Thank you for your interest in our study.

Please take the time to answer the following questions to see if you are eligible to participate in the study.

1. Are you over 18 years old? *

   ○ Yes

   ○ No

2. Are you able to speak English? *

   ○ Yes

   ○ No

3. Have you been diagnosed with asthma? *

- Yes
- No

4. Are you currently being prescribed asthma medication? *

- Yes
- No

5. Have you been diagnosed with any other respiratory condition(s) (e.g., chronic pulmonary obstructive disease (COPD), chronic bronchitis, emphysema, or cystic fibrosis)? *

- Yes
- No

6. Do you own a smartphone and a computer? *

- Yes
- No

7. Do you own a computer, laptop or tablet which has access to the internet? *

- Yes
- No

Link to online Participant Consent Form:

https://forms.office.com/Pages/ResponsePage.aspx?id=lYdfxj26UUOKBwhl5djwkOJ MRzCFJCdLujNOSbJk3DdUMDlIQUNIWUo2QUdEQ1MwUk9RUDFPVzZOTS4u.

Appendix R. *User Preferences - Participant Invite*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Invite Version 0.2 15/04/2020

Researcher: Leanne Tyson, University of East Anglia

Dear ______________,

Thank you for completing the online eligibility questionnaire. We are pleased to tell you that you are eligible to participate in our study.

The research student intends to develop an intervention (programme) to help people with asthma to become more physically active. The intervention will be delivered using a smartphone application (app). This study has been designed for us to share with you our initial ideas for the app and get your views on what key features to include. We would also like to ask you about the current coronavirus (COVID-19) outbreak and how it has influenced your physical activity levels.

If you participate in this research, you will be asked to take part in one online group discussion (focus group) lead by the research student, which will last for about 60-minutes. The online focus group will be conducted using an online app called *Zoom* – which is free to download. With your permission, the focus group will be audio-recorded. Any information that you give us will be treated in confidence.

We will be asking you to think about the current COVID-19 outbreak and how it has influenced your physical activity levels. We understand that this might be emotionally distressing for some people. If you are personally experiencing increased anxiety over the outbreak, we ask you to think **carefully** about participating in the study.

There will be no direct benefit to your asthma from taking part in this research study. However, your involvement will give you the opportunity to inform the development of an intervention (programme) to increase physical activity in people with asthma. As a token of thanks for taking the time to participate, we will offer you a £20 shopping voucher.

Below is a web link to an online Participant Information Sheet which will tell you more about the research:

https://drive.google.com/file/d/1HZyv3FUHxtvs73AXWe3YckpjK-RT1zQD/view?usp=sharing.

Please read this carefully before making your decision regarding whether to take part or not. If you have any questions about the research, please just send us an email [Leanne.Tyson@uea.ac.uk]. You will be contacted by us in a few days, and you can let us know your final decision.

Thank you for taking the time to read the information sheet and for considering taking part in our research.

Kind Regards,
Leanne Tyson (Research Student)

Appendix S. *User Preferences - Participant Information Sheet*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention.

Participant Information Sheet Version 0.2 15/04/2020

Researcher: Leanne Tyson, University of East Anglia

We would like to invite you to take part in a research study. This Participant Information Sheet tells you about the research. Knowing what is involved will help you decide if you want to take part. **Please take time to read the following information sheet carefully and determine if you're going to take part, or not.** Talk to others about the study if you wish. Please email the research student, Leanne Tyson [Leanne.Tyson@uea.ac.uk], if there is anything that is not clear or if you would like more information.

Taking part in this research study is voluntary. By giving consent to take part in this study, you are telling us that you;

- ✓ Understand what you have read;
- ✓ Agree to take part in the research study as outlined below;
- ✓ Agree to the use of your personal information as described.

Why is this research needed?

Asthma is a long-term condition that affects your airways. In the UK alone, approximately 8 million people have been diagnosed with asthma. It is important that people with asthma remain or become more physically active (e.g., walking, cycling, swimming, etc.). This can improve symptoms, and how people feel about their life, and also reduce visits to the doctor or hospital. However, previous research has shown that adults with asthma are less physically active than people who do not have asthma. The current coronavirus (COVID-19) outbreak is likely to make this worse as it is becoming harder to stay active due to the social distancing measures.

We intend to develop an intervention (programme) to help people with asthma to become more physically active. The intervention will be delivered using a smartphone application (app). This study has been designed for us to share with you our initial ideas for the app and get your view on what to key features to include. We would also like to ask you about the current COVID-19 outbreak and how this has influenced your physical activity levels.

Who is running the study?

The research is being undertaken for educational purposes. It will form part of a PhD for the research student, Leanne Tyson, University of East Anglia. The project will take place under the supervision of Professor Andrew Wilson, Dr Wendy Hardeman, and Dr Joanna Semlyen. It will be sponsored by the University of East Anglia.

Why have I been Invited?

You have been invited to take part because you are older than 18 and have a diagnosis of asthma. We anticipate enrolling between 12 - 32 people into the study.

Do I have to take part?

No, taking part is voluntary. You do not have to take part if you do not want to. If you decide not to take part, you do not have to give a reason.

If you decide to take part, you will be asked to complete a short eligibility questionnaire to see if you are eligible to take part. If you are eligible, you will be emailed a link to complete an online consent form. Once you have agreed to take part, we will ask you to complete a short online questionnaire for us to collect some information about you (e.g., age, gender, ethnicity, and employment status), your asthma, and your physical activity levels.

What will I be asked to do if I take part?

We will be invited to attend an online 'focus group'. This is a group discussion where the research student will meet with a few participants taking part in the study. We will be using an online video app called *Zoom* for the focus groups. One week before the online focus group, you will be emailed instructions on how to join. We would advise you to move to a quiet location within your home that has a neutral background, away from any distraction. Try and join the focus group before the scheduled time to make sure you have no problems joining.

During the online focus group, we will share with you our initial ideas for the app and discuss with you what key features you think should be included. We will also ask you about the current COVID-19 outbreak and how it has influenced your physical activity levels.

We expect these groups meetings to last between 60-90 minutes. You can say as much or as little as you want, and there are no right or wrong answers. We will ask your permission for us to audio-record the focus group as part of the consent form. There will be no video imaging. We need to do this so we have an accurate record of what you said during the focus group so we can analyse it later.

What are the potential disadvantages and benefits of taking part?

We will be asking you to think about the current COVID-19 outbreak and how it has influenced your physical activity levels. If you are personally experiencing increased anxiety over the outbreak, we ask you to think carefully about participating in the study. If you do become upset during the online focus group, you will be able to leave at any time. The research student leading the focus group will email you after the focus group to ask how you are feeling, and you can speak to them one-to-one if you would like to. The research student will be unable to recommend any treatment or medication but can signpost you to online support. If you would like any additional support during or following this study, please contact your clinician. Once the focus group has finished, the research student will email you a link to an online form with online resources for support.

There will be no direct benefit to your asthma from taking part in this research study. However, your involvement will give you the opportunity to inform the development of an intervention (programme) to increase physical activity in people with asthma. As a token of thanks for taking the time to participate, we will offer you a £20 shopping voucher.

What if I wish to withdraw at a later stage?

You are free to withdraw at any time - you do not need to give a reason. You can also decline to answer any of the questions asked. However, it will not be possible for us to remove your comments from the recording of the focus group once the session has started.

Will my taking part in this study be kept confidential?

Yes. We will follow ethical and legal practices, and all information about you will be handled with the strictest confidence. All information which is collected about you during the study will be held securely in accordance with the Data Protection Act and the General Data Protection Regulation. You will be assigned a personal code name.

This code will be used rather than any personal details, to make sure your identity cannot be known.

The audio recording of the focus group will be written-up in full (also called 'transcription'). All information that would allow you to be identified (such as names, locations, or specific descriptions) will be replaced with personal code names or generalised summary; this is called 'anonymisation'. Therefore, anything you say will not be able to be linked back to you in any reports or publications. All data collected during the study will be stored in password-protected files on the network of the University of East Anglia that can only be accessed by authorised people (e.g., research team and auditors). We will store information collected for up to 10 years after the study has ended and then it will be destroyed.

What will happen to the results of the research study?

The research is being undertaken for educational purposes. It forms part of a thesis towards a PhD for the research student, Leanne Tyson, University of East Anglia. We also expect to present the findings at conferences and publish the study in a peer-reviewed journal. We will anonymise all information, and you will not be identifiable in any of these.

Will I be told the results of the study?

Yes. You can tell us that you wish to receive feedback by clicking the relevant box on the online consent form. The feedback will be in the form of a one-page summary, which will be emailed to you. You will receive this feedback after the research has finished.

What do I do if I have a complaint?

If you have any concerns about any aspect of this study, you can speak to Dr Wendy Hardeman [W.Hardeman@uea.ac.uk] or Dr Joanna Semlyen [J.Semlyen@uea.ac.uk], who will do their best to answer your questions. If you remain unhappy about the study, then you can contact Mercedes Mills, the Research & Innovation Services Project Office at the University of East Anglia on 0160 359 1574 or rin.reception@uea.ac.uk.

What do I do now?

Take time to consider your involvement in the study. If you decide that you would like to take part, please contact the research student, Leanne Tyson [Leanne.Tyson@uea.ac.uk].

This information sheet is for you to keep.

Link to online Participant Information Sheet: https://drive.google.com/file/d/1HZyv3FUHxtvs73AXWe3YckpjK-RT1zQD/view?usp=sharing.

Appendix T. *User Preferences - Consent Form*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention

Participant Consent Form Version 0.2 15/04/2020

Researcher: Leanne Tyson, University of East Anglia

Please make sure you have read the Participant Information Sheet **carefully** before consenting to take part.

The Participant Information Sheet can be found here: https://drive.google.com/file/d/1HZyv3FUHxtvs73AXWe3YckpjK-RT1zQD/view?usp=sharing.

1. I confirm that I have read and understood the information sheet dated 15/04/2020 (Version 0.2) for the above research and have had the opportunity to ask any questions.

   ○ Yes

   ○ No

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason.

   ○ Yes

○ No

3. I understand that if I do withdraw, it will not be possible to remove my comments once the focus group has started as it is a group discussion.

   ○ Yes

   ○ No

4. I give permission for the research team to keep my contact details confidentially and securely. I agree that members of the research team can use these details to make contact with me for the duration of the study, solely for activities connected with the research.

   ○ Yes

   ○ No

5. I agree to take part in one online focus group of approximately 60-90 minutes in duration.

   ○ Yes

   ○ No

6. I agree for the online focus group to be audio-recorded and written out in full (transcribed) by the research team or by an approved transcription service provider.

   ○ Yes

○ No

7. I agree with the research team using my direct quotes from the focus group when the results of the research are made public. I understand that the research team will not use my name and will ensure neither I nor someone to whom I refer during the focus group will be identifiable in such quotes.

○ Yes

○ No

8. I understand the research team will store the personal information and research data collected from me in accordance with the General Data Protection Regulation.

○ Yes

○ No

9. I understand that my research data may be looked at by responsible individuals from the research team involved in the study and research regularity bodies.

○ Yes

○ No

10. I would like to receive a summary of the findings of the research.

○ Yes

○ No

11. Please type your name in the box below to indicate you agree to participate in the study.

Enter your answer

Link to online Participant Consent Form:
https://forms.office.com/Pages/ResponsePage.aspx?id=lYdfxj26UUOKBwhl5djwkOJMRzCFJCdLujNOSbJk3DdUM1YyWUhUR0pMRFFNM1A4MEM0QVFHSTA1Ni4u.

Appendix U. *User-Preferences - Demographic Questionnaire*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention

Participant Questionnaire Version 0.2 15/04/2020

Researcher: Leanne Tyson, University of East Anglia

Participants will be asked to complete the following questionnaire online after they have given consent.

Thank you for agreeing to take part in our research study.

Please take the time to answer the following questions.

Background Information

1. Age *

- ○ 18 – 20
- ○ 21 – 29
- ○ 30 – 39
- ○ 40 – 49

○ 50 - 59

○ Over 60

2. Gender *

○ Male

○ Female

○ Other | Enter your answer

○ Prefer not to say

3. Ethnicity *

○ White

○ Black

○ Asian

○ Other | Enter your answer

4. Employment Status *

○ Full-Time

○ Part-Time

- Student
- Unemployed
- Retired
- Other

Asthma Status

5. Approximately how long have you had asthma in years? *

Enter your answer

6. What inhalers and tablets do you currently take for your asthma? *

Enter your answer

7. Do you experience asthma symptoms during/after physical activity? *

- Always
- Very frequently
- Occasionally

- Rarely
- Never

8. During the past 4 weeks, how often did your asthma prevent you from getting as much done at work, school, or home? *

- All the time
- Most of the time
- Some of the time
- A little of the time
- None of the time

9. During the past 4 weeks, how often have you had shortness of breath? *

- All the time
- Most of the time
- Some of the time
- A little of the time
- None of the time

10. During the past 4 weeks, how often did your asthma symptoms (wheezing, coughing, shortness of breath, chest tightness, or pain) wake you up earlier than usual in the morning? *

- ○ 4 or more times a week
- ○ 2 – 3 night a week
- ○ Once or twice
- ○ Once a week
- ○ Not at all

11. During the past 4 weeks, how often have you used your rescue inhaler (usually blue)? *

- ○ 3 or more times a day
- ○ 1 – 2 times a day
- ○ 2 – 3 times a week
- ○ Once a week or less
- ○ Not at all

12. How would you rate your asthma control during the past 4 weeks? *

- ○ Not controlled

○ Poorly controlled

○ Somewhat controlled

○ Well-controlled

○ Completely controlled

Physical Activity Level

13. Please tell us the type and amount of physical activity involved in your work. *

○ I am not employed (e.g., retired, retired for health reasons, unemployed, a full-time carer, etc.)

○ I spent most of my time at work sitting (e.g., such as in an office)

○ I spend most of my time at work standing or walking. However, my work does not require much intense physical effort (e.g., shop assistant, hairdresser, security guard, childminder, etc.)

○ My work involves definite physical effort including handling of heavy objects and use of tools (e.g., plumber, electrician, carpenter, cleaner, hospital nurse, gardener, postal delivery worker, etc.)

○ My work involves vigorous physical activity including handling of very heavy objects (e.g., scaffolder, construction worker, refuse collector, etc.) My work involves vigorous physical activity including handling of very heavy objects (e.g., scaffolder, construction worker, refuse collector, etc.)

14. During the last week, how many hours did you spend on each of the following activities? *

		None	Some but Less Than 1 Hour	1 - 2 Hours	3 Hours or More
A	Physical exercise such as swimming, jogging, aerobics, football, tennis, gym workout, etc.)				
B	Cycling, including cycling to work and during leisure time.				
C	Walking, including walking to work, shopping, for pleasure, etc.				
D	Housework/Childcare				
E	Gardening/DIY				

15. How would you describe your usual walking pace? *

- ○ Slow pace (i.e., less than 3mph)
- ○ Steady average pace
- ○ Brisk pace
- ○ Fast pace (i.e., over 4pmh)

Link to online Participant Questionnaire:

https://forms.office.com/Pages/ResponsePage.aspx?id=lYdfxj26UUOKBwhl5djwkOJMRzCFJCdLujNOSbJk3DdUQlBCRENZOUFISlRUVVpYT00yVFEwRVQwMi4u.

Appendix V. *User Preferences - Standardised Topic Guide*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention

Standardised Topic Guide Version 0.2 15/04/2020

Researcher: Leanne Tyson, University of East Anglia

Online Focus Group Schedule

Opening the Online Focus Group

- **Greet participants and thank them for agreeing to take part.**

- **Explain what the research is about, purpose and why –** "We intend to develop an intervention (programme) to help people with asthma to become more physically active. The intervention will be delivered using a smartphone application (app). In a separate part of the study, we have carried out interviews and focus groups with adults with asthma. We have used this information to develop some initial ideas for the intervention. You have been invited to take part in this online focus group because we would like to share with you our initial ideas for the intervention and get your views on what key features to include. We would also like to ask you about the current coronavirus (COVID-19) outbreak and how it has influenced your physical activity levels".

- **Explain the Ground Rules.**

- The discussion should last between 60 – 90 minutes but may go on a little longer.
- Try to talk to each other, rather than (just) answering to me.
- There are no right or wrong answers. Feel free to discuss with each other and offer alternative viewpoints. However, if you disagree, please do so in a respectful manner.
- Please try not to talk over the top of each other, as we won't be able to hear each other. It also makes transcription of the focus group difficult, and we won't be able to hear your viewpoint.

- Explain the Functionalities of Zoom

  - <u>Mute/Unmute Microphone</u> – If need to, you can mute or unmute your microphone at any time by clicking on the microphone icon on the bottom left of the screen.
  - <u>Start/Stop Video</u> – You can also start or stop your video at any time by clicking on the video icon on the bottom left of the screen.
  - <u>Participants</u> – You can click on the participants icon to see everyone that is in the focus group.
  - <u>Choose Video Layout</u> – At the upper right of the zoom screen you can switch between active speaker view and gallery view. You can also switch between the shared screen and video.
  - <u>Leave Meeting</u> – If you feel you need to leave the focus group you can click on the leave meeting option in the lower right corner. You will not be able to re-join if you leave.

- Give participants the opportunity to ask any questions they might have about using zoom or the focus group in general.

- Ask the participants if they are happy to begin and for the recording to be started.

Start the Recording

Introductions and Consent

Ask participants to introduce themselves and give verbal consent to taking part in the research study.

Questions

How often do you use smartphone physical activity/health apps?

What makes you download smartphone app(s) in the first place?

What makes you continue to use them?

The research student to present ideas for our proposed app (this will include the key features (e.g., social comparison, gamification) and the behaviour change techniques we propose to use (e.g., goal setting), in the form of visual images and text. This will be done using the share screen feature in Zoom

What do you like?
What do you dislike?
What would you change?
How useful do you think the proposed features would be?

Is there anything else that would be important to include?

What information do you think would be helpful to include in the proposed app?

(e.g., information about how to be physically active, reassurance and safety information)

What features would need to be included if you were to use an app continuously?

(e.g., comparison with others, gamification, real-time support)

How would you like to access the app?

(e.g., direct download, signposting by clinicians)

How could the proposed app help you to self-manage your asthma?

How could the proposed app be integrated into other aspects of your asthma management?

(e.g., peak flow monitoring, asthma action plan)

We are now going to talk about COVID-19, self-isolating and asthma

What effects has self-isolation had on how physically active you are?

How active have you been during self-isolation?

How have you been staying active during self-isolation?

What if anything has helped you to stay active during self-isolation?

Have you found any resources to help you stay active during self-isolation?

If so, how helpful have these resources been?

What if anything has made it hard for you to stay active during self-isolation?

Closing the Focus Group

- Give participants the opportunity to share any other information they think is important.

- Ask specifically if they are happy for the focus group to end and for the recording to be stopped.

- Once finished, give participants another opportunity to ask questions.

- Once again, thank the participants for agreeing to take part.

Appendix W. *User Preferences - Debriefing Sheet*

Exploring the Views of Adults with Asthma to Inform the Development of a Physical Activity Intervention

Participant Debriefing Form Version 0.1 14/04/2020

Researcher: Leanne Tyson, University of East Anglia

Thank you for participating in our research study.

We hope that you have found it interesting and have not been upset by any of the topics discussed. However, if you have found any part of the experience to be distressing and you wish to speak to the research student, please contact Leanne Tyson by email: Leanne.Tyson@uea.ac.uk.

If you would like any advice about the coronavirus (COVID-19), please take a look at the following webpages:

NHS - https://www.nhs.uk/conditions/coronavirus-covid-19/

World Health Organisation - https://www.who.int/health-topics/coronavirus#tab=tab_1

If you would like any advice on asthma and COVID-19, please take a look at the following webpages:

Asthma UK - https://www.asthma.org.uk/advice/triggers/coronavirus-covid-19/

British Lung Foundation - https://www.blf.org.uk/support-for-you/coronavirus

If you are feeling anxious, please take a look at MIND, the mental health charity, which has produced guidance to support anyone who may be experiencing anxiety worry: https://www.mind.org.uk/information-support/coronavirus/coronavirus-and-your-wellbeing/

Thank you again for taking the time to participate in our research study.

Link to online Participant Debriefing Form: https://drive.google.com/file/d/1d6MKv8AA8BrnDbPKKje9hfAIIuLAFK3U/view?usp=sharing.

Appendix Y: User Preferences - Vignettes

Vignette One

BCT Included: Problem Solving

During the sign-up, John stated that he struggled to find time to be active.
The one-week baseline period recorded information about Johns daily step count, distance walked, and time spent sitting.
When finished, John was given a report of an average day over the week.
John spent long periods of time sitting during the day. He entered his reasoning for this as working and childcare.
From Johns reasoning, the app presented him with some potential solutions (e.g., getting up and having a walk around the office whilst at work, using the stairs instead of the lift whist at work, or taking the children to the park after school). These solutions were given to try and reduce the time John spent sitting and increase his daily step count.

Whilst using the app, John will continue to be prompted to log reasoning for long periods of time spent sitting and tailored messages (e.g., push notifications) will be sent to him when no activity is sensed for a while.

Vignette Two

BCTs Included: Goal Setting and Action Planning

During sign-up, John stated that he was a severe asthmatic and currently inactive.
The one-week baseline period recorded that John did an average of 4,000 steps per day.
John will be prompted to set a step goal that he feels is realistic.
John set the goal of increasing his steps to 4,500 per day for the next week.

During sign-up, John stated that he was interested in tai chi.
John wanted to set a goal to perform tai chi twice a week for 30 minutes.
The app prompted John to confirm what days of the week he would perform the activity, what time of day, and someone in his household he could do this with (if helpful).
John set the goal to do this on Tuesday and Thursday in the evening.
The app prompted John to set reminders to perform the activity.

Vignette Three

BCTs Included: Instruction on how to Perform the Behaviour, Demonstration of the Behaviour, Behavioural Practice/Rehearsal and Graded Task

During sign-up, John stated that he was a severe asthmatic and currently inactive.
John set the goal of performing tai chi over the next week for 30 minutes.
Within the app, John has access to tai chi exercises at three different levels (e.g., beginner, intermediate, and advanced) he can perform at home.
Each activity includes instructions on how to perform it and a demonstration.
John decided to perform the beginner activities. Once John has repeated the beginner level activities and builds-up his confidence, he will have the option to move up a level to intermediate activities.

Vignette Four

BCTs Included: Self-Monitoring of Behaviour, Feedback on Behaviour, Reviewing Behaviour Goals and Discrepancies Between Current Behaviour and Goal

The app will automatically record Johns steps over the next week, which he is able to view.

At the end of the week, the app informs John that he has walked an average of 5,100 steps per day, achieving his goal.

A message will appear congratulating John on completing his goal.

As John has completed his current goal, the app will prompt John to consider modifying his goal accordingly (e.g., increasing his steps to 5,600 per day).

John set a goal to perform tai chi twice a week for 30 minutes.

Within the app, John can record when he has performed the activity and how long for.

At the end of the week, the app informs John that he has only performed tai chi once this week, falling short of his goal.

The app will prompt John to consider why this happened and modify his goal accordingly.

John stated that he now has additional childcare responsibilities on Thursdays and changed his goal to perform the activity on Saturday instead.

List of Abbreviations

APEASE	Acceptability, Practicability, Effectiveness, Affordability, Side-Effects and Equality
BCTTv1	Behaviour Change Techniques Taxonomy v1
BCTs	Behaviour Change Techniques
BCW	Behaviour Change Wheel
COM-B	Capability, Opportunity, Motivation, and Behaviour
COVID-19	Coronavirus Disease
mHealth	Mobile Health
NICE	The National Institute for Health and Care Excellence
SAR-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
TDF	The Theoretical Domains Framework

Glossary

Asthma	A heterogeneous disease usually characterised by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation
Asthma Action Plan	A written and individualised worksheet that shows asthma patients the steps to take to keep their asthma under control. It also provides guidance on when they should call their healthcare providers and what to do in an emergency.
Asthma Control	Determined by the frequency of daytime symptoms, limitations on activities, nocturnal symptoms, need for reliever medication, lung function, and exacerbations.
Behaviour Change Techniques	An active component of an intervention designed to change behaviour.
Behaviour Change Techniques Taxonomy v1	An extensive hierarchically organised taxonomy of 93 distinct BCTs.
Behaviour Change Intervention	Set of techniques used together which aim to change the health behaviours of individual, communities or while populations.
Behaviour Change Wheel	A model that seeks to capture both the factors that affect behaviours, and the different types of interventions that can be used to change behaviours.
Clinically Extremely Vulnerable	Individuals that are at very high risk of severe illness from COVID-19.
COM-B Model	A model comprised of three components – Capability, Opportunity and Motivation – that are necessary for a given

	behaviour to occur; it provides a simple approach to understanding behaviour in context.
Coronavirus Disease	An infectious disease caused by the SARS-CoV-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention.
Dyspnoea	Breathlessness.
Exacerbations	Temporary worsening of asthma symptoms or the appearance of new symptoms.
Exercise	Subcategory of physical activity that is planned, structured and repetitive and has a final or intermediate objective to improve or maintain one or more components of physical fitness.
Exercise Capacity	
Intervention Function	A broad function of an intervention that bring about change in a behaviour.
Intervention Policy	A policy through which an intervention could be implemented to support the delivery of the intervention functions
Non-Communicable Disease	A group of conditions that are not mainly caused by an acute infection, result in long-term health consequences and that often create a need for long-term treatment and care
mHealth	An abbreviation for mobile health referring to the practice of public health and medicine through the use of mobile devices such as mobile phones.
Oral Corticosteroids	Systematic anti-inflammatory medication used to treat asthma attacks or severe asthma.
Physical Activity	Any bodily movement produced by skeletal muscles that result in energy expenditure.

Pulmonary Rehabilitation	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 diseases and to promote the long-term adherence to health-enhancing behaviours.
Quality of Life	The standard of health, comfort, and happiness experienced by an individual or group
Sedentary Behaviour	Involves sitting, reclining or lying during waking hours, undertaking little movement or activity
Self-Management	Healthcare professionals educating, training and supporting people with asthma so they learn to manage their own condition
Self-Isolation	Remaining apart from others, especially in order to prevent the transmission of an infectious disease.
Shielding	Advising those most at risk of becoming seriously ill from COVID-19 to not leave their homes and minimise all face-to-face contact with others.
Social Distancing	Maintaining a safe and appropriate physical distance from other people.
Theoretical Domains Framework	A synthesis of constructs from a range of behaviour change theories designed to make theories more accessible for implementing in behaviour change interventions.
The Theory of Techniques Tool	An interactive resource providing information about links between behaviour change techniques and their mechanisms of action.

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