Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

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Abstract

Cardiovascular disease (CVD) is a significant cause of death and disability, especially in deprived areas. Most English Local Authorities provide harder-to-reach populations with weight management interventions to reduce obesity, a risk factor for CVD. This study examined whether the use of Fitness Trackers (FT) impacted the outcomes of such interventions using the Healthy Hearts (HH) weight management programme. Two theoretical frameworks were used as a backdrop to this research: the Theory of Planned Behaviour (TPB) and the Capability, Opportunity, Motivation, Behaviour framework (COM-B).

This research had four main objectives. First, it evaluated the effectiveness of adding FTs to the HH intervention, comparing outcomes with and without FTs. Second, it studied psychological factors linked to weight loss and assessed whether these varied over time and across study conditions. Third, it examined whether psychological factors could predict HH intervention outcomes. Lastly, it explored the experiences of service users and health professionals involved in the HH weight management programme utilising FTs.

A scoping review of seven studies looking at the use of FTs in weight management was initially conducted to provide a broader context and position the current research. The review partially supported the use of FTs to achieve better weight outcomes and identified some research gaps, which are subsequently addressed in the current study. Using mixed methods within a pragmatic framework, 57 participants who were taking part in the HH intervention were randomly assigned to either the FT or control group. They completed questionnaires at three time points: baseline (wave 1), after the 10-week intervention (wave 2), and at six months (wave

3). Data from the HH programme and FTs were also analysed. Additionally, nine FT users and four health professionals were interviewed.

Overall, the results show that those wearing FTs had more favourable weight-related results when compared with the control group. The FT group experienced significant reductions in weight, waist circumference, and BMI at wave 3 and achieved greater weight loss at wave 2. FT users also showed better Physical Activity (PA) outcomes and more positive changes in psychological well-being than non-FT users, including reduced anxiety and depression scores. Furthermore, FT users attended 1.72 more HH sessions than those without FTs. While associations between attitudes, anxiety, and pre-post-intervention weight changes were observed, these factors did not predict the differences in weight loss. FT data revealed that those who recorded more steps and physical activities had better weight outcomes overall.

In general, service users and health professionals reported positive experiences with the use of FTs in weight management interventions, particularly in terms of motivation and self-monitoring of PA and other behaviours involved in weight management. They also identified some drawbacks and barriers related to FT use (e.g., personal or technical). While many participants used FTs effectively, these devices were not suitable for everyone.

When considered collectively, the results have significant implications. It is recommended that FTs should be provided as weight management intervention tools as they could positively impact self-monitoring of PA, programme attendance and outcomes. Nevertheless, more research is needed to identify the user groups that could most benefit from these tools. Practical recommendations for FT implementation are also provided. If offering FTs to individuals from harder-to-reach

backgrounds at increased risk of CVD can improve intervention outcomes, these devices should be considered cost-effective in the long run. They can also serve as additional resources for addressing health disparities when provided to individuals with limited financial means.

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To Stella, Flora et al…

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List of abbreviations

BCT = Behavioural Change Techniques

BMI = Body Mass Index

COM-B = Capability, Opportunity, Motivation & Behaviour

CVD = Cardiovascular Disease

DH = Department of Health and Social Care

FT = Fitness Trackers

GP = General Practitioner

HH = Healthy Hearts

IPAQ = International Physical Activity Questionnaire

LBHF = London Borough of Hammersmith and Fulham

MET = Metabolic Equivalent of Tasks

MVPA = Moderate to Vigorous Physical Activity

NDPP = National Diabetes Prevention Programme

NHS = National Health Service

NICE = National Institute for Health and Care Excellence

OHID = Office for Health Improvement and Disparities

PA = Physical Activity

PBC = Perceived Behavioural Control

PH(E) = Public Health (England)

TA = Thematic Analysis

TDF = Theoretical Domains Framework

TPB = Theory of Planned Behaviour

UK = United Kingdom

(W)LOC = (Weight) Locus Of Control

Overview of the thesis

Wrist-worn Fitness Trackers (FT) have been available to consumers since the early 2010s and have become very popular. However, studies investigating their impact on Cardiovascular Disease (CVD) prevention, especially within a structured Local Authority-funded weight management intervention, remain rare. This thesis investigated the utilisation of FTs as part of an established intervention programme. The main aim of the work contained in this thesis was to investigate whether the use of FTs impacted the outcomes of a weight management intervention in “harder-to-reach” populations.

CVD is a significant cause of death and disability. Individuals from more deprived areas and some ethnic minority groups are at a greater risk of CVD, and tailoring interventions to help people from these population segments can be seen as addressing health inequalities. This study offers insights into FT use for CVD prevention within a tailored weight management programme called Healthy Hearts (HH), operating in Central London, primarily targeting deprived communities and ethnic minorities.

It was unclear whether people attending weight management programmes would find FTs useful and whether these devices could enhance the service users’ experience and improve their self-monitoring of PA, programme attendance rates and health outcomes. This study addressed these questions. The overarching goal of this research was to enhance comprehension of how FTs can be utilised in weight management interventions. This knowledge was intended to be applied practically to guide the design and implementation of weight management strategies incorporating FTs.

Chapter 1 presents an introduction to the research. It provides the background to CVD, its prevalence, aetiology, associated risk factors such as obesity and physical inactivity, and its prevention. It also outlines theoretical frameworks of behaviour change relevant to the field and the significance of Behaviour Change Techniques (BCTs). FTs are also introduced and discussed in relation to these techniques, weight management and theoretical frameworks. The chapter concludes by presenting the rationale, research questions, aims and objectives that guided this research and presents HH intervention, which was the setting of this study.

Chapter 2 contains a scoping review of studies that used FTs in weight management interventions and compared them with control conditions. The chapter presents the review's background, aims, methodology, and key results. The discussion section provides a summary of the main findings and implications for the current thesis.

Chapter 3 presents the overall methodological approach used in the research. It outlines the pragmatic paradigm and the rationale for employing a mixed methods approach. It also provides the details of the research setting and the HH weight management intervention, including its background, intervention methods, and BCTs. The methods used for the quantitative phase are presented, encompassing research design, sampling, materials, ethical considerations, and statistical analysis. Finally, the methods for the qualitative phase are described, outlining the methods employed in the exploration of service user and health professional participants' experiences of weight management programmes utilising FTs. The data analysis strategy for both participant cohorts is also outlined.

Chapter 4 presents the findings of the quantitative phase of the research that assessed the impact of FTs on weight management intervention outcomes. This chapter presents the profile of the participants, study scale diagnostics and the measures used to address the three quantitative research objectives. It subsequently presents the quantitative results by looking at physical and psychological measures, as well as weight management programme attendance rates. The analysis of the data captured by the FTs (such as steps, activity and sleep) complements these results. The discussion section provides a summary of the main findings of this research phase, its strengths and limitations and the implications for the thesis.

Chapter 5 presents the findings of the qualitative research phase conducted with the weight management service users and the health professionals delivering these interventions. In addition to presenting results from the data analysis of each participant cohort, the chapter also presents them in the context of the quantitative findings, providing valuable triangulated insights. The strengths and limitations of this research phase and its implications for the thesis are also discussed.

Chapter 6 synthesises the findings of both phases of the research and offers interpretation in the context of existing literature and selected theoretical frameworks. It highlights the novel contribution of this research to the current knowledge on the use of FTs in the field of weight management. It discusses the study's key recommendations and practical implications for stakeholders and outlines the strengths and limitations of this study. Future research directions are also provided, and a conclusion is presented at the end of this chapter.

Chapter 1 - Introduction to the thesis

This chapter introduces CVD, discussing its prevalence and aetiology, associated risk factors, and prevention. Additionally, the chapter delves into theoretical frameworks of behaviour change and the significance of Behaviour Change Techniques (BCTs) that are relevant to this research. It then introduces Fitness Trackers (FTs) and discusses them in relation to these BCTs, weight management and theoretical frameworks. Subsequently, it outlines the rationale, research questions, aims and objectives guiding this research. The chapter concludes by introducing "Healthy Hearts" (HH), the weight management intervention which serves as the setting of this study.

1.1 Background

As highlighted in the 'Fair Society, Healthy Lives' – the Marmot review (Marmot, 2010), health inequalities that can be prevented by reasonable means are unfair and should be addressed as a matter of social justice. According to Marmot and colleagues, the recommendation of putting health equity at the heart of the government decision-making process and treating it as an indicator of societal well-being has not been implemented in England (Marmot, Allen, Boyce, et al., 2020). Ten years on from the initial Marmot review, as documented in 'Health Equity in England: The Marmot review 10 years on' (Marmot, Allen, Boyce, et al., 2020), health inequalities have widened. Particularly among women living in the most deprived areas of England, life expectancy has declined by 0.3 years between 2012 and 2018; in men, the increase in life expectancy has been negligible (Marmot, Allen, Boyce, et al., 2020). In the most deprived areas of England, life expectancy was 77.9 and 81.7 for males and females, respectively, while in the least deprived

areas, both groups lived on average 2.8 years more (Marmot, Allen, Boyce, et al., 2020).

People who live in the most deprived areas of England, in addition to living shorter lives, also live with limiting long-term illnesses (Marmot, Allen, Boyce, et al., 2020). These health inequalities were amplified by the COVID-19 pandemic, as highlighted in the report ‘Build back fairer’ (Marmot, Allen, Goldblatt, et al., 2020). The authors of the report emphasised that in order to reduce health inequalities, action is needed, with more intense intervention targeted lower down the social gradient.

The National Health Service's ‘Long-term Plan’ (NHS, 2019a) has emphasised that people living in deprived areas and people from certain ethnic minority groups should be prioritised in targeted interventions. For example, a systematic review by Meeks and colleagues (2015) reported that the risk of developing type 2 diabetes in ethnic minority groups residing in Europe is higher than that of their host European populations and varies based on their geographical origin. South Asian groups have a three to five times higher risk, Middle Eastern and North African groups have a two to four times higher risk, and Sub-Saharan African groups have a two to three times higher risk than their host European populations to develop type 2 diabetes (Meeks et al., 2015). Expanding some interventions, such as the United Kingdom (UK) National Diabetes Prevention Programme (NDPP), to these communities is vital in tackling health inequalities, but NDPP has demonstrated low participation and high attrition rates, particularly among socio-economically disadvantaged and ethnically diverse populations (Howarth et al., 2020; Whelan & Bell, 2022).

1.1.1 Prevalence and aetiology of Cardiovascular Disease

CVD is a term used to describe a range of disorders of blood vessels and the heart (World Health Organisation [WHO], 2021a). It includes conditions such as coronary heart disease, stroke, atrial fibrillation, heart failure and vascular dementia (British Heart Foundation, 2021a). Over the past few decades, there has been a notable rise in the incidence of CVD. This increase can be attributed to various factors, including the transition from physically demanding jobs to more sedentary ones, busier lifestyles, lack of physical activity (PA), and the consumption of high-calorie diets (Olvera Lopez et al., 2023). These factors can contribute to the development of atherosclerosis, a condition characterised by the accumulation of plaque in the arteries. As a result, blood flow may become restricted, and the risk of heart attacks or strokes may escalate (Olvera Lopez et al., 2023). These changes typically occur gradually over an extended period and may initially show no symptoms (Toth, 2008).

Globally, CVD is a leading cause of death, estimated to be 31% of all deaths worldwide, with 85% of these accounted for by stroke and heart attack (WHO, 2021a). In 2021, 7.6 million people were living with CVD in the UK (British Heart Foundation, 2021b), and 6.8 million lived with CVD in England, where CVD accounts for one in four deaths (Raleigh et al., 2022). According to the Office for National Statistics, CVD caused one in five preventable deaths and half of all treatable deaths in 2020 (Office for National Statistics, 2022a). There was a 6% rise in premature CVD mortality in England and Wales in 2020, marking the first increase of this kind in fifty years (NHS Digital, 2022). According to Raleigh and colleagues (2022), there are some early indications that CVD and diabetes have been major contributors to the excess deaths in England and Wales since April 2022.

In a report published by Watt and colleagues (2023), a 2.5 million increase in adults living with major illnesses, including CVD, is projected in England by 2040. In a systematic review, Bae and colleagues (Bae et al., 2021) examined how CVD and its risk factors impacted fatal outcomes in patients with COVID-19 and concluded that fatal outcomes in those patients were closely associated with CVD risk factors (hypertension and diabetes). CVD increased the risk of severe COVID-19 disease by 3.9 times and death resulting from COVID-19 by 2.7 times (Raleigh et al., 2022). CVD can also negatively impact the quality of life and cause considerable disability (Moryś et al., 2016). In addition, CVD can cause a financial burden, and it is estimated that CVD-related healthcare costs in England amount to £7.4 billion annually (Public Health England [PHE], 2019a). For instance, hypertension accounted for 12% of all GP appointments, costing at least £2 billion annually (PHE, 2019a).

CVD is one of the leading contributors to disparities in health (Raleigh et al., 2022). In deprived areas, CVD is the most significant cause of premature death and is strongly associated with health inequalities (PHE, 2019a). There is a life expectancy gradient due to CVD between England's most deprived and most affluent areas (Marmot, Allen, Boyce, et al., 2020), with people living in the most deprived areas of England being almost four times more likely to die prematurely from CVD than people living in the least deprived areas (Robson et al., 2016; PHE, 2019a). CVD is also the most significant cause of premature mortality in people with serious mental illness, whose life expectancy is 20 years lower when compared with the general population (NHS, 2019b). CVD risk factors can vary according to ethnicity, with people from South Asian and Black groups being at the highest risk of CVD (Raleigh et al., 2022).

Higher Body Mass Index (BMI; *NHS,* 2021) levels are also seen in individuals living in the most deprived areas (Marmot, Allen, Boyce, et al., 2020). In a large-scale observational study conducted in England (Lewer et al., 2020), where premature mortality rates attributable to socioeconomic inequalities were looked at, one in three premature deaths was attributable to deprivation, with inequalities being most significant for respiratory, CVD, and infectious diseases.

According to the NHS 'Long-term Plan' (NHS, 2019a), broader action on the prevention of CVD is needed to help people stay healthy and moderate demands on NHS services. Preventing and effectively managing CVD holds substantial potential for alleviating the societal burden and reducing overall morbidity and mortality costs (Raleigh et al., 2022).

Approximately 90% of CVD incidence can be attributed to modifiable risk factors, and as much as 80% of premature CVD-related deaths are avoidable (Raleigh et al., 2022). Efforts to address CVD should commence by mitigating the modifiable risk factors responsible for its development (Raleigh et al., 2022). CVD risk factors include non-modifiable ones, for example, age, sex and ethnicity and those that can be modified, such as lack of PA, smoking and obesity (World Heart Federation, 2017). Modifiable risk factors are often behavioural and can be addressed at population-wide and individual levels (WHO, 2021b). Smoking, inadequate physical activity, obesity, unhealthy diet and excessive alcohol consumption are the most important lifestyle factors to focus on in CVD prevention (Raleigh et al., 2022). As Noble and colleagues highlighted in their systematic review (Noble et al., 2015), many unhealthy behaviours such as smoking, physical inactivity, poor nutrition and high alcohol intake tend to manifest themselves together. People with more significant social disadvantage also show riskier health behaviour patterns

(Noble et al., 2015). Therefore, addressing behavioural risk factors, especially among people from disadvantaged areas, is essential in reducing health inequalities.

1.1.2 Cardiovascular disease risk factors relevant to this research

While several risk factors contribute to the development of CVD, obesity and physical inactivity were focused on in the current thesis as they were most relevant to the research and the study setting. It has been reported that the health consequences of obesity can offset advancements in certain other risk factors (Watt et al., 2023). Obesity and physical inactivity are considered behavioural risk factors for CVD, and unlike other risk factors (e.g., age or ethnicity) can be modifiable (WHO, 2021c). Modifiable risk factors have been highlighted as important in weight management interventions to reduce the risk of CVD (WHO, 2021b). As the decline in PA contributes significantly to increases in obesity rates (Swift et al., 2014), it is essential to consider them together. These two risk factors are of particular importance as they are often targeted within structured weight management interventions, including HH (2023), the intervention utilised in this study.

1.1.2.1. Obesity

Overweight and obesity refer to "abnormal or excessive fat accumulation that presents a risk to health" (WHO, 2021b). BMI is a tool commonly used to assess whether adults are overweight (BMI of 25 or over) or obese (BMI of 30 or over), using height and weight in its calculation (*NHS, BMI*, 2021). A slight difference in these BMI thresholds is applied to Asian ethnic groups, where a BMI of 23 for overweight and 27.6 for obese thresholds are used in line with the current recommendations (National Institute for Health and Care Excellence [NICE], 2013).

This is due to the fact that Asian populations are susceptible to central fat accumulation and experience cardiometabolic risks and a heightened chance of developing type 2 diabetes at a lower BMI (NICE, 2013). It is thought that this tendency to central fat accumulation is due to a combination of lifestyle factors and genetics (NICE, 2013).

Obesity is considered a major public health problem in England as it is associated with several chronic diseases (e.g., diabetes type 2, high blood pressure) contributing to CVD-related morbidity (Guh et al., 2009). Obese people are up to 80 times more likely to develop type 2 diabetes when compared with those with a BMI below 22 (Watts, 2022). Those with obesity are also over 2.5 times more likely to develop high blood pressure (PHE, 2017a), with both conditions directly contributing to CVD. This was particularly relevant in the context of the COVID-19 pandemic, as obesity also puts people at high risk of mortality from COVID-19 (Tartof et al., 2020).

As highlighted in the recent report 'Health in 2040' (Watt et al., 2023), obesity rates almost doubled in England between 1993 and 2023. According to the statistics published by the Office for Health Improvement and Disparities (OHID, which assumed the health improvement responsibilities previously held by PHE in 2021), 68.6% of men and 59% of women in England were overweight or obese in 2021 (*OHID*, 2023a). In 2019, 25.4% of men and 26.5% of women were classified as obese (*OHID*, 2023a), an increase from 13% and 16%, respectively, from rates reported in 1993 (NHS Digital, 2019). According to OHID, these rates are on the rise (2023).

It was stressed that social deprivation, being from a minority ethnic group, and low income increase the likelihood of becoming obese (Marmot, 2010). Longitudinal data from three British cohorts spanning different generations showed that

socioeconomic disadvantage was associated with higher BMI (Mayor, 2017). For instance, in 2019, 22.4% of men and 21.9% of women from the least deprived areas were obese, while in the most deprived areas, 39.5% of men and 30.2% of women were classified as obese (*OHID*, 2023a). It is also known that obesity-linked hospitalisation rates in the most impoverished areas of England are 2.4 times higher compared to those in the least deprived regions (Noble et al., 2019).

To tackle obesity effectively, it is essential to make changes in both the amount of consumed energy (energy intake) and the amount of burnt energy through PA (energy expenditure). It is not sufficient to focus on just one aspect; both need attention (Hill et al., 2012). For example, in a review of Randomised Controlled Trials focusing on the role of PA in achieving and maintaining weight loss (Catenacci & Wyatt, 2007), authors reported that the weight loss results observed in these studies aligned with the prescribed exercise levels. The authors also reported that successful maintenance of weight loss was linked to engaging in high levels of PA.

Depression and anxiety have also been linked to obesity (Nigatu et al., 2016). The risk of obesity is doubled for those with severe mental illness (Raleigh et al., 2022). Brumpton and colleagues previously demonstrated that participants with high depression and anxiety scores had an increased incidence of obesity (2013). It seems that depression has a bi-directional relationship with obesity – in that depression is associated with weight gain, and obesity is associated with the development of depression (Fabricatore et al., 2011). Depression and anxiety have been reported as frequently coexisting with obesity (McLean et al., 2016). In their Glasgow-based study, McLean and colleagues found that among their 1838 weight management programme attendees, the prevalence of anxiety was 33% and of depression was 27%. They also reported lower programme completion and

attendance rates among those with anxiety and depression. It is, therefore, crucial to examine both anxiety and depression as they can potentially impact weight management intervention engagement and outcomes.

1.1.2.2. Physical activity and inactivity

Caspersen and colleagues (1985) defined PA as any movement produced by skeletal muscles that results in energy expenditure, which can be measured in kilocalories. Daily PA can be divided into categories such as occupational, sports, conditioning, household, or other activities. Exercise, according to Caspersen et al. (1985), is a specific type of PA that is planned, structured, and repetitive, with the goal of improving or maintaining physical fitness. Physical fitness itself is defined as a set of health- or skill-related attributes (Caspersen et al., 1985). Physical inactivity is characterised by an insufficient level of PA to meet current guidelines, while sedentary behaviour refers to any waking activity with an energy expenditure of ≤1.5 metabolic equivalents (METs) carried out in a sitting, reclining, or lying posture (Sedentary Behaviour Research Network, 2024).

The lack of PA is another major lifestyle factor linked to CVD (Raleigh et al., 2022). According to the PA guidelines issued by the Department of Health and Social Care (DH, 2019), to achieve health benefits, adults are recommended to do at least 150 minutes of moderate activity per week or at least 75 minutes of vigorous activity per week (or a combination of both) with strength building activities two days a week. It is also recommended for adults to minimise sedentary time by breaking periods of inactivity. To prevent obesity, the majority of individuals require engaging in moderate-intensity PA for 45 to 60 minutes per day (NICE, 2006). In 2018, only 64% of women and 68% of men were classified as physically active per these

government guidelines (NHS Digital, 2019). The UK population is now 20% less active than in the 1960s (PHE, 2019b). As with obesity, activity levels vary by deprivation levels - they decrease as deprivation rates increase. In 2018, 72% of adults in the least deprived areas of England were classified as physically active, whereas only 34% of adults in the most deprived areas met the same criteria (NHS Digital, 2019). Worldwide, approximately 9% of premature deaths are caused by inactivity (Lee et al., 2012). According to the DH, inactivity and sedentary behaviours lead to poor health outcomes and should be reduced (DH, 2019). Strong evidence suggests that regular PA is related to decreased incidence of many chronic conditions, including CVD, depression (Warburton et al., 2006) and type 2 diabetes (Aune et al., 2015). Engagement in PA is the focus of several interventions, including the “WeAreUndefeatable” campaign (Sport England, 2019). Inactive adults at risk of CVD living in areas of deprivation are an important target group for PA and sedentary behaviour interventions (Chater et al., 2022). PA helps maintain a healthy weight as it is the most effective way of increasing daily energy expenditure; therefore, it plays a vital role in preventing weight gain and reducing body fat (DH, 2019). In severely obese individuals, weight loss is promoted by regular PA (Jakicic & Davis, 2011). However, overweight or obese adults may find it challenging to attain and maintain high levels of PA (Catenacci & Wyatt, 2007). Walking is expected to be a more attainable and appropriate option for a significant portion of the at-risk population, including those who are obese, inactive, and have a high risk of CVD, especially when strenuous forms of exercise might not be suitable (Murtagh et al., 2015).

A comprehensive review of guidance and literature on CVD prevention (Stewart et al., 2017) showed that any increase in PA reduces CVD risk, with the

most significant benefits seen in people newly starting to exercise. In their men-focused study utilising pedometers, Andersen and colleagues (2021) reported that the positive effects of enhancing PA and diet on CVD risks primarily seemed to result from their impact on body weight alterations. Increased levels of PA are essential for maintaining weight loss over an extended period (Catenacci & Wyatt, 2007; Elfhag & Rossner, 2005; Wing & Phelan, 2005). Engaging in PA has also been linked to a decreased risk of CVD mortality (Lee et al., 2014). The opposite of PA, sedentary behaviour, has also been considered, independently of PA, in relation to obesity. In a systematic review conducted by Ekelund and colleagues (2016), a connection between prolonged sitting and the risk of death from all causes and CVD-related causes was demonstrated, regardless of individuals' level of PA.

1.1.3 CVD prevention

"Prevention is about helping people stay healthy, happy and independent for as long as possible" (PHE, 2018a). Primary, secondary and tertiary types of prevention are being used (Caplan, 1964), and NHS and OHID's approach to CVD prevention is spread across these. Primary prevention aims to reduce instances of CVD in the population and, if they occur, reduce their duration. Initiatives include social marketing campaigns, such as 'Better Health' (NHS, 2020), which encourages healthy eating and exercising. Secondary prevention is designed to detect and treat pre-symptomatic CVD, for example, atrial fibrillation, high blood pressure or high cholesterol levels. Tertiary prevention is aimed at those with symptomatic CVD and aims to reduce the incidence and/or recurrence of incapacity.

Many people live with undiagnosed or poorly treated conditions that fall within the CVD umbrella. For instance, about 12.5 million adults in England are affected by

high blood pressure, but half of them are not diagnosed or receiving treatment (PHE, 2017b). There are also 1.4 million people in England with atrial fibrillation, and almost 500,000 of them have undiagnosed or untreated atrial fibrillation (National Institute for Health and Care Excellence, 2023a). Approximately 5 million individuals in the UK are diagnosed with diabetes, an additional 850,000 remain undiagnosed, and a further 14 million are at risk of developing the condition (Diabetes UK, 2023).

These individuals can be targeted under a secondary prevention approach. Thanks to improved detection and treatment of high-risk conditions such as atrial fibrillation or high blood pressure (secondary prevention), 150,000 CVD events can be prevented over a decade (NHS, 2019a). As 40% of preventable CVD deaths happen in the three most deprived deciles, over 40% of the action on those ambitions should be delivered in these most deprived areas of England; this should help prevent health inequalities from widening further (PHE, 2019a).

In England, many prevention services addressing obesity are commissioned by Local Authorities to deliver behavioural change weight management interventions to their most disadvantaged residents. PHE argued that a comprehensive system approach considering behavioural and social sciences, including psychology, is needed to prevent poor health (PHE, 2018b). Obesity is complex, and a whole system approach to tackling it across multiple levels and sectors is needed (Holmes, 2021). Coordinated efforts across healthcare, education, transport, and urban planning are essential.

The whole systems approach can be used in prevention and it views obesity as influenced by interconnected factors at various levels (Bagnall et al., 2019). This approach can be beneficial by enabling the engagement of stakeholders across the broader healthcare system to create a shared vision and implement actions

addressing the upstream drivers of obesity, which lie beyond the scope of Public Health (PHE, 2019c). Upstream determinants are defined as elements of the social environment, including socioeconomic status and discrimination, that affect individual behaviour, disease, and health status (Gehlert et al., 2008). Interventions can be guided by the whole systems approach and range from individual counselling to community programmes and national policies (Bagnall et al., 2019).

The Social Ecological Model (Stokols, 1992), which can also be used in prevention, provides a framework for understanding health behaviours influenced by individual, interpersonal, organisational, community, and policy-level factors. Interpersonal involvement of family and social support is crucial. At the organisational level, healthcare settings influence behaviours and should promote healthy food options and wellness programmes. Community-level interventions address environmental and social factors, with partnerships to improve access to healthy foods and safe spaces for PA. Weight management interventions commissioned by Local Authorities are often guided by the whole systems approach and the Social Ecological Model.

In addition to these models, the format of intervention delivery is also important to consider. To prevent CVD, weight management services are often provided face-to-face, but digital interventions are increasingly popular due to funding reductions and increases in demand. In 2021, NHS launched its digital weight management programme to complement the face-to-face offering (NHS, 2021c). Community-based weight management programmes focusing on behavioural change in relation to the reduction of energy intake and increase of energy expenditure are also important to the weight management pathway.

Behaviour change interventions can be described as organised activities aimed at modifying specific patterns of behaviour (Michie et al., 2011). Behaviour change is central to preventing, managing and treating obesity for individuals, groups and entire populations (Chadwick et al., 2019). The current study focused on the use of FTs as part of such community-based intervention (HH).

Addressing obesity and physical inactivity is complex as several factors play a part in developing and maintaining unhealthy behaviours, for instance, environment, employment and housing (Holmes, 2021). In terms of obesity and physical inactivity, it is recommended that biological and social/environmental factors and psychological evidence should be considered when trying to understand their causes (Chadwick et al., 2019). Some health beliefs (e.g., about a degree of control over one's health) are particularly relevant in this context. The evidence on the role of psychological factors in obesity and PA, for example, addressing unhelpful attitudes and behaviours, should be incorporated into prevention interventions and treatments of obesity (Chadwick et al., 2019). Some psychological factors may be better understood within the context of organised theoretical frameworks. The following section presents two frameworks that were particularly useful in the current study.

1.2 Theoretical frameworks of behaviour change

There are many theories and models that could be used to explain behaviour change, but in the context of this thesis, two models were considered particularly relevant: the Theory of Planned Behaviour (TPB; Schifter & Ajzen, 1985) and the Capability, Opportunity, Motivation and Behaviour - COM-B model (Michie et al., 2011). Other theories and models were carefully considered, including the Health Belief Model (Becker, 1974; Rosenstock, 1974) and the Stages of Change model [Trans-Theoretical Model, (Prochaska & Diclemente, 1982)]. As the Health Belief

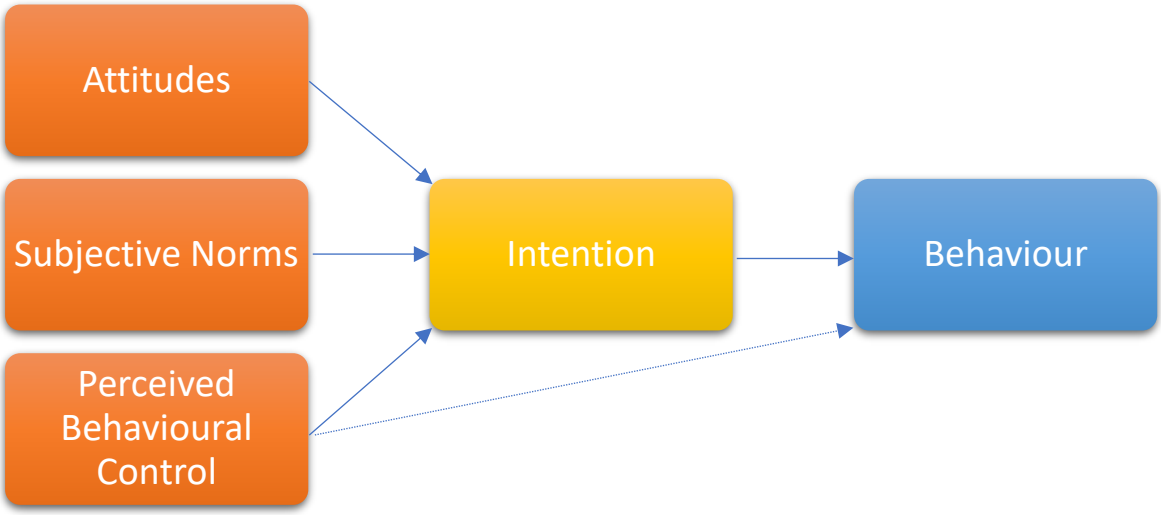
Model has predominantly been used to study healthcare-related matters, including the acceptance of immunisations (including the COVID-19 vaccine) and adherence to medical treatments (Wong et al., 2020) as well as cancer screening behaviours (Lau et al., 2020), it was not the most suited to examine weight management related behaviours. In addition, as the Health Belief Model was previously reported to have a weak predictive power (Taylor et al., 2006), it was decided that it was not the most appropriate model to utilise.

Similarly, the Stages of Change model was regarded as too focused on attaining desired outcomes rather than explaining behavioural variance on reported data, as previously highlighted by Taylor and colleagues (2006). TPB and COM-B models, as well as BCTs, are discussed in the following sections.

1.2.1 The Theory of Planned Behaviour (TPB)

TPB considers intentions the key factor in behaviour change (Ajzen, 1991; Schifter & Ajzen, 1985). The TPB is a prominent theory that has been extensively used to predict, explain and alter health behaviours (Hagger et al., 2022). According to the TPB model, intention is a central factor in performing a particular behaviour (Ajzen, 1991). It is believed that three variables in combination lead to the formation of this intention (Ajzen, 1991): attitudes, subjective norms and Perceived Behavioural Control (PBC), as shown in Figure 1.1.

Figure 1.1. *Theory of Planned Behaviour model components (Ajzen, 1991)*



According to Ajzen (2020), attitudes are linked to the evaluation of the behaviour by individuals and their belief regarding the likely consequences/outcome of the behaviour, for instance, that attending the weight management programme (the behaviour) will lead to weight loss (outcome). Subjective norms are related to the perception that significant others approve or disapprove of them performing the behaviour, for instance, exercising to lose weight. PBC is the perception of how much control individuals have over performing the behaviour, and it refers to perceived difficulty or ease of performing behaviours (Ajzen, 1998). According to the TPB, more positive attitudes, supportive subjective norms, and higher PBC will lead to a stronger intention to perform the behaviour, and the likelihood of the behaviour being performed will be greater.

There is a large body of evidence on TPB and its efficiency in predicting behaviour change across different types of health behaviours, settings and populations (e.g., Armitage & Conner, 2001; Dilekler et al., 2016; Gao et al., 2020; Steinmetz et al., 2016). PBC has been frequently highlighted as the strongest

predictor of intention to perform various behaviours. The utilisation of TPB in the current research is supported by the evidence discussed below. The broader context of TPB, focusing on its efficiency in predicting behaviours related to weight management, is provided below.

In a review by McEachan and colleagues that looked at an array of health behaviours, researchers found that TPB accounted for 19.3% of the variability in behaviour and 44.3% of the variance in intention, which shows that the TPB model had good predictive power. The TPB's effectiveness in prediction varied depending on the type of behaviour, with PA and dietary behaviour being the most accurately predicted (McEachan et al., 2011). This indicated that the TPB can be useful in the weight-management domain. When looking at weight-related behaviours specifically, Schifter and Ajzen's original study focusing on TPB in weight loss (1985) found that attitudes, subjective norms and PBC all predicted the intention to lose weight, while PBC predicted actual weight loss. In a review looking at the application of TPB to predict actual weight loss (Chung & Fong, 2015), PBC and intention were found to be significant determinants of weight loss.

When it comes to predicting behaviours linked to weight management, e.g., regarding fruit and vegetable intake, Guillaumie and colleagues suggested that TPB was the most appropriate model (2010). Conversely, in another study (Lash et al., 2016), looking at overweight and obese participants mainly from ethnic minority groups, it was found that while TPB predicted dietary intention, it did not predict dietary behaviour. The current study aimed to examine the predictive power of TPB, testing the predictors of actual weight loss.

When looking at the UK context, where the current research was based, in a cross-sectional study by Payne and colleagues (2004), attitudes and subjective

norms explained 14%, and PBC explained 10% of intention to exercise. They also found that attitudes and subjective norms explained 27% of intention to eat healthily, while PBC explained 2%. Intentions to perform both behaviours were, therefore, successfully predicted by the TPB.

Psouni and colleagues (2016) also studied the application of TPB to exercise and healthy eating. The authors examined the TPB across two samples - overweight/obese adults and participants with average weight. Psouni et al. found that relationships between TPB variables and both behaviours were more significant in the average weight groups when compared with the overweight/obese group (Psouni et al., 2016). This finding is important to consider as the current research looked at the population of overweight/obese participants. Psouni and colleagues (2016) also reported that in their study, PBC was the strongest predictor of exercising and healthy eating. Hagger and colleagues also focused on PBC in their meta-analysis and confirmed that PBC moderated the intention-behaviour relationship (2022).

When examining PA, Cheng and associates found that PBC was associated with the intention to conduct PA in their study, also using a sample of overweight and obese participants (2019). However, attitudes were not associated with PA. Authors speculated that weaker correlations in their study could have been due to the sample being overweight/obese. This explanation was similar to the one provided by Psouni and colleagues (2016).

The current research aimed to examine all TPB components as predictors of weight loss, paying close attention to PBC, highlighted in previous research as a strong predictor of weight-related intentions or behaviours. PBC predicted the intention to exercise and eat healthily in a study conducted by Gardner and

Hausenblas (2006) looking at a population of overweight women. However, while PBC predicted intention, intention was not found to predict exercising and healthy eating behaviours, and authors critiqued TPB as unviable for predicting these two behaviours (Gardner & Hausenblas, 2006). This highlights that, while successful at predicting intention, the TPB is not always successful at predicting actual behaviours. Intentions hardly, if ever, completely account for the differences in behaviour and this phenomenon is commonly referred to as the intention-behaviour gap (Conner & Norman, 2022).

Aside from the application of the TPB model to PA, TPB has also been applied to sedentary behaviours. For instance, intention within the TPB model was a significant predictor of sitting behaviour, accounting for 11% of the variance, as reported by Howlett and colleagues (2021). Authors of this study also reported that PBC, attitudes and subjective norms were all highly predictive of intention.

In conclusion, the TPB is a versatile framework widely employed to examine health behaviours related to weight management and PA. The TPB's utility lies in its capacity to explain and predict behavioural intentions and outcomes, with PBC often reported as the strongest predictor of intentions. McEachan and colleagues also emphasised that TPB is clearly operationalised and provides measurement and analysis guidelines (2011).

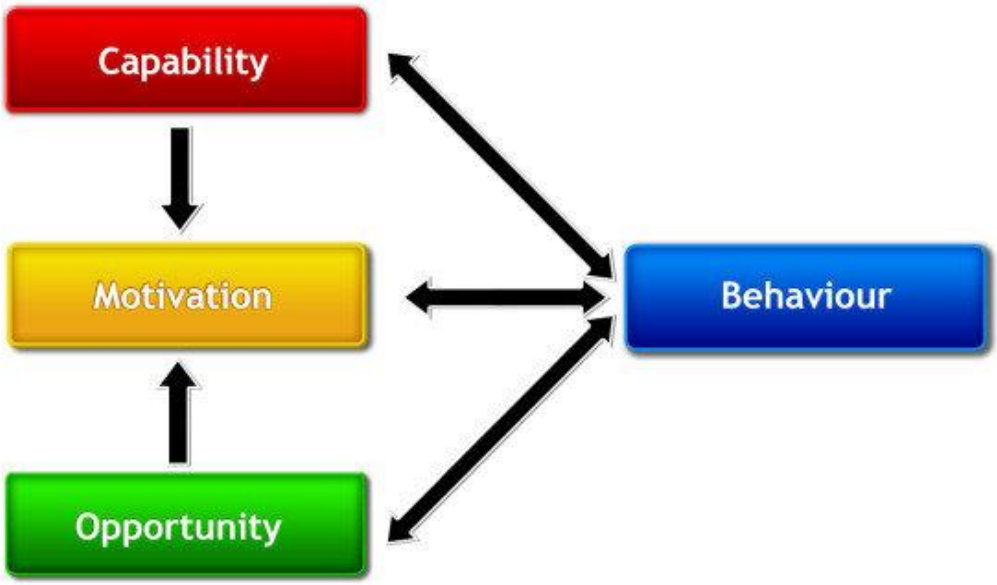
Overall, the TPB serves as a valuable tool for predicting health behaviour change. Consequently, this model was chosen in the current study to enable the exploration of which TPB components predict weight loss in a sample of obese individuals where the evidence has been inconclusive. The TPB is one of the health behaviour frameworks providing origins to the more recently developed COM-B model (Michie et al., 2011), which is discussed next.

1.2.2 The Capability, Opportunity, Motivation-Behaviour model (COM-B)

As mentioned earlier, the COM-B model is at the centre of the Behaviour Change Wheel (Michie et al., 2011), a comprehensive framework used to understand behaviour change and design effective interventions. COM-B is a transdisciplinary model of human behaviour (West & Michie, 2023). The central tenet of the COM-B model is that for a person to engage in a particular Behaviour (B) at a specific time, they must have the Capability (C), the Opportunity (O) and the Motivation (M) to do so, compared to any other potentially conflicting behaviours (Michie et al., 2011).

By consolidating theories of behaviour, which may have overlapping constructs, researchers synthesized 33 theories (including TPB) and 128 theoretical constructs (Michie et al., 2005). This exercise enabled to overcome previous theories' limitations (Michie et al., 2011). The synthesis resulted in the development of the Theoretical Domains Framework (TDF), comprising 14 domains of theoretical constructs (Cane et al., 2012). The TDF provides a structure to understand and analyse behaviour, encompassing a wide range of behavioural determinants and can be directly aligned with the COM-B model (Cane et al., 2012). Closely linked with the TDF and COM-B are also Behavioural Change Techniques (BCTs). BCTs are the active ingredients of interventions designed to change behaviour, and they are observable, irreducible (cannot be broken down further) and replicable (Michie et al., 2013). The Behaviour Change Wheel integrates the TDF, the COM-B model, and BCTs to offer a systematic approach to behaviour change. By considering these key components and their interactions, interventions can be designed and implemented in a way that maximises their effectiveness in promoting behaviour change (Michie et al., 2013).

Figure 1.2. *COM-B model components (Michie et al., 2011)*



As West and Michie (2023) elaborated, capability includes both psychological and physical capability. Psychological capability involves a person's emotional, social and intellectual understanding, self-regulation and reasoning abilities to facilitate the behaviour. Physical capability, on the other hand, involves sensory and physical abilities. Opportunity includes both physical and social opportunities. Physical opportunity involves a person's physical environment needed for the behaviour to occur, while social opportunity relates to a person's social environment. Motivation is the third factor that must be present for any behaviour to occur within the COM-B model (Michie et al., 2011). Motivation is considered a core part of the COM-B model (West & Michie, 2020). Two types of motivation are distinguished: reflective/conscious, involving intentions or plans and judgements, and automatic/less conscious, including habit formation, subjective wants and needs (Michie et al., 2011).

Using PA as an example of behaviour to change, capability relates to the psychological understanding of what safe exercise is, and the physical aspect of capability might relate to, for example, being physically able to exercise. Opportunity might relate to physical aspects of a person's environment (e.g., having the financial means or facilities to exercise) and/or social aspects of the environment (e.g., PA being accepted by others). The environment surrounding individuals may affect their ability to maintain PA (NICE, 2014a). In terms of motivation, the reflective type of motivation may relate to, for example, goal-setting, monitoring and feedback around PA and the automatic motivation to, for example, habits and routines around exercising.

The COM-B model lays the groundwork for examining and influencing particular behaviours among specific populations (Howlett et al., 2021). The employment of COM-B in the current research is substantiated by the evidence linked to the weight management context presented next.

When looking specifically at studies examining the application of COM-B to the context of weight management, most studies published to date focused on designing and developing weight management interventions using COM-B (e.g., Coupe et al., 2021) or investigating barriers and facilitators in weight management (Gu et al., 2022). Most studies also employed qualitative designs.

Willmott and colleagues looked at PA and eating behaviours by examining the application of the COM-B model to successful weight gain prevention (2021). In the context of the PA model, authors reported that capability and opportunity showed a positive relationship with PA behaviour, and this was mediated by motivation. In the eating behaviour context, capability was linked to behaviour through the mediating effect of motivation, while capability played a mediating role in the association

between opportunity and motivation. As seen, every component of the COM-B framework contributed to these behaviours.

In another study that looked at the COM-B model and the Behaviour Change Wheel applied to the design of a weight management intervention for people with low socioeconomic status (Coupe et al., 2021), the authors concluded that changes within the domains of psychological capability, physical opportunity and reflexive motivation needed to occur to improve dietary behaviours. Coupe and colleagues (2021) also reported low motivation, knowledge cost, time and social influences among the barriers to adherence to lifestyle behaviours. The authors also highlighted barriers related to literacy and language when working with individuals from low socioeconomic communities, which would be classified under capability. As the current study focuses on participants from harder-to-reach backgrounds, these findings are particularly important to consider because similar barriers that can be mapped around the COM-B model could be present.

The application of COM-B to PA and sedentary behaviours has also been explored. In the first study testing the predictive validity of the COM-B model components applied to the examination of Moderate to Vigorous Physical Activity (MVPA), Howlett and colleagues reported that the most important drivers of PA were psychological capability followed by reflexive motivation (Howlett, Schulz et al., 2019). The authors used Cane and colleagues' mapping of the TDF onto COM-B (Cane et al., 2012). They reported that psychological capability was characterised by self-monitoring of PA, action planning and habits, opportunities related to social support from family, social support from non-family, and subjective norms (Howlett, Schulz et al., 2019). Reflective motivation included exercising self-identity, intentions and self-efficacy. Capability strongly predicted motivation, while opportunity had a

weaker association with motivation. Capability and motivation together accounted for 50% of the variance in MVPA (Howlett, Schulz et al., 2019). The amount of variance explained was comparable to other psychological models of PA, like the TPB (Howlett, Schulz, et al., 2019).

In the second study conducted by the same group of researchers but focusing on sitting behaviour (Howlett et al., 2021), the COM-B model explained 27% of the variance in sitting behaviour. Capability was shaped by self-monitoring of sitting behaviour, while the subjective norms influenced opportunity. Motivation, on the other hand, was constituted by intention, positive affect and PBC. While the current research was not designed to utilise the TDF or test the predictive qualities of COM-B, the mapping of themes identified in the qualitative phase of the research against COM-B was planned to check whether similar links between capability, opportunity, motivation and behaviour could be established.

In summary, studies looking at the utilisation of COM-B within a weight management context, including PA, showed that the model has been successfully applied in a variety of ways. Previous research found that capability, opportunity and motivation all played important roles in weight-related behaviours and PA. Studies mainly had qualitative designs, while those testing the predictive power of COM-B were rare. The COM-B model and Behaviour Change Wheel were deliberately designed as practical tools for developing behaviour change interventions rather than explanatory theories (Pinder et al., 2018). With this in mind, COM-B was not intended to be used in the current research as a model to test predictions or explain causes of weight-related behaviours. Instead, the model was intended to be used to map out psychological factors implicated in weight loss behaviours.

The following section focuses on BCTs that are often utilised in weight management programmes. Some of them can also be mapped directly against the TPB and COM-B models.

1.2.3 Behavioural Change Techniques (BCTs)

BCTs such as self-monitoring of weight, PA or sedentary behaviour can be seen as essential ingredients of both models outlined above. BCTs should be embedded in weight management interventions (NICE, 2014c). The BCT Taxonomy lists 93 BCTs grouped into 19 clusters (Michie et al., 2013). These techniques form a tool that can be used to design and evaluate behavioural change interventions, including weight management programmes as recommended by PHE (2017c). It is advised that only techniques that are effective in existing interventions should be used in weight management programmes (NICE, 2014c). These techniques can be used alone or with other BCTs (NICE, 2014c). PHE (2017d) emphasised that specific BCTs make weight management programmes more effective. As Dombrowski and colleagues pointed out in their large-scale systematic review (Dombrowski et al., 2012), complex weight management interventions are heterogeneous and consist of many ingredients; there is no standard set of behavioural techniques that are systematically utilised in weight management interventions. The researchers highlighted, however, that some BCTs, such as self-monitoring of dietary behaviour and feedback, were found to have significant moderating effects on weight loss (Dombrowski et al., 2012). This is covered in the next section.

1.2.3.1 Self-monitoring and feedback techniques

Self-monitoring involves the observation and recording of behaviours in a systematic way (Kanfer, 1970) and is sometimes considered the centrepiece of weight management programmes (Burke et al., 2011). Self-monitoring e.g., keeping food and activity records helps to increase awareness of one's actions and their consequences (Foster et al., 2005) and is thought to facilitate greater accountability through diet and activity changes, which may lead to weight loss (Khaylis et al., 2010). It is thought that tools leading to improved self-monitoring, for instance, dietary intake or PA, are necessary to improve weight loss outcomes (Borg et al., 2004). The provision of feedback and self-monitoring of weight and behaviours that may affect weight are crucial components of weight management interventions (NICE, 2014b). Self-monitoring of behaviour is the most commonly used BCT in effective PA and diet interventions (Michie et al., 2009). Self-monitoring of behaviour has also been assessed in chronic health conditions. For instance, McDonald and colleagues looked at the effects of self-monitoring in the context of glaucoma. They reported that participants found the web-based diary tool for self-monitoring to be of high value. While the majority found self-monitoring of their behaviour to be a positive experience, one patient reported negative feelings arising from a constant focus on monitoring symptoms (McDonald et al., 2017).

Self-monitoring can refer to a specific behaviour (e.g., keeping a diary) or an outcome (e.g., weight changes). It can be seen as central to the self-regulation process as deliberate attention to specific behaviours is paid. As a result, self-evaluation of progress and self-reinforcement can occur (Burke et al., 2011). PHE (2017d) recommends that weight management programme attendees receive regular feedback on their behaviour and its outcomes. Regular feedback seems to

be beneficial, especially within the context of the negative feedback loop described by Carver and Scheier (1998). Technology, particularly portable devices, enable individuals to self-monitor their behaviours and provide feedback, presenting the potential for enhancing weight management programme outcomes (Lewis et al., 2015). In a large meta-analysis conducted by Michie and colleagues (2009), self-monitoring of behaviour was a successful moderator in healthy eating and PA studies. In a review looking at BCTs incorporated into FTs specifically, it was found that the majority of techniques focused on self-monitoring (of activity levels) and self-control, both of which have been linked to enhanced PA (Mercer et al., 2016).

1.2.3.2 Self-regulation techniques

It was pointed out previously that the use of techniques associated with self-regulation or control theory (Carver & Scheier, 1998) leads to higher weight loss (Dombrowski et al., 2012). According to the control theory, behaviour is regulated by a negative feedback loop where the individual's state is compared to their goal, which explains people's actions, behavioural change and maintenance of health behaviour (Carver & Scheier, 1998). The techniques linked to self-regulation and control theory include goal-setting, intention formation, providing feedback on performance, self-monitoring of behaviour, and review of behavioural goals (Carver & Scheier, 1998). Dombrowski and colleagues found in their systematic review that BCTs associated with control theory were linked to significant increases in weight loss and suggested that including these techniques (specifically goal-setting, self-monitoring of dietary behaviour, and review of behavioural goals) might lead to increases in the intervention effectiveness (Dombrowski et al., 2012). Michie and colleagues (2009) reported that interventions that integrated self-monitoring of

behaviour with at least one additional technique based on control theory (e.g., goal-setting) demonstrated significantly greater effectiveness compared to other interventions.

Three concepts are seen as particularly linked to the degree of control over one's health: Locus of Control (LOC), Patient Activation and Self-Determination. According to LOC, individuals interpret events differently and attribute them to factors such as luck, chance, fate or powerful others (external LOC), while others see actions as dependent on their behaviour [internal LOC, (Rotter, 1966)]. LOC is a concept that refers to the degree to which individuals believe that they have control over events in their lives (Rotter, 1966), related to weight in this case. Adolfsson and colleagues reported that internal LOC orientation was associated with more significant weight loss in participants in weight management programmes (2005). In a study on behavioural and psychological pre-treatment predictors of short and long-term weight loss (Jorge et al., 2020), Weight LOC (WLOC) appeared to be among the key factors for long-term success in a population of women.

When looking specifically at LOC and self-monitoring, Bennett and colleagues (2017) explored digital interventions focused on self-monitoring tools for health-related behaviours (e.g., diet, exercise and sleep) and emphasised that there is a lack of research exploring LOC and its impact on the willingness to use digital interventions (apps and mHealth applications), which might affect individuals' engagement. In their study, internal LOC predicted willingness to use health apps and online trackers while external LOC did not. The authors concluded that individuals with internal LOC were more willing than those with external LOC to use a form of technology to monitor or change health behaviours.

Patient Activation is a behavioural concept capturing the core components of people's involvement in their health and health care, each important for individuals' active engagement and participation (Hibbard & Gilburt, 2014). Patient Activation is viewed as an evidence-based mechanism for establishing the capacity of individuals to manage their health (Hibbard & Gilburt, 2014). It is defined as an individual's knowledge, skill, and confidence in managing their health and health care, and it indicates an individual's ability to self-manage (Hibbard & Gilburt, 2014); therefore, it can be seen as closely linked to the concept of self-monitoring of behaviour.

Individuals who display higher Patient Activation scores are considerably more inclined to engage in preventive behaviours compared to those who score lower (Hibbard & Gilburt, 2014). People with a low Patient Activation level have a greater need to self-monitor their current behaviours and how they feel. This is because they need to build self-awareness around key health behaviours and gain an understanding of their vital role in their health and healthcare process and that it is not the responsibility of other people (this can also be linked to the concept of LOC). Previous research found that increases in activation coincide with increases in self-management behaviours (Hibbard et al., 2007).

The BCT of self-monitoring of behaviour is crucial when assisting people to move to a higher activation level. Individuals can be assisted to take responsibility for their health and be more accountable for health-related behaviours. This can be achieved by helping individuals with goal-setting and feedback, and helping them to see connections between lifestyle choices and their effect on the individual's condition or onset of symptoms. When individuals are helped to increase their activation level, their health outcomes improve as increasing activation levels

supports enhancements in both specific and broader aspects of health and healthcare engagement (Hibbard & Gilburt, 2014).

Multiple studies showed that Patient Activation scores are predictive of most health behaviours, including preventive behaviours, healthy behaviours, self-management behaviours and health information seeking (Hibbard & Gilburt, 2014). Patient Activation can be used to predict future activity, reduce health inequalities and deliver improved outcomes (Hibbard & Gilburt, 2014). It is frequently used in prevention, for example, in weight loss, smoking cessation and willingness to exercise (Hibbard et al., 2007). It is also important to note that individuals experiencing depressive symptoms showed a notably lower tendency to increase activation and enhance their self-management behaviours. It seems that the presence of ongoing depressive symptoms hinders the likelihood of activation taking place (Hibbard et al., 2007).

There is a general agreement that Patient Activation plays a vital role in enhancing healthcare outcomes and reducing healthcare expenses (Golubinski et al., 2020). Utilising Patient Activation can reduce health disparities and achieve enhanced results, improved healthcare quality, and reduced costs (Hibbard & Gilburt, 2014). The correlation between Patient Activation scores and costs of intervention revealed that individuals with lower activation levels have healthcare costs around 8 - 21 % higher than those with higher activation levels. Research on interventions aimed at enhancing activation indicated that patients with the lowest activation scores tend to experience the greatest improvements. This suggests that effective interventions have the potential to engage even the most disengaged individuals (Hibbard & Gilburt, 2014).

The Self Determination Theory approach (Deci & Ryan, 1985; Deci & Ryan, 2000) can be also linked to self-regulation techniques. The Self-determination theory focuses on the motivation behind choices people make without external influence and interference. Autonomous motivation relates to intrinsic goals and outcomes where the behaviour is self-determined, for instance, the involvement in an activity for the sheer pleasure and satisfaction it offers (Hartmann et al., 2015). Introjected and external motivation are forms of extrinsic motivation where behaviours are performed to avoid the feeling of guilt (introjected) or in response to external punishment or incentives (external/controlled) (Deci & Ryan, 1985; Deci & Ryan, 2000). Understanding what encourages positive shifts in weight-related behaviours involves exploring personal psychological aspects, such as individuals' underlying reasons for aiming towards a healthy body weight (Hartmann, Dohle & Siegrist, 2015). Looking at Self Determination Theory tenets was therefore considered important in the current research.

1.2.3.3 Goal-setting and planning techniques

Goal-setting and planning techniques are also closely linked to self-monitoring of behaviour and self-regulation and can also be viewed within the control theory (Carver & Scheier, 1998). Goal-setting and planning have been outlined as some of the main BCTs in weight management (NICE, 2014c). Goal-setting and planning involve a group of techniques that help to set goals for both the behaviour itself (e.g., being more active) and the behaviour outcome (e.g., weight loss), involving steps to ensure that the goals can be met. A clear description of what needs to happen is required to formulate action plans; this should include information on how often the action will take place (e.g., exercising twice a week), for how long (e.g., 45 min per

exercise session) and where (e.g., at the gym/park) (NICE, 2014b). In a UK-based study analysing weight management intervention outcomes of 24,447 obese Slimming World service users (Avery et al., 2016), the goal-setting BCT was examined. Authors reported that at 12 months, the weight loss was greater among service users who set goals, with those who set four goals or more having the greatest weight loss. In a systematic review conducted by Howlett and colleagues (Howlett, Trivedi, et al., 2019), goal-setting was identified as the most frequently used BCT in PA interventions. Goal-setting was also considered an effective BCT to improve PA (McEwan et al., 2016).

A regular review of behavioural goals in light of experience is needed as further plans can be developed according to progress made towards achieving goals (PHE, 2018b). This links to the negative feedback loop described by Carver and Scheier (1998), which states that individuals make assessments of current behaviours, potential external influences and the progress towards an established goal. If any discrepancies are detected, the behaviour is performed in order to reduce those discrepancies (Carver & Scheier, 1998).

A key recommendation made by PHE (2017d) was to assist weight management programmes' service users in setting goals that are Specific, Measurable, Attainable and Time-Bound (SMART). The use of SMART goals was also recommended to healthcare professionals within NHS settings (Michie et al., 2008). PHE also suggested that setting individual energy intake and activity goals may be helpful. Intention formation (forming the basis of the intention) is another example of the techniques identified as a successful ingredient of weight management interventions (2017d), and it links to goal formation closely. While SMART goals are recommended to be set in weight management programmes, it

does not always translate into practice. A UK-based study looking at weight loss among groups in low socioeconomic areas reported that while health professionals were trained to set SMART goals with service users, the latter struggled to understand and set them (Coupe et al., 2021). Additionally, in a recent review published by Swann and colleagues (2023), the SMART goal-setting approach has been criticised. Authors argued that SMART goals are not applied consistently and lack detailed guidelines, potentially leading to suboptimal outcomes, concluding that better goal-setting strategies are needed.

Having reviewed the BCTs used in weight management programmes, the following section concentrates on FTs, the specific BCTs they utilise, their effectiveness in weight management and how they fit within the key theoretical models.

1.3 Fitness trackers

1.3.1 Fitness trackers overview

FTs are wearable devices that are usually worn as wristbands like watches (see Figure 1.3 for an example). From simple pedometers to advanced smartwatches and health apps, these tools are now widely used for personal health management. '2.0 technologies' refer to the advanced features and capabilities that have significantly enhanced FTs' functionality and user experience. Key components of 2.0 technologies include advance sensors and tracking capabilities (e.g., motion sensors, heart rate monitoring), health monitoring features (e.g., sleep tracking, blood oxygen levels monitoring) and greater connectivity with smartphones and improved personalisation (e.g., tailoring goals and plans). M-health (mobile health) involves using mobile devices like smartphones, tablets, and wearables to support medical and public health practices, including fitness tracking apps, telemedicine

services, and health monitoring devices. E-health (electronic health) covers the broader use of electronic processes and communication technologies in healthcare, such as the Internet, telehealth services and digital health platforms.

2.0 FTs are upgraded versions of pedometers that traditionally measured steps only. Pedometers were reported to be successful at increasing PA (Bravata et al., 2007). In Bravata and colleagues' systematic review, it was reported that individuals using pedometers increased their PA (steps per day) by 27% compared to baseline (2007). The authors of this review concluded that the use of a pedometer is linked to substantial increases in PA as well as notable reductions in BMI and blood pressure. In 2011, Tudor-Locke and colleagues reported that simple and inexpensive pedometers, although less sensitive to very slow walking and limited, are popular in real-world applications, including direct use by the general public.

In addition to counting steps, FTs also measure many other fitness-related metrics such as heart rate, cardio fitness levels, hours of sleep and sleep quality, the number of calories burnt and daily PA/active minutes. Most modern FT varieties now provide these options and are available as consumer products. FTs have significantly evolved since they were first introduced in the early 2010s and are now very popular, especially among populations choosing to improve their health and well-being (Ryan et al., 2019). The global market for FTs has grown immensely over the past decade (Ferguson et al., 2022). FTs can be seen as part of the 'Quantified self' movement, where aspects of lives are being regularly measured so individuals can find ways to improve them (Hoy, 2016).

Figure 1.3. *Fitbit Charge 2 Fitness Tracker*

Note. The image obtained from Fitbit.com

It was stated that in the future, the data held by the NHS in conjunction with the data generated by smart devices worn by individuals (such as FTs) would start a new wave of ‘intelligent public health’ where interventions will be personalised and individuals will have access to their health information (NHS, 2019a). FTs seem to successfully promote higher levels of PA across diverse age groups and clinical and non-clinical populations (Ferguson et al., 2022). The significant clinical advantage of this effect remains consistent over an extended period, and there is substantial evidence to recommend FTs’ use as an addition to interventions focusing on increasing PA (Ferguson et al., 2022).

Most FTs provide real-life feedback data displayed on the device’s screen summarising the last 24 hours of activity. However, they also work in conjunction with a cloud-based data storage system where data are regularly uploaded (via Wi-Fi) and stored. This external storage enables users to view patterns of their activity data over more extended periods. This can be accessed through a smartphone/tablet or a computer, providing data sets in an accessible format that is easy to interpret. While some devices rely on users’ own data analysis, others contextualise and present data more analytically (Hänsel et al., 2015), for example,

by presenting breakdowns and daily comparisons in an accessible format. This makes data easy to understand for users and enables them to self-monitor their activity in real-time and assess how active they have been over a more extended period, for example, a week/month.

Applications connected to sensors and FTs are now being recommended as digital therapies for self-monitoring of PA and self-care. Simultaneously, the concept of patients using health apps, such as monitoring heart rhythms through smartwatches, is gaining momentum. A challenge for integrating digital health in the NHS lies in effectively combining these two evolving trends (*NHS Health Education England*, 2019).

1.3.2 Fitness trackers and behavioural change techniques

FTs provide an opportunity for goal-setting, feedback and self-monitoring of behaviour and outcomes of behaviour (Chia et al., 2019), enabling their users to set behavioural goals by, for instance, setting daily targets of steps and monitoring progress against them. As mentioned above, FTs provide real-life feedback, displayed directly on the device and visible as weekly/monthly breakdowns when accessed through cloud-based data storage. Self-monitoring of behaviour is therefore available around the clock, and users can self-regulate their behaviours in real-time, for instance, by keeping exercise intensity in an appropriate heart rate zone (which may help users learn how to exercise safely).

Some devices also provide nudges by enabling reminders to move when a sedentary period is detected. A gamification component is available where FT users earn points for reaching goals or appearing in various rankings (social sharing and social competing). Many FTs provide a platform for users to compare and share their achievements with their family or friends, obtaining additional support and positive

reinforcement. In a cross-sectional study looking at the experiences of FT users (Maher et al., 2017), 65% of participants reported that they did not use their devices' social features, but among participants who did use them, competing with friends was their primary motivation for data sharing. In a content analysis of BCTs utilised in FTs (Düking et al., 2020), authors reported that the most common BCTs were goal-setting, devising action plans, evaluating behaviour goals, highlighting disparities between current behaviour and goals, providing feedback, self-monitoring behaviour, social support and comparison, prompts/cues and utilising biofeedback.

Self-monitoring of behaviour, a key BCT in weight management, when enabled through FTs, can play an essential role in the behavioural change process. Commercially accessible FTs can be used for self-tracking behaviour (Lewis et al., 2015). These technologies offer an objective assessment of PA in one's daily routine and can deliver feedback beyond merely displaying basic activity count data (Lewis et al., 2015). This feedback is provided either on the monitor's display or through a complementary application, encouraging consistent self-monitoring of PA. When accessing online accounts (in addition to what is displayed directly on the devices), several other functions are available; these include a food or water intake diary, which some users might find helpful. The evidence supports FTs as reliable and effective health behaviour change tools (Ryan et al., 2019). It was also reported that FTs provide a valid method for data collection that is more accurate than self-reporting (Bolyard et al., 2015).

Individuals' awareness can be significantly enhanced by seeing key metrics thanks to the tracker. For instance, in a Scottish study focusing on the use of pedometers to increase PA in men in a football-focused weight management setting (Donnachie et al., 2017), participants stated that pedometers gave them a clear

understanding of how active or inactive they were, and they could not contest the PA information they obtained. The study by Donnachie and colleagues also demonstrated how some men having started using pedometers were motivated to use other self-tracking technologies (including FTs) post-intervention because they enjoyed self-monitoring PA-related metrics (2017). In another qualitative study exploring the perceptions of FTs, many participants reported that the feedback the devices provided gave them a sense of achievement and validation (Burford et al., 2021). In a study by Henriksen and colleagues (2021), participants reported being more conscious about their PA, and it was concluded that their understanding of different activity types and their effects improved.

FTs incorporate evidence-based BCTs that align with self-management strategies, known to enhance PA levels and decrease sedentary behaviour. These devices present an opportunity for cost-effective and readily accessible PA interventions, catering to a broad population (Chia et al., 2019).

1.3.3 Effectiveness of fitness trackers in weight management

Previous systematic reviews reported that FTs can increase PA levels and significantly decrease weight (Ferguson et al., 2022). In their large-scale review of 39 systematic reviews, the data from 163,992 participants showed that FTs were effective in increasing PA and, on average, led to reductions of 1 kg in body weight. Some individual studies, however, produced contrasting results. A study by Jakicic and colleagues (Jakicic et al., 2016) concluded that FTs did not help people lose weight following a weight management intervention when participants were given wearable devices six months into the programme. Similar results were found in a study conducted by Finkelstein and colleagues, in which healthy participants were randomly assigned into experimental (with FTs) or control groups. Each group was

also further divided into either receiving or not receiving a financial incentive (no structured weight management intervention was offered), with weight and blood pressure used as study outcomes (Finkelstein et al., 2016). The study found no benefits of the devices worn, either in the incentive or the non-incentive group.

In a systematic review of interventions that utilised FTs, it was reported that when experimental (a group with FTs) and control conditions had access to the same intervention components, e.g., counselling or group interaction, the addition of the FT for self-monitoring of PA behaviour within the experimental group did not lead to more favourable results (Sypes et al., 2019). In 22 studies examined, only seven studies found significantly improved intervention results in the FT condition when compared with control groups (Sypes et al., 2019). The authors added that interventions seemed to achieve better results when participants were directed to utilise various functions of the FT, like setting goals or engaging with fellow users in a virtual setting. Sypes and colleagues also pointed out that combining the use of FTs with other types of support, such as coaching or social support, was an effective way to increase PA and weight loss.

In 2019, Brickwood and colleagues conducted a separate meta-analysis, examining 16 studies employing multifaceted interventions and seven studies solely utilising FTs. Their findings revealed that the multifaceted interventions produced outcomes approximately 50% greater in magnitude compared to those relying solely on FTs (Brickwood et al., 2019).

Conflicting results into FTs' effectiveness in weight management programmes might be explained by the use of different methodologies, such as introducing a FT six months into the intervention or providing incentives with no face-to-face

behavioural support. The heterogeneity of studied populations might also explain differences in results. One of the core limitations of early FT studies was that they mainly recruited White female participants (Lewis et al., 2015). While more recent studies focused on the use of FTs in specific populations, for instance, breast and colorectal cancer survivors (Cadmus-Bertram et al., 2019), people with severe mental health illness (Aschbrenner et al., 2022), older adults with chronic conditions (Brickwood et al., 2020), there was still a need to investigate how different demographic groups could benefit from these interventions, especially people from more disadvantaged backgrounds. Conducting research in this area was also desired as many studies published so far were not conducted with real-life interventions and hence lacked ecological validity.

Weight management programme attrition rates and how FTs can affect them are also important to explore. PHE recommended that, where possible, self-monitoring and feedback on behaviour should be provided as part of weight management interventions (PHE, 2017d). This includes biofeedback, for instance, heart rate monitoring devices during exercise (PHE, 2018b). This is especially recommended in relation to the uptake and retention of group-based weight-management services (PHE, 2018b). According to NICE guidance (NICE, 2014b), attrition and completion rates, as well as the initial engagement levels, are essential process measures to consider to assess the effectiveness of weight management programmes. It is thought that weight management programmes can be affected by attrition. Some of the previous studies utilising FT in weight management interventions reported reduced attrition rates in participants from study conditions utilising FTs. For instance, Ashe et al. (2015), Jakicic et al. (2016) and Peyer et al. (2017) all reported better attendance in FT conditions when compared with control

conditions. Other research, however, e.g., Bender et al. (2017) and Kozey Keadle et al. (2014), did not find a more favourable pattern among those using FTs.

When looking at commercial weight management programmes (such as Slimming World or Weight Watchers), it was reported that service users who drop out usually provide reasons that fall into three categories: practical/physical difficulties, barriers related to the programme and psychological barriers (Miller & Brennan, 2015). Predictors of dropping out from weight management interventions identified in previous research included younger age, higher weight loss and maintenance expectations, lower levels of PA, personality factors and greater body dissatisfaction (Moroshko et al., 2011). PHE recommended that technology such as pedometers may be considered to sustain service users' motivation on weight management programmes (2017d).

In conclusion, self-monitoring of behaviour is seen as a technique used to promote weight management programme compliance (Teixeira et al., 2004), and since FTs enable self-monitoring of PA and other metrics e.g., sleep, they can be viewed as potentially helpful tools to reduce attrition rates, increase PA and enhance weight loss.

1.3.4 Fitness trackers and theoretical frameworks (TPB and COM-B)

When looking specifically at the TPB and the use of FTs, several studies reported using the TPB to explain intention within weight management and exercise interventions context. In a study that looked at the TPB and FTs in the context of PA, the authors found that intention to exercise was mediated by individuals' evaluation of exercise, belief about significant others' approval of exercise, and PBC upon

exercise (Zhu et al., 2017). Specifically, there was a strong relationship between exercise intention, social sharing and competing (enabled through the FT device). The study authors concluded that sharing the exercise data significantly influenced exercise intention (Zhu et al., 2017). In another study that looked into FTs and e-coaching applications (such as apps and websites promoting healthy lifestyles) in healthy people with low socioeconomic status in Greece and the Netherlands, the components of TPB were also explored in relation to exercise intention (Spelt et al., 2019). Spelt and colleagues found that participants in the FT condition were significantly more active and reported increased levels of PBC and well-being (2019). In another study looking at the application of TPB to changing PA, a group of participants using FTs showed a significant rise in activity with a moderate effect size (O'Shea & Frazer, 2018). However, the results of this study showed that the TPB was not a significant predictor of PA in a technology-driven intervention setting. In another study by Chen and colleagues (2023), the TPB was used in the context of FT utilisation. The authors of the study found that attitudes, subjective norms and PBC all predicted the willingness to use FTs.

When it comes to the COM-B model, digital technology, such as FTs, when utilised as part of weight management programmes, can potentially enhance the effectiveness of many BCTs. In terms of capability, FTs can greatly increase knowledge and understanding of physical health and lifestyle choices and increase cognitive ability by self-monitoring of behaviour (psychological capability). Additionally, FTs can help develop skills, such as guided breathing exercises to manage stress or provide an opportunity for behavioural practice and rehearsal (physical capability). The provision of the FT can be seen as an opportunity when individuals from deprived backgrounds are provided with one (physical opportunity).

FTs can also enable social opportunities such as buddying up with other people with the same devices and receiving social support (social opportunity).

It was previously reported (Friel & Garber, 2020) that in a 12-week study using FTs in older adults, the social interaction enabled through FT increased participants' adherence to wearing their devices. This can be viewed as a social opportunity that FTs provided. In a review of 20 studies focused on PA among older adults or individuals at risk of chronic conditions in rural healthcare settings by Pelletier and colleagues (Pelletier et al., 2022), the intervention components were mapped against the COM-B framework. Authors of the review found that effective strategies for boosting PA behaviour encompassed the utilisation of FTs, along with regular check-ins or reminders from trusted sources. Interventions classified under physical opportunity, automatic motivation, and psychological capability within the COM-B model demonstrated higher success rates compared to other factors. Successful intervention approaches involved progress tracking, counselling provision, and follow-up reminders to facilitate behaviour change.

Behaviour change can also be encouraged via incentivisation techniques provided by the FT (Jarrahi et al., 2017). FTs can also aid motivation; for instance, Fritz and colleagues (2014) found in their study that the data and the feedback provided by FTs motivated participants to improve their physical fitness. While the novelty of FTs began to wear off for some participants, they still had motivational effects and helped them to create routines (Fritz et al., 2014).

To the researcher's knowledge, no studies looking specifically at the application of COM-B to FT utilisation within the weight management context in adults have been published at the time of writing (2023). The COM-B model applied

in relation to the use of FTs has been examined previously using the TDF; however, it was in relation to children and adolescents in a general context of PA.

In conclusion, based on the literature reviewed above, the TPB and COM-B can be viewed as models within which the use of FTs can be considered. The integration of FTs in weight management and exercise interventions can be informed by the TPB and COM-B models and their components, ultimately contributing to more effective behaviour change strategies. The following section outlines the rationale for the current study, research questions, aims and objectives.

1.4 Research rationale, questions, aims and objectives

1.4.1 Study rationale

It is evident that a gap existed in the understanding of how self-monitoring devices such as FTs work when incorporated into real-life weight management programmes in the CVD prevention context. It was also not clear whether people from more disadvantaged populations benefit from them, as many previous studies concentrated on their use in groups of privileged users already focused on fitness and interested in activity tracking. Although some recommendations for the use of pedometers in weight management interventions were given for the purpose of self-monitoring of PA behaviour and enhancing motivation, especially in relation to programme uptake and retention (PHE, 2018b), there was still plenty to learn about the use of FTs in England, specifically within a structured weight management intervention offered as part of a more comprehensive obesity management pathway. Understanding why some populations respond to wearable technology well and utilise it to enhance their weight loss or improve other health outcomes is crucial, alongside understanding why others do not and what factors influence the outcome.

The current study focused on overweight and obese people from less privileged backgrounds where the purchase of FTs might be a barrier and where the prevalence and the negative impact of CVD are greater (as explained in section 1.1.1). A better understanding was to be achieved of how FTs impact weight management programme outcomes and what part BCTs play in addressing modifiable CVD risk factors, specifically in the context of self-monitoring of behaviour. As presented above, several factors might contribute to different weight management intervention outcomes, and these were also explored. Experiences of service users and health professionals seeing the intervention that utilises FTs from different standpoints were also considered important to explore as these might help gain a new perspective and influence CVD prevention programme retention rates.

The current study also explored whether the variables within the TPB could predict weight management programme outcomes in both the population using FTs and those in the control group. Furthermore, as the COM-B model can also be used as a framework to promote uptake and retention in group-based weight management programmes (PHE, 2018b), it was also used in the current study to help map out weight-related factors. Additionally, as highlighted earlier, self-monitoring of PA behaviour was linked to FTs, TPB and COM-B; therefore, exploring weight management programme outcomes and attrition rates and seeing how these variables relate was considered important in the current study.

The current study was not restricted to one of these models; instead, it aimed to make use of various concepts within them. The main models' variables were examined in combination with WLOC, Patient Activation, anxiety and depression data. Participants' engagement within programmes and attrition rates were also considered. As motivation was linked to weight loss, self-monitoring of PA behaviour

and many psychological factors such as those discussed above, this research also aimed to explore motivation in greater detail. It was felt that since obesity is very complex, it would be beneficial to look at various factors that potentially play a role in addressing it.

This study focused on FTs utilised as part of a CVD prevention intervention for weight management (HH). Similarly to many other weight management interventions, this intervention used several BCTs that emphasised goal-setting, feedback and self-monitoring of behaviour. FTs can potentially assist with these BCTs; therefore, the main focus in the current study was on FTs and their impact on programme outcomes when incorporated as part of the chosen intervention.

1.4.2 Research questions, aims, objectives and hypotheses

The primary research questions that were addressed in this research are as follows:

1. Does the use of FTs impact upon the weight management intervention outcomes in those at risk of CVD disease?
2. Would health beliefs as defined by the TPB, WLOC, Anxiety, Depression, Patient Activation levels and Motivation differ between FTs and the intervention as usual (control) conditions and change over time?
3. Can health beliefs as defined by the TPB, WLOC, Anxiety, Depression, Patient Activation levels and Motivation predict weight loss outcomes in the weight management intervention?
4. What are service user participants' and health professional participants' experiences of the weight management intervention utilising FTs?

The aim of this research was to provide further insights into the use of FTs in weight management intervention in the context of CVD prevention in a harder-to-reach population and examine whether these could be used as an addition to programmes. It had four research objectives:

1) The first objective was to assess the effectiveness of FTs when used in addition to the standard weight management intervention. It assessed whether the 'intervention with FTs condition' and the 'intervention as usual condition' (control) had different weight management intervention outcomes (primary outcome – weight and secondary outcomes - waist circumference, BMI, PA and programme attendance).
2) The second objective was to assess the psychological factors associated with successful weight loss and tested whether they differ across the study conditions (FTs versus control) over time.
3) The third objective was to examine the psychological factors associated with successful weight loss and other intervention outcomes.
4) The fourth and final objective was to explore service users' experiences taking part in the weight management programme utilising FTs. Additionally, it aimed to explore the subjective experiences and perceptions of health professionals delivering weight management interventions utilising FTs.

This research had three hypotheses:

1: FTs will impact the weight management intervention outcomes in those at risk of CVD disease.

2: Health beliefs (TPB), WLOC, Anxiety, Depression, Patient Activation levels and Motivation will differ between FTs and the intervention as usual conditions and change over time.

3: Health beliefs (TPB), WLOC, Anxiety, Depression, Patient Activation levels and Motivation will predict weight loss outcomes in the weight management intervention.

The first three research objectives (and hypotheses) are addressed in Chapter 4, while the fourth objective is addressed in Chapter 5. In order to provide the context for the current research, a scoping review is presented in Chapter 2. The following section describes the setting of the current study.

1.5 Healthy Hearts - the study setting

HH (‘Healthy Hearts’, 2023) was a CVD prevention intervention offered to residents of Central London’s most deprived areas (the reasons for the discontinuation of the service are provided in section 3.2.1). The development of the HH programme was informed by various sources of evidence and guidance, including the NICE guidance on the Prevention of Cardiovascular Disease (NICE, 2010). Additionally, evidence from Skender et al. (1996) was considered as it highlighted the effectiveness of combining diet and exercise for both initial weight loss and maintenance. Consistent with this research, the HH programme integrated sustainable nutritional education with appropriate PA, aiming to support individuals in achieving and maintaining a healthy weight.

Furthermore, the HH programme was underpinned by behaviour change principles, as outlined in several pieces of evidence from NICE guidance on "Managing overweight and obesity in adults" (NICE, 2014b). These principles

included goal setting, action planning, and barrier identification, which were incorporated into the programme to enhance its effectiveness in promoting healthy behaviours and supporting long-term behaviour change.

Residents identified as at risk of CVD due to being overweight or obese and other risk factors were recruited through the Local Authority-commissioned service. In general, HH delivered primary and secondary prevention activities (primary prevention through campaign activities and identification of obese patients; secondary prevention through its dedicated weight management programme). HH weight management programme was an example of a tier-two secondary prevention intervention within a broader approach to preventing and treating obesity (NICE, 2014b). HH met the NICE recommendation for tier-two weight management interventions (NICE, 2014b), delivering evidence-based sessions concentrating on diet, PA and incorporating behavioural change components. In addition to addressing weight, a reduction in sedentary behaviour and an increase in PA was also aimed at as part of HH, which aligned with the PA guidelines (DH, 2019). As PHE (2017d) recommended, the HH intervention was tailored to the targeted population, considering the needs of disadvantaged communities and populations such as Black, Asian and Minority Ethnic groups and people with low socioeconomic status. The HH intervention was selected as a part of the current research as it followed the recommendations outlined above, i.e., had diet, PA and behavioural change components and was tailored to the needs of disadvantaged communities. The details of HH intervention are provided within the methodology chapter of this thesis (Chapter 3).

The next chapter presents a scoping review and synthesis of the quantitative evidence on the use of FTs in weight management.

Chapter 2 - Scoping review

This chapter presents a comprehensive literature review on the use of FTs in weight management that was conducted to identify articles published between 01/01/2013 and 31/01/2018. The information about the methodology employed in the review and the steps involved in the data analysis are provided. The search criteria encompassed primary research studies examining weight management programmes for obese and overweight adults, which incorporated commercially available FTs as an intervention component in at least one of the study groups. Both peer-reviewed Randomised Controlled Trials (RCTs) and non-RCTs (provided there was a control condition) were included. Only studies published in English were included in the review. The results, including outcome measures reported in seven studies and overall findings, are subsequently presented. Relevant findings to the current study are outlined and examined. This chapter offers insight into the incorporation of FTs in weight management interventions found in previous studies. It contributes to the current thesis by setting the context for the empirical research presented in subsequent chapters.

2.1 Background and aims of the review

This scoping review aimed to answer the question, 'How effective are FTs when used as part of a weight management programme for overweight and obese people?' The review also explored whether FTs lead to different weight management programme outcomes, for instance, weight loss, compared with the intervention as usual (control). Additionally, the review intended to investigate whether FTs affect participation rates of weight management interventions. This review provided a

broader context for the current study and looked explicitly at face-to-face interventions with control conditions.

At the time of conducting the present scoping review (2018), the state of the literature was assessed, and systematic reviews looking at FT use in weight management interventions were identified. Cai and colleagues, for instance, examined wearable technology used as intervention components in adults with type 2 diabetes in 11 studies and reported decreased weight and BMI across interventions using pedometers when compared with control conditions (2016). However, the devices used in the reviewed studies were basic pedometers, and the reviewed interventions were delivered in different formats (e.g., providing written content, telephone support, and receiving diabetes education). In another systematic review (Cheatham et al., 2018), 25 studies were investigated, and in 20 of them, weight management interventions using FTs were reported to be a better option than a standard intervention. The weight management interventions in Cheatham and colleagues' review varied considerably; for instance, some delivered support to clients via texts, websites and apps (2018).

In another systematic review by Lewis and colleagues (2015), 11 studies were evaluated, and the authors concluded that FTs could lead to significant increases in PA and reductions in weight. However, their effectiveness compared to other interventions could not be established. The reviewed studies also encompassed mainly remote interventions.

In summary, some systematic reviews on FTs within weight management were available before the current scoping review was carried out. However, none provided the information sought for the research (using FTs instead of pedometers

and face-to-face weight management community-based interventions). Therefore, the current scoping review aimed to review the literature and provide the context for the empirical research comprised in this thesis. The following section focuses on the methodology employed in the current review.

2.2 Method

2.2.1 Search strategy

Searches were conducted to retrieve articles published between 01/01/2013 and 31/01/2018. The start date was selected to ensure that only contemporary studies utilising consumer-rated FTs providing real-time feedback were considered. The end date corresponded to the start of the research programme. The following databases were selected as they were the most related to the disciplines of interest (health and social sciences) and used in previous systematic reviews in the field: SPORTDiscus, PubMed, PsychArticles, CINAHL, CENTRAL via Cochrane Library and Web of Science. Databases were searched individually to identify studies that met the search criteria. Broad search terms included phrases related to FTs, weight intervention and population-related terms. The complete list of search terms is provided below:

> ("activity monitor" OR "activity track*" OR "Commercial wearable*" OR "electronic activity monitor*" OR Fitbit OR "fitness band" OR "fitness device" OR "fitness monitor*" OR "Fitness Track*" OR "fitness watch" OR smartwatch OR "wearable activity track*" OR "wearable device*" OR "wearable electronic device" OR "wearable monitor*" OR "wearable track*" OR "Wearable Sensor*" OR "Wearable technolog*" OR "Smart wearable*") AND ("weight loss" OR "weight reduction" OR "lose weight" OR "weight manag*" OR "weight program*" OR "weight counsel*" OR "weight intervention" OR "overweight" OR obes*)

A manual search was also conducted on references of key articles to check whether any additional studies met the inclusion criteria. The researcher conducted the initial search and the screening of articles while the researcher's supervisors performed an independent review of 10% of the retrieved articles' titles and abstracts. Full-text articles were reviewed independently. Articles were allocated to supervisory team members to review and/or resolve discrepancies between the researcher and members of the supervisory team. A different member of the supervisory team reviewed articles when any discrepancies arose. The search process is illustrated in Figure 2.1.

2.2.2 Study inclusion and exclusion criteria

A set of inclusion and exclusion criteria was applied to define articles of interest that addressed the review's research question. Primary research studies aiming to provide insights into weight management programmes for obese and overweight adults utilising FTs as part of an intervention (as opposed to assessment purposes only) were included. Articles describing research conducted with participants under 18 years old, pregnant women, and people with certain debilitating conditions, e.g., diagnosed CVD, terminal cancer, eating disorders, and severe mental health conditions, were excluded.

Additionally, the review looked only at studies describing structured weight management interventions with a comparison condition/conditions and utilising a FT device as an intervention component in at least one of the study groups. FT was defined as an external wearable device/activity tracker (worn on the body) linked to an app/website platform (not merely an app/website platform tracking fitness). The FT had to be commercially available and provide feedback directly to the user to

enable self-monitoring of PA metrics and sleep (either on a display screen or through the associated app/website).

Peer-reviewed Randomised Controlled Trials (RCTs), as well as non-RCTs (providing that there was a control condition), were included, while any grey literature articles were excluded. Only studies published in the English language were considered. In terms of outcome measures, studies that reported weight outcomes (i.e., weight, BMI, % weight loss, waist circumference, body composition, muscle and fat mass) as one of the primary outcomes were included. Changes in PA levels were also of interest (i.e., daily step count, distance walked, stairs climbed, Moderate to Vigorous PA [MVPA], MET [Metabolic Equivalent of Tasks], sedentary minutes, peak oxygen uptake and energy expenditure), but studies reporting these were only included if they also reported weight outcomes. Additionally, as weight management programmes' attrition rates were to be examined, studies had to report these to be included. A summary of the inclusion and exclusion criteria is provided in Table 2.1 below.

Table 2.1. *A summary of the scoping review's inclusion and exclusion criteria*

Criteria	Inclusion	Exclusion
Design	• Primary research involving weight management interventions utilising FTs • RCTs and non-RCTs (providing that there was a control condition) • Weight reported as the primary study outcome	• Grey literature articles • Review articles • Studies with no control condition • Non-English studies
Participants	• Obese and overweight adults attending structured weight management interventions	• Participants under 18 years old • Pregnant women • People with certain debilitating conditions
Setting	• Community and research • Face-to-face • 1:1 or group format	• Studies reporting remote interventions only
FTs	• FTs utilised as part of the intervention in at least one of the study groups • Commercially available FTs enabling self-monitoring of PA behaviour, linked to an app/website platform	• FT used for assessment purposes only • Studies using only apps/websites for tracking fitness

Key. FT=Fitness Trackers; RCT=Randomised Controlled Trail

2.2.3 Screening and selection process

Duplicates were removed, and study titles and abstracts (n=824) were examined. After the elimination of articles that were not suitable, full texts were retrieved (n=29) and thoroughly examined. A list of articles included in the review was finalised (n=7). See Figure 2.1.

The data extraction was piloted to map out all the essential information and to design the extraction table. The supervisory team members reviewed this, and the final layout was decided. The extraction table summarised the study's goals, methods, participants, interventions, outcomes, and limitations. The table was subsequently populated following a thorough examination of each paper. The appraisal of the papers and the review of the data extraction table were conducted by supervisors, their feedback was incorporated, and the table was finalised (Table 2.2).

The ‘Effective Public Health Practice Project Quality Assessment Tool’ (EPHPP) was utilised to assess the quality of the studies in the current review (Thomas et al., 2004). This tool was selected as it enabled the assessment of various types of research designs (e.g., RCTs and non-RCTs). It was also relatively easy to use and appropriate for studies published in the Public Health domain. This quality assessment tool was also suitable for reviews assessing intervention effectiveness (Armijo-Olivo et al., 2012). EPHPP has six components: selection bias, the study design and randomisation, confounders, blinding, data collection methods and withdrawals and drop-outs. The potential outcomes in these areas were weak, moderate, and strong. The tool enabled the calculation of a global rating based on the individual components. The dictionary for the EPHPP was used in conjunction with the tool. The researcher and the supervisors conducted the quality assessment exercise independently. Results were subsequently discussed, and a different supervisor looked at any discrepancies. The quality assessment results are displayed in Table 2.3.

2.2.4 Data analysis

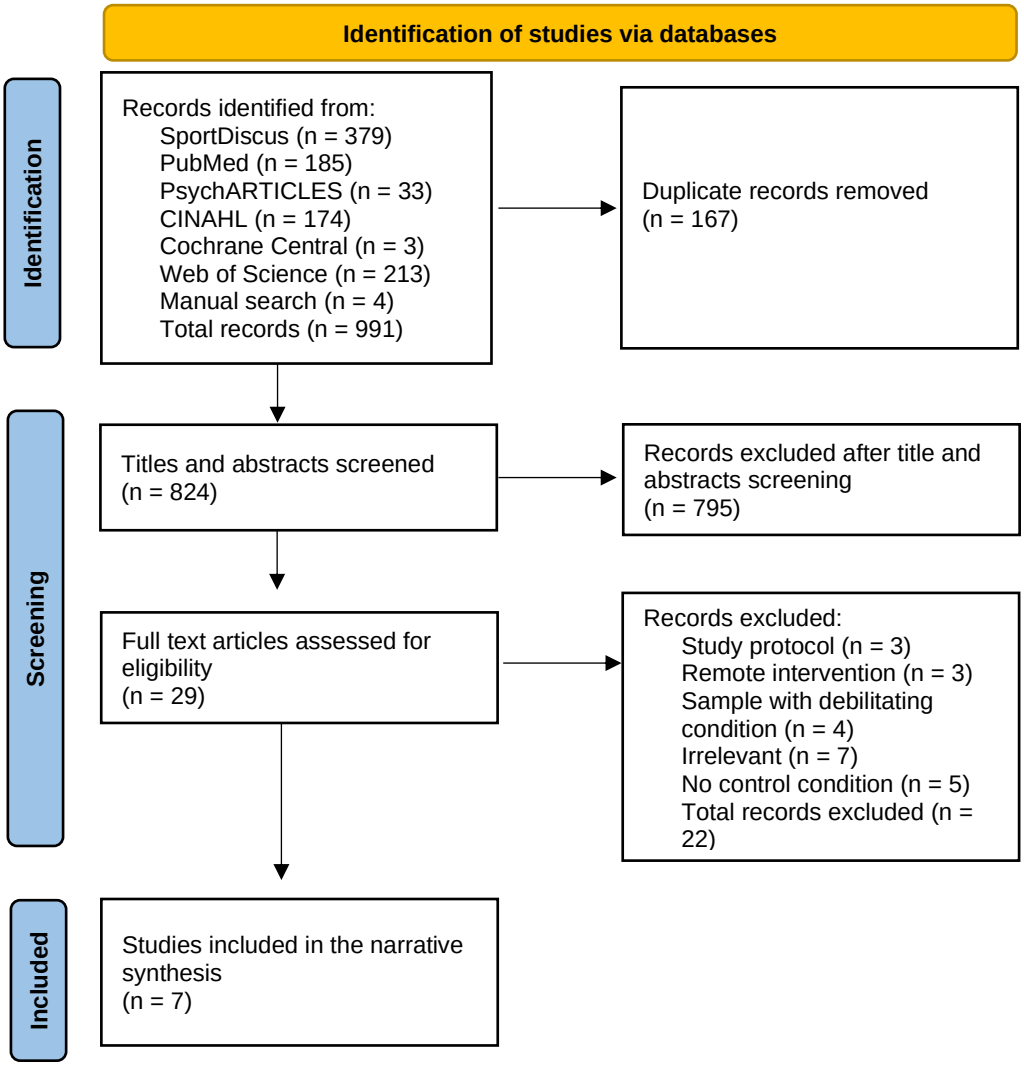
Meta-analysis was not conducted as it was thought to be an inappropriate method for this review. The reasons for this included the heterogeneity of studies (e.g., not all studies being classified as RCTs), the majority being pilot studies (hence a small sample size) and broad variation in protocols – for example, study designs, participant samples and additional elements such as financial incentives. Instead, the review results are presented using the narrative synthesis approach.

2.3 Results

2.3.1 Search results

The search process and results are illustrated in Figure 2.1 below.

Figure 2.1. *A PRISMA flow chart including searches of databases and the process of study identification*



2.3.2 Included studies

Seven studies met the inclusion criteria. Five studies were conducted in the USA (Bender et al., 2017; Jakicic et al., 2016; Kozey Keadle et al., 2014; Peyer et al., 2017 and Rogers et al., 2016), one in Canada (Ashe et al., 2015) and one in South Korea (Shin et al., 2017). A summary of these studies and the main findings are included in Table 2.2. For the remainder of this chapter, studies will be referred to by the number allocated to them in Table 2.2.

Table 2.2. *Summary of studies included in the scoping review*

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
1. Ashe et al. (2015); Canada	• Testing study feasibility and determining the effect of the EASY (Everyday Activity Supports You) model on physical activity (PA), sedentary behaviour, and health-related outcomes • RCT pilot • Community setting	• N=25 • Healthy, inactive, community-dwelling overweight/obese women at retirement age • 100% female • Age range: 55–70 (mean age 64.1, SD= 4.6 years) • BMI: 26.9 (SD=6.8) in Group 1, 32.9 (SD=6.8) in Group 2 • Participants had a median of 2 comorbidities (assessed by the Functional Comorbidity Index) • All participants completed secondary school; some also completed further education • 30% were employed • Ethnicity breakdown not provided • Participants were recruited between May 2013 and December 2013 through advertisements in local community newspapers, posters in local libraries and emails sent to relevant groups	• Intervention length: 6 months • The intervention consisted of 4 weekly education group sessions followed by 5 monthly ones in Group 1; participants in Group 2 only met monthly for 6 months; assessments done at baseline, 3 and 6 months • **Group 1 (N=13)**: The intervention group consisting of education and social support, individualised PA prescription (called Activity 4-1-1), and use of a FT, 10 transit tickets also provided to encourage the use of public transportation • **Group 2 (N=12)**: The control group - provided with health-related information only, receiving a $20 gift certificate at 1 and 4 months	• Fitbit One (Fitbit Inc., San Francisco, CA); immediate feedback on activities provided (daily step counts, distance walked, and stairs climbed); an online tool to monitor sleep and nutrition and facilitate social networking and/or friendly competitions • Participants not required to share Fitbit data with the research team • ActiGraph GT3X+ accelerometer, Pensacola, FL; worn on the hip for 7 days (at baseline, 3 and 6 months) to assess activity patterns, i.e., moderate to vigorous PA (MVPA), steps and sedentary behaviours	• Weight • Blood pressure • PA patterns (daily step count, distance walked, stairs climbed, Moderate to Vigorous PA [MVPA] and sedentary minutes) • Psychosocial variables (social connectedness, self-rated health, self-efficacy, and intentions for PA)	• Weight loss at 3 months: - 1.76 kg in Group 1 - 0.13 kg in Group 2 • Weight change at 6 months: - 2.36 kg in Group 1 + 1.41 kg in Group 2 • An average between-group difference in weight loss of −4.3 kg (p<.001) in favour of Group 1 at 6 months • A between-group difference in diastolic blood pressure, a reduction of −8.54 mmHg (p<.05), in favour of Group 1 • A significant group difference in step count; Group 1 had, on average 2,080 steps more than Group 2 at the final assessment (p<.05) • At the 3- and 6-month follow-up, Group 1 participants increased their daily step counts and MVPA and decreased sedentary time; there was a larger increase at 3 months compared with 6 months • Group 2 decreased step counts and MVPA over the 6 months and increased sitting time • No significant differences between groups for other variables except unadjusted behavioural intentions for PA, where there was a 0.82 difference in favour of Group 1 (p<.05), meaning that they had greater intentions to perform PA • The attrition rate was 20% (8% in Group 1 and 23% in Group 2) at 6 months • Session attendance was 10 (median) for Group 1 and 6.5 for Group 2 • The study supports the feasibility of using Fitbit and online resources to support women to be more active	• Small sample size • No formal sample size calculation • Limited recruitment time (3 weeks), which limited the number of participants recruited • Groups slightly different at baseline (weight, BMI, and step count) in favour of Group 1 • Differences in outcomes reported at 6 months may not be present in a scaled-up version of the intervention • Differences are likely conservative due to the lower number of control participants

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
2. Bender et al. (2017); USA	• Assessing feasibility and efficacy of a culturally adapted mHealth weight loss lifestyle intervention (Pilipino [i.e., Filipino] Americans Go4Health [PilAm Go4Health]) promoting PA and healthy eating to reduce subsequent CVD risks • RCT pilot • Research office setting with recruitment and study administration delivered as part of the community health worker model	• N=45 • Obese Filipino Americans, mainly immigrants • 62% female • Age range not provided (mean age 58, SD=10 years) • BMI: 30.1 (SD=4.6) • All participants had type 2 diabetes • 80% were college-educated, and 20% completed graduate school • 69% were employed • 100% Asian (Filipino) • Participants recruited between December 2014 and December 2015 from the San Francisco Bay Area through word of mouth, community events, snowball methods, using Facebook and paid local ads	• Intervention length: 6 months (3 months intervention and 3-month follow-up period for Group 1; 3 months waitlist and 3-month intervention for Group 2) • PilAm Go4Health incorporated a FT, mobile app with a diary for health behaviour tracking (steps, food/calories, and weight) and social media (Facebook) for virtual social support • 7 in-person monthly visits in both groups but scheduled in a different order (individual sessions, family members attending some sessions); assessments done at baseline, 3 and 6 months • **Group 1 (N=22):** received the PilAm Go4Health in phase 1 followed by a 3-month follow-up maintenance phase • **Group 2 (N=23):** Control/waitlist in Phase 1 and PilAm Go4Health intervention in Phase 2	• Fitbit Zip (Fitbit San Francisco, USA) used to self-monitor real-time PA steps; an associated app with a diary used to self-report daily food/calorie intake and weekly weight • The device used during the intervention and the waitlist/follow-up period	• Weight and % weight • BMI • Waist circumference • Blood glucose • Dietary intake • Steps (measured continuously via the Fitbit)	• Weight loss at 3 months: - 2.1 kg in Group 1 - 0.12 kg in Group 2 • Weight loss at 6 months: - 1.8 kg in Group 1 - 2.4 kg in Group 2 • Group 1 and Group 2 had significantly greater weight loss (p value not specified), *d*=.53 and .37, respectively, compared with the non-intervention group • 18% of Group 1 achieved a 5% weight loss in phase 1; 82% maintained or lost 2% to 5% of the weight and maintained this weight loss in the 3-month follow-up • In Phase 1, over 83% of Group 2 maintained or gained 2% to 5% more weight; a reversal of his pattern was seen in Phase 2, with 70% of Group 2 receiving PilAm Go4Health having maintained or lost between 2% and 5% of their weight; 30% of Group 2 achieved the 5% weight loss goal in phase 2, almost twice that of phase 1 in Group 1 (chi-square, *p*<.001 in each phase) • Waist circumference and BMI improved when each arm received the PilAm Go4Health, blood glucose outcomes were non-significant • Overall step counts significantly increased for each group that received the PilAm Go4Health compared with the non-intervention group (statistically significant [*p* value not specified], *d*=1.74 and 1.44, respectively) • 0% attrition rate at 6 months in both groups (everyone completed the study) • Near-perfect attendance at all 7 sessions (95% in Group 1 and 100% in Group 2) • Technology-enhanced, culturally adapted lifestyle intervention was feasible and potentially efficacious in weight reduction in this population	• Small sample size; mainly highly educated immigrants from the specific geographic area, limiting the internal validity and generalisability • During Phase 1, the waitlist group self-monitored PA steps using the Fitbit app; this prior PA tracking behaviour may have contributed to the greater number of waitlist participants achieving the 5% weight loss goal in Phase 2 compared with the intervention Group • Short intervention duration, potentially influencing participants' ability to achieve 5% weight loss • Study limited to English-literate participants who owned smartphones with Internet access

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
3. Jakicic et al. (2016); USA	• Testing the change in weight between two groups and testing the hypothesis that, compared with a standard behavioural weight loss intervention, a technology-enhanced intervention would result in greater weight loss • RCT • Research setting (the University of Pittsburgh)	• N=470 • Overweight/obese adults • 77.2% female • Age range: 18-35 (median age 31) • BMI: 31.2 (range 25-40) • 2.7% had depressive symptoms, no other health conditions were reported • 24.9% completed high school, and 75.1% were college-educated or higher • 90.2% were employed • 71.1% White • Participants recruited between October 2010 and October 2012, data collection completed by December 2014; all recruited using direct mail, mass media advertisements, or referrals from clinical research registries	• Intervention length: 24-months • Both groups received a behavioural weight loss intervention for 6 months (low-calorie diet, prescribed PA and group counselling sessions); subsequently, both groups received different interventions until month 24 (phone support, text messaging and website access added to both groups and participants randomised to Group 1 or Group 2) • Weekly group sessions were delivered (first 6 months), then monthly between months 7 and 24, with assessments at 6-month intervals (0, 6, 12, 18 and 24 months); participants received $100 for completing each of the assessments • **Group 1 (N=233):** Standard intervention using the website to self-monitor diet and PA as well as text messaging prompts • **Group 2 (N=237):** Enhanced intervention, FTs (191 participants used devices) and access to the accompanying website and educational materials (not for self-monitoring purposes)	• Commercially available FT (not specified) that included a web-based interface (BodyMedia Fit, Pittsburgh, PA) • This multi-sensor device worn on the upper arm provided feedback to the participant on energy expenditure and PA through a small display or web-based software developed by the manufacturer	• Weight and % weight • Body composition (fat mass, lean mass, % body fat, tissue % body fat, Bone mass) • PA (METs and MVPA) • Cardiorespiratory fitness • Dietary intake	• Weight loss at 6 months (ns): -8.6 kg in Group 1 -8 kg in Group 2 • Weight loss at 12 months (p<.05): -8.3 kg in Group 1 -6.7 kg in Group 2 • Weight loss at 18 months (p<.05): -7.3 kg in Group 1 -5.4 kg in Group 2 • Weight loss at 24 months (p<.01): -5.9 kg in Group 1 -3.5 kg in Group 2 • % weight loss was significantly greater in Group 1 compared to Group 2 at 12, 18 and 24 months (p<.01) • Both groups improved their body composition, PA and diet but no significant differences between groups were found • 25.5% attrition rate at 24 months (27.5% in Group 1 and 23.6% in Group 2) • Session attendance rate not provided • A programme with FTs did not offer any advantage over the standard intervention	• Study sample restricted to young adults, results cannot be generalized to other ages • Absence of 'a no treatment' control condition • The FT device worn on the upper arm, potentially not reflecting the effectiveness of more contemporary, wrist-worn FTs • The use of FT was not initiated at the onset of the intervention, potentially influencing how the participants adopted and utilised them • Assessment staff aware that participants were engaged in a weight-loss study, potentially introducing additional bias

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
4. Kozey Keadle et al. (2014); USA	• Examining whether the combination of exercise training and reducing sedentary time can result in greater changes to health markers than either intervention alone • A clinical trial pilot study (not randomised as control participants were able to re-enrol), no further RCT was conducted • Research setting/ University	• N=58, 68 randomised (after the initial 12 weeks in the control group, these participants were randomised into other conditions and were therefore counted twice) • Overweight/obese adults • 67% female • Age range: 20–60 (mean age 43.6, SD=9.9 years) • BMI: 35.1 (SD=4.6) • All participants were non-exercising and at risk of CVD; comorbidities were not provided but those with conditions preventing exercise were excluded • Education level not reported • All employed in an inactive/sedentary occupation • Ethnicity breakdown not provided • Participants recruited between March 2010 to May 2011 from Amherst, Massachusetts, USA, through fliers and emails to the campus community	• Intervention length: 12 weeks • Group 1 & 3: 1:1 exercise session 5 days a week for 12 weeks; Group 2: had weekly meetings with researchers to discuss successful strategies, barriers, challenging times and how to overcome them; Group 4: no structured sessions, participants asked to maintain their current activity levels; assessments done at baseline 3, 6, 9, and 12 weeks • **Group 1 (N=20):** exercised using gym equipment; sessions supervised and PA monitored using Polar heart monitor • **Group 2 (N=18):** strategies to increase non-exercise PA and decrease sedentary time provided (to encourage self-monitoring of behaviour, they wore Omron device daily), targets and progress reviewed weekly with researchers • **Group 3 (N=20):** a combination of the two groups described above • **Group 4 (N=10):** Control group participants asked to maintain their current level of PA for the 12-week study period, PA measurements completed in line with other groups	• Omron device (HJ720-ITC, Healthcare, Bannockburn, Ill., USA) used daily to facilitate compliance and encourage self-monitoring of behaviour (measuring steps only) • ActivPAL activity monitor worn on the mid-right thigh used by all participants for 7 days at baseline and weeks 3, 6, 9, and 12 • HR; Polar RS400, Polar, USA was also used to monitor heart rate during exercise	• Weight • BMI • Total % fat & fat mass • Blood pressure • Fasting lipids • Systolic and Diastolic blood pressure • Peak oxygen uptake • 2-h oral glucose tolerance • Dietary intake	• Weight loss at 12 weeks: -2.3 kg in Group 1 (p<.01) 0 kg in Group 2 -3.4 kg in Group 3 (p<.01) -0.4 kg in Group 4 (ns) The differences between groups were not significant • Significant reductions in % BMI seen only in Groups 1 and 3 (2.2% and 3.3% respectively, both at p<.01); between-group differences non-significant • Insulin concentration significantly decreased in Group 3 only (p<.01) • Groups 2 and 3 decreased sedentary time by 7% and 10%, respectively (p<. 05), no significant differences between the groups present • Systolic Blood pressure decreased in all intervention groups except Group 4 (all at p<.05) • Diastolic Blood pressure decreased only in Group 2 (p<.05) • Groups 1 and 3 improved peak oxygen uptake (p<.01) • 21% attrition rate (54/68 completed the study) at 3 months (20% in group 1, 22% in group 2, 20% in group 3 and 20% in group 4) • Participants completed over 99% of exercise sessions (Groups 1 & 3) • Exercising and reducing sitting time may result in improvements in metabolic biomarkers that are not seen with exercise alone	• The sample size small, potentially underpowered for detecting between-group differences in metabolic outcomes • The measure of diet used a 24-hour recall method, which is associated with recall errors • Possibly, variations in the menstrual cycle were present that may have affected the metabolic outcomes for the females

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
5. Peyer et al. (2017); USA	• Comparing the effectiveness of a FT, a guided weight loss programme and the combination of these approaches on weight loss and metabolic risk • A randomised pilot study • The study setting was not specified, but likely to be a research setting/ University	• N=89; 78 completed the study; 53 participants returned for follow-up measurements • Adults with obesity • 59% female • Age range: 18–72 (mean age 38.6, SD=14.6 years) • BMI: 36.7 (SD=5.5) • 24% met the criteria of metabolic syndrome • Well-educated (69% with ≥4-year degree) • Employment information not provided • 94% White • Participants recruited between Autumn 2010 and Spring 2011 through advertisements in newspapers and radio, posted flyers and word of mouth	• Intervention length: 8 weeks • Weekly 1:1 contact with coaches for 8 weeks; assessments conducted at baseline, 8 weeks (i.e., end of intervention) and 4 months after the intervention ended • **Group 1 (N=31):** Guided weight loss programme (structured 1:1 weekly meetings with the health coach) • **Group 2 (N=29):** FT provision (weekly meetings with coaches solely focused on addressing technical issues) • **Group 3 (N=29):** a combination of the two groups above	• SenseWear® armband, Jawbone (San Francisco, CA, USA) and associated online weight management system designed for self-monitoring applications • Worn on the back of the left triceps, used daily and provided with a wristwatch displaying real-time minutes of PA, calories and steps	• Weight • Metabolic risk (computed from waist circumference BMI, blood pressure and lipids)	• Weight loss at 8 weeks: -3.69 kg in Group 1 -4.05 kg in Group 2 -4.88 kg in Group 3 • Weight loss at 4 months: -3.94 kg in Group 1 -5.2 kg in Group 2 -5.57 kg in Group 3 The reductions in weight significant at 8 weeks in all 3 groups (p<.001) but not at 4 months; Group 3 lost the most weight but there were no group differences at 8 weeks or 4 months • All groups showed significant improvements over time when clustered together (weight: −4.16kg [p<.001], BMI: −1.37 [p<.001], waist circumference: −4.25cm [p<.001], body fat: −0.96% [p<.001]) • Group 3 had significantly larger changes in metabolic risk score than other groups (p<.05) • 12% attrition rate during intervention (16% in Group 1, 10% in Group 2 and 10% in Group 3) • Participants dropping out were significantly younger and had lower body fat than the completers (data not provided) • The use of FTs yielded improvements in weight and metabolic risk that were similar to those achieved through a standard guided weight loss programme; however, the combination of FTs with the guided weight loss programme resulted in significantly larger reductions in metabolic syndrome score than either approach alone	• A small, relatively homogeneous sample consisting of generally well-educated, White adults • The need to recruit participants in two waves may have influenced the outcomes • The lack of an actual control group

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
6. Rogers et al. (2016); USA	• Comparing an in-person, group-based behavioural weight loss intervention with technology-based interventions, participants randomised to one of three groups • RCT • The study setting was not specified, but likely to be a research setting/ University	• N=39 • Adults with obesity • 79% female • Age range: 21-55 (mean age 39.9, SD=11.5 years) • BMI: 39.5 (SD=2.8) • Comorbidities not provided, but those with some conditions (e.g., preventing exercise, chronic diseases or medicated psychological conditions) were excluded • Education information not provided • Employment information not provided • 71.8% White • Recruitment took place between February 2012 and July 2013; participants were recruited from respondents to the advertisement	• Intervention length: 6 months • Energy-restricted diet and PA prescribed in all groups • Weekly group sessions attended by Group 1 participants (Groups 2 and 3 had session content emailed to them weekly, complemented by monthly telephone sessions); assessments done at baseline, 3 and 6 months • **Group 1 (N=14):** control condition-standard behavioural weight loss including behavioural counselling, weekly weighing, self-monitoring of diet and written material • **Group 2 (N=12):** a technology-based intervention including FT and access to accompanying website to record and track information (participants had to transfer the data to a web-based portal using their computer) • **Group 3 (N=13):** an enhanced technology-based intervention, FT and Bluetooth capability to automatically transfer data to a smartphone application (which also allowed for self-monitoring of dietary behaviours and self-report of body weight)	• Jawbone-Body Media FIT system with the LINK activity monitor worn on the upper arm • No real-time feedback was provided on the device (only available through the app); the device worn throughout the intervention	• Weight • Body Mass • Body composition • BMI • Waist circumference • PA (energy expenditure) • Dietary intake and eating behaviours measuring self-monitoring, shopping practices and emotional eating	• Weight loss at 3 months: -3.39 kg in Group 1 -5.06 kg in Group 2 -4.76 kg in Group 3 • Weight loss at 6 months: -6.57 kg in Group 1 -5.18 kg in Group 2 -6.25 kg in Group 3 All changes in weight across time were significant (p<.001), no significant differences between groups • A similar pattern for change in BMI, waist circumference and % body fat (all at p<.001) • A decrease in total energy intake (p<.001) and per cent dietary intake (p<.05) across time • PA (energy expenditure) increased across the 6-month intervention (p<.001) • An increase in eating behaviour inventory scores (p<.001) indicating improvement in successful weight management strategies • 13% attrition rate at 3 months (7% in Group 1, 0% in Group 2 and 31% in Group 3) and 31% at 6 months (29% in Group 1, 25% in Group 2 and 38% in Group 3) • Group 1 completed 74% (SD=26.8%) of intervention contacts; Group 2 completed 83.3% (SD=22.5%) of the telephone calls compared with 62.8% (SD=34.1%) of the telephone calls in Group 3 • Findings provide initial information on the use of technology-based interventions that include FTs combined with brief monthly telephone calls for weight loss in adults with obesity • FTs providing feedback on PA or energy expenditure may provide an additional intervention option	• Small sample size limiting the ability to make definitive conclusions • Limited statistical power to determine with certainty that the weight loss achieved was not different between the intervention group • The participants may not reflect the demographic characteristics of the general population seeking weight loss treatment • Participants had to have access to a computer, the Internet and a compatible mobile device, which may have impacted the findings

Study	Aim, design and setting	Sample	Interventions and study groups	Fitness Tracker (FT) device	Outcome measures	Results, outcomes and comments	Limitations
7. Shin et al. (2017); South Korea	• Assessing the feasibility and effectiveness of an intervention combining Smartcare (FT with a smartphone application) and financial incentives • RCT pilot • The study setting was not specified, but likely to be a research setting/ University	• N=105 • Overweight and obese university students • 100% male • Age range: 19-45 (mean age 27.8, SD=5 years) • BMI: 29.8 (SD=2.7) • Comorbidities not provided • All participants were current higher education students (27.6% undergraduate, 58.1% Master level and 14.3% PhD) • Full-time students (not employed) • Ethnicity breakdown not provided but likely to be 100% South Korean • The recruitment took place between June and July 2015 at Seoul National University	• Intervention length: 12 weeks • Each participant received a 1:1 education session from a trained nurse for 5 minutes per session (4 pre-specified appointments during the study period); diet, exercise, and PA education materials were provided to all participants; assessments done at baseline and 4, 8, and 12 weeks • **Group 1 (N=35):** Traditional education • **Group 2 (N=35):** Traditional education and Smartcare (FT with a smartphone app) • **Group 3 (N=35):** Traditional education, smartcare and financial incentives (received depending on the achievement of daily PA goals and weight loss targets	• Fitmeter accelerometer (Fit.LifeTM, Suwon, Korea) used to monitor PA, calories and exercise; the device did not have a display to show feedback; this was available through the associated website and app	• Weight • Weight loss goals achieved (3%, 5%, and 7%) • BMI • Waist circumference • Muscle and fat mass • Blood pressure • Fasting glucose • Cholesterol • PA (energy expenditure) • Dietary intake	• Weight loss at 12 weeks: -0.4 kg in Group 1 -1.1 kg in Group 2 -3.1 kg in Group 3 (significantly greater when compared with Groups 1 & 2, p<.01) • The final weight loss goal was achieved by 0, 2, and 10 participants in Groups 1, 2 and 3, respectively • Reductions in BMI (p<.01 and p<.05) and waist circumference (p<.01) were higher in Group 3 relative to Groups 1 and 2 • No significant changes seen in anthropometric measurements between Groups 1 and 2 • Levels of PA were significantly higher in group 3 (relative to Groups 1 and 2, p<.01) • 7% attrition rate (9% in Group 1, 3% in Group 2 and 9% in Group 3) • The results provide promise for implementing non-surgical or non-pharmacological interventions focused on lifestyle modification	• Small sample size, as this was a pilot study • The selected population of male university students, not including female participants, made results harder to generalise

Key. PA=Physical Activity; RCT=Randomised Controlled Trial; FT=Fitness Tracker; BMI=Body Mass Index; MVPA= Moderate to Vigorous Physical Activity

2.3.3 Quality assessment

The results of the quality assessment exercise are shown in Table 2.3.

Table 2.3. *The summary of quality assessment ratings for the seven studies included in the review*

	Study	Selection Bias	Study Design	Confounders	Blinding	Data collection methods	Withdrawal & Dropouts	Global Rating
1.	**Ashe et al., 2015**	weak	strong	weak	moderate	weak	moderate	weak
2.	**Bender et al., 2017**	weak	strong	weak	weak	strong	strong	weak
3.	**Jakicic et al., 2016**	weak	strong	moderate	moderate	weak	moderate	weak
4.	**Kozey Keadle et al., 2014**	moderate	moderate	weak	weak	strong	moderate	weak
5.	**Peyer et al., 2017**	moderate	strong	weak	weak	strong	weak	weak
6.	**Rogers et al., 2016**	weak	strong	strong	weak	strong	moderate	weak
7.	**Shin et al., 2017**	weak	strong	strong	weak	strong	strong	weak

All studies received a global rating of 'weak' as, according to the EPHPP tool, studies with two or more components classified as weak have to receive the same global rating. The selection bias component assessed whether participants

were likely to be representative of the target population and whether they agreed to participate in the study. As seen above, ratings ranged between weak and moderate, mainly due to the representation issue (studies recruited limited populations, making it difficult for the results to be generalised). The second component looked at the way the study was designed and whether participants were randomised to study conditions. Most studies received a strong rating here as they were either RCTs or randomised studies, except for study 4, where participants from the control condition were allocated to other conditions following their initial intervention period. Another quality component assessed confounders, such as the differences between groups prior to the intervention. Ratings here ranged from weak to strong as some studies had important differences between groups (e.g., weight or PA) before the intervention started.

The blinding component looked at the assessors' awareness of the intervention status of participants and whether participants were aware of the research question. Ratings varied between weak and moderate, as in most cases, assessors were aware of which condition participants were allocated to. This would have been hard to avoid as wearing FTs makes participants stand out from those who do not. Regarding the data collection methods, most studies were assessed using valid and reliable measures (e.g., objective measures such as weight loss or using a validated questionnaire). The final component (withdrawals and drop-outs) looked at the number of participants dropping out, the reasons behind this, and the percentage of participants completing the study. Ratings ranged from weak to strong as studies explained the reasons for participants' drop-outs to various degrees and met various thresholds of study completers.

This scoping review, while including studies rated as ‘weak’, highlighted the state of literature in 2018. It is important to note that the presence of weak studies in this review does not invalidate the overall review’s findings and allows for a comprehensive assessment of the available evidence at the time of writing, helping to provide a more balanced understanding of FTs used in weight management programmes.

2.3.4 Description of the studies

Five selected studies were described as pilot studies, and the remaining two (studies 3 and 6) were described as actual RCTs. While all studies tested differences in weight outcomes between study groups, three studies (1, 2 and 7) also aimed to test the feasibility of the described interventions. Six studies were thought to be delivered in a university setting (in some articles, this is firmly stated, while in others, it is inferred, e.g., in study 7, the setting is not explicitly stated, but the recruitment of participants takes place at the university campus) and one in a community setting (1).

All studies looked at weight management interventions, but these varied in duration between eight weeks and 24 months. Participants were required to attend a different number of sessions ranging from four (7) to 60 (4), and in some studies, face-to-face attendance was only required in certain study conditions. Four studies offered sessions in a one-to-one format (2, 4, 5 and 7), while three offered group sessions (1, 3 and 6). In terms of assessments, all studies had a baseline assessment followed by at least two other assessments (the majority at either 3 or 6 months). However, there was no pattern to this, as assessment intervals depended on the duration of interventions.

In summary, studies considered in this review were very heterogeneous; they varied in their design and delivered interventions, duration, format, and assessment intervals.

2.3.4.1 Sample information

Across all studies, there was a total of 831 participants taking part. The pilot studies had the smallest sample sizes, for instance, 25 participants (1), while the largest sample (n=470) was reported in an RCT study by Jakicic and colleagues (3). All study participants were overweight or obese, with an average BMI of 33.2 (average BMI ranging from 29.8 to 39.5). 61% of all participants were females. One study (1) recruited females exclusively, while another (7) recruited only males.

Two studies recruited solely participants representing non-White populations: South Korean students (7) and Filipino immigrants living in the USA (2). In study 3, 71.1% of the participants were classified as White. In study 5, this percentage was 94%, while in study 6, it was 71.8%. Two studies (1 and 4) did not provide any ethnicity breakdown.

The age range between all participants across seven studies was 18-72. The average age of participants was 43.3 years, with the youngest sample (mean age 27.8) reported in study 7, in a population of South Korean University students, while the oldest sample was reported in study 1, in a population of community-dwelling women who had a mean age of 64.1 years.

In studies that reported employment information, the percentage of employed participants ranged from 30% to 100%. Participants were generally well-educated in studies that reported the education breakdown (5/7). Most study participants were at increased risk of CVD due to their weight. It was reported that

participants in some studies had underlying health conditions: type 2 diabetes (2), 24% of the sample met the criteria of metabolic syndrome (5), 2.7% met the criteria of depressive symptoms (3), while a median of two comorbidities was reported in another study (1). No information about comorbidities was provided in other studies. Participants were recruited between March 2010 and December 2015, mainly utilising advertisements in different formats and by word of mouth.

In summary, studies varied in sample size and participants' ethnicity breakdowns. Age ranges were also varied, and while some studies used a mixture of different ages, other studies concentrated on either younger or older populations. Participants were mainly female and well-educated. The information regarding comorbidities was patchy, but most participants were at increased risk of CVD due to being overweight or obese.

2.3.4.2 Intervention groups

In study 1, researchers reported using an intervention condition that utilised FTs and a control condition with a different structure of sessions and an incentive payment. In study 2, two conditions were used where one group received an active intervention with FTs in the first phase while the control condition was on the waitlist; this was reversed in the second phase, which meant that both groups utilised FTs in different phases of the study. In study 3, participants in both study groups received the same intervention during the initial six months, and this was followed by the randomisation of participants to two groups where, subsequently, one received a standard intervention and the other an enhanced one with FTs. In study 4, there were four study conditions; the first one focused on supervised exercise, the second on the FTs use, strategies to increase PA and reduce

sedentary behaviour, the third one was the combination of these two groups, and the fourth group was a control condition where no intervention was applied.

In study 5, three intervention groups were examined. The first group received the guided weight intervention programme. Participants in the second group utilised FTs on top of the guided weight intervention, complemented by meetings with study coaches focusing mainly on providing technical support related to FTs. The third group was a combination of the first two groups. In study 6 (an RCT study), three groups were also utilised. Participants in the first group received a standard weight intervention involving face-to-face session attendance (authors called this group the control condition), while the other two groups received FTs. Group 2 (technology-based intervention) received access to an accompanying website to record and track information in addition to the FT, while group 3 (enhanced technology-based intervention) could transfer their data to a smartphone application. Participants in groups two and three had the session content emailed to them, and monthly telephone sessions complemented this.

In study 7, a similar set-up to study 6 was utilised, and participants in the first group received an intervention consisting of traditional education. Participants in the second group utilised FTs and the related smartphone app in addition to the traditional education, while participants in the third group also received financial incentives in addition to these components (traditional education, FTs and access to the smartphone app).

To summarise, intervention groups across studies were also very heterogeneous, and while each study had a condition with FTs and at least one

other comparison condition, no pattern of how intervention groups were set up was observed.

2.3.4.3 Fitness tracker devices

All FT devices were commercially available and varied considerably between the studies in terms of their functions. The devices manufactured by Fitbit (Fitbit One and Fitbit Zip) were utilised in two studies (1 and 2). Both FTs were clip-on devices that provided real-time feedback on the built-in screen to enable self-monitoring of various PA aspects. Both devices had an accompanying website and an app to enable users to view and record more detailed information (e.g., daily food/calorie intake and weekly weight). Another study (4) utilised a clip-on device (Omron HJ720-ITC) with a display screen providing participants with real-time feedback. Fitmeter FT device (Fit.Life TM) was used in another study (7); this device could be worn as a clip-on or wristband. This FT did not provide immediate feedback on the device; this was available through the associated website or the app.

The other three studies (3, 5 and 6) used devices worn on the upper arm. A commercially available FT device (brand not specified) was utilised in study 3. They were multi-sensor devices with a display screen to provide real-time energy expenditure and PA feedback. Additionally, a web-based interface was available to participants. The SenseWear armband by Jawbone was used in study 5. This device was worn on the back of the left triceps and displayed real-time feedback on a linked wristwatch. Additionally, the device was connected to an online weight management system. In study 6, a device by Jawbone was used; it was worn in the same place, but it was a different model (Body Media FIT system), which did

not have a display of real-time feedback. Participants were able to monitor their activity on the accompanying app.

Two studies (1 and 4), in addition to the FTs described above, also utilised research-grade devices to measure activity patterns at assessment points (usually worn for 7 days). As researchers used these for assessment purposes only (as opposed to enabling participants to self-monitor their PA), these are not described further in this review.

In summary, the devices utilised in the included studies varied considerably. While devices used across five studies (1-5) provided real-time feedback on the display screen, enabling immediate self-monitoring of PA-related metrics (and the additional option to view the data presented on the website and an app), two devices used in other studies (6 and 7) did not offer immediate feedback and instead, relied on an associated website and app to enable participants to monitor their activity. Most FTs were either clip-on devices or devices worn on the upper arm. The device utilised in study 7 was universal and could be worn as a clip-on or wristband.

2.3.5 Outcome measures

All studies reported weight in kg as the primary study outcome, and three studies (2, 3 and 7) also reported percentage weight loss. In the latter study, the results were only reported as numbers of participants achieving goal percentage weight loss. Participants' initial BMI was reported in all studies, but only five studies reported BMI as an outcome measure (2, 4, 5, 6 and 7). Most studies also reported PA outcomes, but these were reported in various formats. Some studies reported other physiological measures, for instance, glucose, blood pressure and

cholesterol, but again, there was no consistency in reporting these between studies (see Table 2.2 for the details). Five studies also reported dietary intake (2, 3, 4, 6 & 7). Attrition rates were reported directly or calculated based on available study results. Two studies (1 and 6) also measured psychological outcomes. Social connectedness, self-rated health, self-efficacy, and intentions for PA were looked at in study 1, while study 6 examined eating behaviours measuring self-monitoring, shopping practices and emotional eating. Other studies did not report psychological outcomes.

2.3.6 Overall results of studies

2.3.6.1 Weight outcomes

Study 1 reported more significant weight loss in the group of participants utilising FTs compared to the control condition at six months (-4.3 kg difference, $p < .001$). In this study, participants in the control condition (group 2) initially lost some weight (reduced from 90.2 kg at baseline to 90.1 kg at the 3-month follow-up) but subsequently gained it (91.6 kg at six months). As a result, control condition participants concluded the intervention with a higher weight (+1.4 kg) than when they started. Participants in group 1 (using FTs) decreased their weight from 69.7 kg at baseline to 67.9 kg at three months. This subsequently decreased to 67.3 kg at the 6-month follow-up (-2.4 kg). No significance levels were provided for the differences between time points (only the between-group difference *p* value was reported).

In study 2, both groups received an active intervention but at different stages. Group 1 received the intervention with FTs in the first three months, followed by the 3-month follow-up period. This was reversed in group 2, where participants were initially on the waitlist for three months, subsequently receiving

the 3-month intervention in phase two. Group 1 started with a baseline weight of 72.6 kg, which reduced to 70.5 kg at three months (-2.1 kg) and then increased slightly to 70.8 kg at six months (-1.8 kg from baseline and +0.3 kg from the end of the active intervention). In the second group, participants had a baseline weight of 78.8 kg, which reduced slightly to 78.6 kg (-0.2 kg) at the end of the waitlist period and then reduced to 76.4 kg (-2.4 kg from baseline and -2.2 kg since the start of the active intervention). This means that both groups receiving the active intervention (whether at phase 1 or 2) had significantly greater weight loss compared with the non-intervention group (the authors stated that the difference was statistically significant, but the *p*-value not specified, *d*=.53 and .37, respectively, compared with the non-intervention group).

Researchers in study 3 reported that their study participants in group 1 (attending the standard intervention without FTs) had a greater weight loss than those in group 2 (attending the standard intervention with FT) at 24 months. Participants in group 1 started with a mean weight of 95.2 kg at baseline, which decreased by -8.6, -8.3, -7.3 and -5.9 kg at 6, 12, 18 and 24 months, respectively. In group 2, on the other hand, participants had a mean baseline weight of 96.3 kg, which decreased by -8, -6.7, -5.4 and -3.5 kg at 6, 12, 18 and 24 months, respectively. The difference between groups was significant ($p < .01$) at 12, 18 and 24 months (not at 6 months). The intervention utilising FT technology (group 2) in this study was found to be less effective than the standard intervention (group 1). Study authors suggested that people utilising FTs were fixated on exercise goals and perhaps forgot to follow the diet advice. The authors also suggested that further investigation was needed and emphasised that since FT devices were introduced at the 6-month point (after the main behavioural change intervention),

this might have negatively influenced how the participants adopted and utilised them. Additionally, as devices were worn on the upper arm, the authors highlighted that they may not have reflected more contemporary devices.

Study 4 reported that the weight of participants decreased from the average weight of 97.7 to 95.4 kg (-2.3 kg) in group 1 (exercise-focused condition), stayed the same (101.2 kg) in group 2 (FTs and strategies provided to increase PA and reduce sedentary behaviour), decreased from the average of 100.1 to 96.7 kg (-3.4 kg) in group 3 (a group that combined approaches from group 1 & 2) and decreased from the average of 96.3 to 95.9 kg (-0.4 kg) in group 4 (control condition) at post-intervention (12 weeks). Therefore, the greatest weight loss was seen in group 3, where FT was combined with a structured exercise intervention. Only the differences in groups one and three were significant ($p < .01$). Differences between study groups did not reach statistical significance.

In study 5, there were no group differences for weight loss at the end of the 8-week intervention, but each group had a significant weight loss difference ($p < .001$) between baseline and the 8-week assessment point (weight loss was -3.7 kg, -4.1 kg, and -4.9 kg respectively). When all participants were clustered together, the weight reduction was −4.2 kg. The mean weight continued to decline modestly during follow-up, with an average weight loss of 4.8 kg from baseline for all participants at four months, broken down into 3.9 kg, 5.2 kg, and 5.6 kg for each group, respectively. Differences at four months were not significant. The third group (two interventions combined) had the greatest weight loss at eight weeks and four months, but as highlighted earlier, only the difference at eight weeks was significant.

Study 6 reported a weight loss of -3.4 kg, -5.1 kg, and -4.8 kg at three months (in groups 1, 2 and 3, respectively) and a weight loss of -6.6 kg, -5.2 kg and -6.3 kg across the same groups at six months. All changes in weight across time were significant ($p < .001$), but there were no significant differences between groups. The initial mean weight in group 1 decreased from 110.9 kg at baseline to 107.5 kg (-3.4 kg) and 104.4 kg (-3.1 kg) at three and six months, respectively. In group 2, the mean weight decreased from 112.2 kg at baseline to 107.2 (-5kg) and 107.1 kg (-0.1 kg) at three and six months, respectively and in the third group, the baseline mean weight of 111.6 kg decreased to 106.8 kg (-4.8 kg) and 105.3 kg (-1.5 kg) at three and six months respectively.

In study 7, the average weight loss in groups one, two and three was -0.4 kg, -1.1 kg, and -3.1 kg, respectively, with significantly greater ($p < .01$) weight loss in the third group (FTs with financial incentives) relative to that observed in groups one and two. The weight change difference between groups one and three (standard intervention versus smart care with FTs and financial incentives) was seen from the second appointment onward and was greater at the final appointment.

In summary, studies reported mixed results in terms of weight outcomes. In studies 1 and 2, weight loss was significantly greater in FT conditions. Similarly, in study 7, significant weight differences were observed in favour of the group where FT usage was coupled with financial incentives. In contrast, study 3 reported an opposite trend where significant differences were found but favouring the control condition (not the condition utilising FTs). Group differences were not significant in studies 4-6.

2.3.6.2 Physical activity outcomes

As highlighted earlier, PA outcomes were reported in different formats across the studies, for instance, steps, energy expenditure and moderate to vigorous PA (MVPAs). In the first study, steps and MVPA were reported, and it was found that group 1 (the intervention with FTs) had, on average, 2,080 more steps per day at six months than participants in group 2 (control group). This difference was significant ($p < .05$). MVPA increased at three and six months while sedentary time decreased in group 1 (with a more considerable increase at 3 months). A reversed trend was seen in group 2, where participants decreased both step counts and MVPA while sitting time increased over six months. However, these differences were not significant.

In study 2, improvements in step counts were observed in both intervention groups when the active intervention was received in phase one or two. Overall, step counts increased significantly for each group that received the PilAm Go4Health compared with the non-intervention group. The differences were reported as statistically significant, but the *p*-value was not specified ($d = 1.74$ and 1.44, respectively).

In study 3, the differences between intervention groups for PA (MVPA and sedentary time) were not significant. However, regardless of the study condition, there was a significant change in MVPA (an increase in 10-minute sessions of MVPA) and a reduction in sedentary time across 24 months ($p < .001$ for all).

In study 4, at 12 weeks, participants in group 1 (exercise condition) increased MVPA ($p<.05$). In group 2 (the group utilising FTs and sedentary time reduction strategies), there was an increase in MVPA and a reduction in sedentary

time by 7% ($p < .05$). Group 3 increased MVPA significantly ($p < .05$) and decreased sedentary time by 10.3% ($p < .05$). In group 4 (control group), sedentary time increased significantly by 6.5% ($p < .05$). All between-group differences were non-significant.

In study 5, PA was not reported, while in study 6, PA was reported as energy expenditure (calories per week) that significantly increased across the 6-month intervention ($p < .001$). Group 1 (the standard intervention) more than doubled the number of calories burnt per week between the baseline and the 3-month assessment (from 530.2 to 1294.9) and then increased it further to 1407.7 at the 6-month assessment. Group 2 (technology intervention incorporating FTs) increased calorie expenditure per week from 913.6 at baseline to 1135.2 at three months and then reduced it to 1048.7 at six months. The final group (an enhanced technology-based intervention with FTs and Bluetooth) more than doubled the same outcome measure from 444.5 to 1188.9 between the baseline and 3-month assessment and subsequently increased it to 1933.3 at six months. There were no significant differences between these three study conditions. The authors pointed out, however, that participants in study conditions utilising FTs (groups 2 and 3) monitored their PA more often than participants in group 1 (standard intervention), even though it did not result in greater changes in PA.

Lastly, in study 7, levels of PA were significantly higher in group 3, where smart care with FTs and incentives were utilised (relative to groups 1 and 2; $p < .01$). The PA (calorie expenditure per day) at 12 weeks increased by 76 in group 1 (traditional education group), by 43.5 in group 2 (smart care with FTs) and by 535.4 in group 3 (smart care, FTs and incentives).

In summary, most studies reported PA outcomes (6/7), but these were reported in different formats. In the first two studies, steps were reported, and these increased significantly in conditions utilising FTs. MVPA outcomes were reported in three studies (1, 3 and 4), and sedentary time was reported in two studies (3 and 4). While some differences in measurements across time were present, there were no differences in PA between the study groups. Studies 6 and 7 reported PA in calorie expenditure. While this measure increased significantly across time in study 6, there were no differences between study groups. In the final study, however, a significant difference in energy expenditure was reported favouring the study group (smart care and FTs), which also utilised financial incentives.

The studies presented above reported PA outcomes with varying measurement formats. While some changes were observed in PA over time, there were no significant differences in PA between the study groups in most cases. Only some studies (1, 2 and 7) reported significant PA differences between study groups.

2.3.6.3 Attrition rates

When reported attrition rates were examined, it was revealed that in some studies, attrition rates were lower in groups where FTs were utilised. The first study reported an 8% attrition rate in group 1 that utilised FTs and 23% in group 2 (standard intervention). Similarly, in the third study, the attrition rate in group 2 (utilising FTs) was 23.6%, while in group 1 (standard intervention), it was 27.5%. Study 5 also reported slightly lower attrition rates in conditions where FTs were utilised. A 10% attrition rate was seen in groups two and three, while in group 1 (standard intervention without FTs), the rate was 16%. Another study (6) reported

7% and 29% attrition rates in group 1 (standard intervention) at three and six months, respectively, while in group 2 (technology-based intervention utilising FTs), there were 0% and 25% attrition rates at the same assessment times. Interestingly, attrition rates were comparatively higher in the third study group (enhanced technology-based intervention utilising Bluetooth to transfer FT data automatically to an associated app). Similar patterns were seen in study 7, where group 1 (traditional education) had a 9% attrition rate, group 2 (smart care) had a 3% attrition rate, and group 3 (smart care with incentives) had an attrition rate of 9%.

In two other studies, attrition rates were very similar across conditions. Study 2 reported 5% attrition in group 1 (receiving FTs in phase 1) and 0% in the second group (receiving FTs in phase 2 following the waitlist period). Study 4, on the other hand, reported 20% attrition rates in group 1 (exercise), group 3 (exercise, sedentary time reduction and FTs) and group 4 (control group). In comparison, group 2 (sedentary time reduction and FTs) had a slightly higher attrition rate of 22%.

In summary, while some studies reported lower attrition rates in conditions with FTs (studies 1, 3 and 5), other studies (2 and 4) had similar attrition rates between conditions. In studies 6 and 7, where two study conditions utilised FTs, attrition rates were varied (the highest in the enhanced technology condition in study 6 and mixed in study 7, where the FT condition with financial incentives had higher attrition rates than the FT condition without incentives). It must be pointed out that it is difficult to compare those attrition rates as the duration of interventions, study conditions, and intervention delivery methods differed.

2.3.6.4 Other outcomes

As no universal pattern of reporting other measures was observed (blood pressure, BMI, waist circumference, dietary intake, blood glucose, lipids, body composition and peak oxygen uptake), no comparisons were made as not enough studies reported these. It is, however, essential to point out that in addition to reporting weight loss, PA, and anthropological measures (e.g., BMI and waist circumference), two studies (1 and 6) also reported psychological outcomes. In study 1, where social connectedness, self-rated health, self-efficacy, and intentions for PA were looked at, the only significant difference between groups was found in intentions to perform PA (in favour of group 1 utilising FTs; $p < .05$). Study 6 examined eating behaviours (measuring self-monitoring, shopping practices and emotional eating) but no differences between study conditions were identified. There was, however, an increase in eating behaviour inventory scores across time for all participants clustered together ($p < .001$), indicating an improvement in successful weight management strategies. Other studies did not report psychological outcomes.

2.3.7 Limitations of the studies

As studies in this review were mainly pilot studies (5/7), their sample size was small, highlighted as a limitation by almost all researchers. The third study was the only exception, as the number of participants in this RCT study was larger (n=470). However, the main limitation of this study was related to the sample being restricted to young adults, making results impossible to generalise to other age groups. The problem of generalisability was also highlighted by the authors of the second study, where mainly highly educated immigrants from a specific geographic area were recruited, making results hard to generalise to other groups and other

areas. Similarly, study 5 emphasised that a relatively homogenous sample of well-educated, White adults might make results difficult to generalise. Authors of study 6 also pointed out that their study participants might not have reflected the demographic characteristics of the general population seeking weight loss treatment. Authors of study 7 also highlighted this study limitation as their study recruited only male university students.

Authors of studies 2 and 6 also highlighted that their studies were limited to participants who owned smartphones with Internet access. While this was explicitly highlighted only in those two studies, it can be said that this applies to all reviewed studies. However, mitigating this issue in studies utilising FTs that rely on modern technology and internet access is difficult.

The authors of the first study stressed that their research had a limited recruitment period (3 weeks), which led to low participant numbers. Study 5 pointed out that recruiting participants in two waves may have influenced study outcomes as these cohorts started their interventions in two different seasons. The duration of interventions was also listed as a potential limitation; for instance, authors of the second study highlighted that their intervention (3 months and an additional waitlist/follow-up period of 3 months) could have influenced participants' ability to achieve 5% weight loss due to the short intervention duration.

Other limitations highlighted the design of the study conditions. Researchers in the third study flagged that they had no control condition (a group receiving no treatment). Similarly, the authors of study 5 listed having no control group as a study limitation. None of the studies offered a design solution where two groups would have received the same weight management intervention while one group

would have used FT on top of the standard intervention. It is believed that this solution would have made the comparisons of groups easier and enabled an actual assessment of the FTs' efficacy.

Regarding FTs, most studies used upper-arm worn or clip-on FT devices, and these might not accurately represent the efficacy of more modern devices worn on the wrist (Jakicic et al., 2016). Authors of study 3 pointed out that the device used in their study did not potentially reflect the effectiveness of more modern, wrist-worn FT devices. As devices were generally cumbersome, this could have led participants to experience barriers to wearing them.

2.4 Discussion

This scoping review aimed to answer the main review question, ‘How effective are FTs when used as part of a weight management programme for overweight and obese people?’ The review also explored whether FTs lead to different weight management programme outcomes, e.g., weight loss, compared with the intervention as usual (control). Additionally, the review intended to investigate whether FTs affect participation rates of weight management interventions. Finally, the review aimed to provide a broader context for the current thesis.

2.4.1 Summary of findings

Studies considered in this scoping review were highly heterogeneous in many respects. Participant samples varied greatly in terms of age, ethnicity, and education/employment status. Since some studies were designed as pilots and others as RCTs, the numbers of participants across these also varied greatly. There were no common patterns regarding the intervention design, duration, and

assessment intervals. Aside from weight outcomes, PA and attrition rates, other measures were not reported across enough studies to enable comparisons between the studies. Only two studies reported psychological outcomes. Additionally, studies were mainly Western (North America), with only one study conducted in South Korea.

Across the studies, mixed results were reported regarding weight loss and PA outcomes, as well as attrition rates in relation to the use of FT. Three studies (1, 2 and 7) reported significantly greater weight loss outcomes in conditions utilising FTs than other groups. In three other studies (4, 5 and 6), while no significant differences in weight outcomes between the study groups were found, the direction of the results was in line with the other studies (the interventions that included FT tended to report more prominent weight loss in comparison to other interventions). One study (3) reported an opposite trend where significant differences were found but favouring the control condition (the condition without FTs).

These trends are broadly in line with the results presented by Cheatham and colleagues (2018). In their systematic review, 20 out of 25 studies reported more significant weight loss when FTs were used with the weight management intervention. The authors of this review also concluded that weight management interventions shorter than six months that utilise FTs might be more effective than programmes longer than six months. The current review presents similar results while looking at a more up-to-date evidence base – most studies with a duration shorter than six months had more prominent weight loss in conditions with FTs (but some were not significant).

Due to PA outcomes being reported in various formats (steps, MVPA, sedentary time or calorie expenditure), results were difficult to compare. Studies reporting steps as PA outcome (1 and 2) found significant differences between study conditions favouring those utilising FTs. Studies reporting MVPA (1, 3 and 4) and sedentary time (3 and 4) found no significant differences between study groups. One study (5) did not report any PA outcomes, while the latter two (6 and 7) used calorie expenditure as the PA outcome measure. There were no significant differences between the study groups in PA in study 6. In study 7, however, a significant difference in energy expenditure was reported favouring the FTs study group that also utilised financial incentives (when compared with the traditional education and FTs-only groups).

The inconsistency in PA reporting was also highlighted previously. For instance, Lewis and colleagues (2015) stressed that the heterogeneity in reporting PA makes it challenging to compare PA changes across studies. While this group of researchers concluded that FTs could increase PA and decrease weight (Lewis et al., 2015), other reviews concluded that adding FTs may not confer more favourable results (Sypes et al., 2019).

Reported attrition rates were also mixed. Some studies reported lower attrition rates in conditions with FTs (studies 1, 3 and 5). In other studies (2 and 4), attrition rates were fairly similar between conditions. In the other two studies (6 and 7), attrition rates were varied between conditions. Due to the various durations of studies and intervention delivery methods, comparing attrition rates was also difficult. In the studies considered in the current review, the attrition rates ranged from 0% to 38% (4 studies below 10% and 3 studies between 23.6% and 38%) in study conditions that utilised FTs. In Lewis and colleagues' (2015) review, 7 of 11

studies reported 20% or lower attrition rates. Another review (Cheatham et al., 2018) reported that attrition rates ranged from 2% to 32%.

2.4.2 Limitations of the review

One of the key limitations of this review is the heterogeneity of the included studies. As each study employed a different methodology, participants' samples, and various devices, no direct comparison nor a meta-analysis could have been conducted. Each study concentrated on a different age group of participants ranging from male students to women of retirement age. Due to this, direct comparisons between studies were difficult, while results cannot be generalised to wider populations. Apart from one study (7) where participants were male only, most were females. This can also be seen as a limitation, as studies cannot be generalised to both sexes. Similarly, except for two studies where participant cohorts consisted of non-White populations (2 and 7), the ethnicity breakdown in other studies was either unknown or the sample mainly consisted of White participants. Thus, results should be treated cautiously as they might not be generalisable to wider populations, including people from ethnic minority backgrounds.

Additionally, due to the time frame the papers were searched within, devices used in the studies were primitive (arm-worn/clip-on as opposed to a more modern wrist-worn device), and this could also have been seen as a limitation as more modern versions of FTs may be possibly more attractive and easier to use, and that in turn could lead to different results. Only two studies took into account psychological factors. Due to only English language publications being considered, the review was limited to a particular pool of evidence, perhaps omitting evidence

from non-English studies. Finally, all but one of the studies (7) were based in North America, and none were UK-based.

2.4.3 Implications for the thesis

Studies considered in this scoping review have provided a valuable context for the thesis, but several limitations were also highlighted in the review process. Due to the heterogeneity of the included studies, a direct comparison of results was not conducted, and instead, findings were presented in a narrative synthesis format describing observed trends. In summary, the results were mixed; three studies reported significantly greater weight loss in groups using FTs, and the other three reported the same trend, but it did not reach a significance level. Only one study out of seven reported greater weight loss in their control condition compared to the FT condition.

The attrition rates on programmes utilising FTs appeared to be lower in three studies or relatively equal to other conditions in two studies, while the remaining two reported varied attrition rates. All studies included in the review used study conditions that received different intervention components, making it hard to isolate the effect of FTs. The review highlighted the need to conduct a study designed in a format that allowed a direct comparison of groups that received the same intervention except for one group receiving the FT as an addition. A study design including a true control condition (with a standard weight management programme and no FT), such as the one proposed in this thesis, was believed to be more appropriate to assess the effect of FT devices and test whether they influence participants' outcomes. A need to conduct more research looking at psychological factors associated with FT usage and weight management programme outcomes was also identified.

The reviewed studies utilised female participants in a larger proportion; participants were mainly well-educated and largely came from White ethnic backgrounds. It was felt that studies considering participants from less-represented backgrounds were needed to build on the existing research.

FT devices used across the studies were considered dated as more modern wrist-worn devices became available in this rapidly evolving field of wearables. The review highlighted the need to undertake studies that utilised more modern FTs providing real-time feedback in an accessible format to enable self-monitoring of behaviours that can have an impact on weight management e.g., PA.

As none of the studies was based in the UK, it was felt that conducting research that investigates the use of FTs as part of the UK-specific weight management intervention was crucial to examine whether similar trends could be observed.

Overall, the results of these studies suggested that FTs may be effective in promoting weight loss. However, more research was needed to confirm these findings, determine the optimal usage of FTs for weight loss and examine which populations respond well to these devices. The results of this scoping review strengthened the argument for conducting the empirical study included in this thesis.

2.4.4 Scoping review search update

Since the initial search was conducted in February 2018 (retrieving articles published between 01/01/2013 and 31/01/2018), several studies on FTs in weight management have been published. A new search was conducted in July 2023 using the same search terms as before and applying 01/02/2018-30/06/2023

timeframes. PubMed, PsychArticles, CINAHL and CENTRAL via Cochrane Library were searched. Access to SPORTDiscus and Web of Science was no longer available.

A total of 657 articles were identified; 103 of these were duplicates. After their removal, titles and abstracts of the remaining articles (554) were screened, and 540 were excluded. Full texts of the remaining 14 articles were retrieved and assessed for eligibility. Subsequently, 12 studies were excluded. Reasons for excluding records were as follows: study protocols (2), interventions being digital (3), having no control condition (5), using a device for tracking bites (a wrist-worn device that detects food/beverage consumption) as opposed to PA (1) and focusing on FT use discontinuation (1). Two studies were identified as suitable to be included in a potential update of the scoping review (Clemes et al., 2022; Rosas et al., 2020). The first one was UK-based - Clemes and colleagues (2022) – and it reported a significant increase in daily steps taken by participants (truck drivers with a mean BMI of 30.4) utilising FTs when compared with the control group at six months (1008 steps per day more). Participants in the FT condition also spent significantly less time sitting (-24 minutes per day) and spent more time on MVPA (6 minutes per day) than those in the control condition. No significant differences in weight between conditions were observed but the authors highlighted that the utilised weight management programme should be revised to put a greater emphasis on diet.

In the second study, which was US-based, obese Latino adults at high risk of diabetes were focused upon (Rosas et al., 2020). The authors found that weight management intervention with FTs led to greater weight loss within 12 months compared with the control condition (-2.6 versus -0.3 kg). Weight did not

significantly differ between the two study groups at 24 months, suggesting that the intervention's effectiveness diminished over time.

It is also important to note that two key differences were observed when comparing the recent and original database searches. Firstly, the results of the second, more recent search included mainly digital weight management interventions, likely influenced by the pandemic-related restrictions on face-to-face group sessions in various countries. Secondly, there was a notable rise in the number of studies showcasing the implementation of Artificial Intelligence and Machine Learning techniques for analyzing FT data. These results highlight the emphasis on digital approaches for weight management and growing interest in advanced technologies for gaining insights from FT data.

In 2022, an extensive umbrella review (a review of systematic reviews and meta-analyses) of the effectiveness of FTs for increasing PA and affecting physiological outcomes (including weight) was published (Ferguson et al., 2022). In this large-scale review, 39 systematic reviews were analysed (with 26 reviews published since 2018), and the data from 163,992 participants were looked at, including all age groups and healthy and clinical populations. Ferguson and colleagues found that FTs were effective in increasing PA and, on average, led to reductions of 1 kg in body weight (2022).

2.4.5 Conclusions

This review provided important insight into the use of FTs as part of weight management interventions. While the results are encouraging and partially support the use of FTs to achieve better weight outcomes and potentially contribute to lower attrition rates, the review has identified some research gaps worth

addressing. In particular, a UK-based study was needed to look at more modern FT devices utilised by participants from less privileged backgrounds. It was believed that conducting such a study would add essential insights to the existing evidence base regarding FTs. The broader context provided by the review helped position the current study and prioritise areas highlighted as gaps and/or limitations in some of the studies. This scoping review has also highlighted the potential doctoral contribution of the current study. The next chapter provides a detailed description of the methodological steps utilised as part of this research.

Chapter 3 – Methodology

This chapter describes the methodological approach employed in the current research. The paradigm underpinning the study, namely the pragmatic paradigm, and the rationale for using a mixed methods approach to address the research objectives are outlined in the initial section of this chapter. The setting of the study – the Healthy Hearts (HH) weight management programme is subsequently presented, providing the rationale for using this particular intervention. The methods utilised in the quantitative phase of the research are discussed in the section that follows. These include the research design, sampling, materials, procedures, ethical considerations, data analysis, and statistical tests. The final section of the chapter presents the methods employed in the qualitative phase of the research, firstly in the study concentrating on the experience of service users, followed by the study looking at health professionals.

3.1 Main research paradigm

Creswell and Plano Clark (2011) describe paradigms as worldviews underpinned by philosophical assumptions. Paradigms can be viewed as "shared belief systems that influence the kinds of knowledge researchers seek and how they interpret the evidence they collect" (Morgan, 2007, p.50). Researchers conducting work in their field of inquiry bring their own assumptions and beliefs into their study, shaping their research (Creswell & Plano Clark, 2011). According to Creswell and Plano Clark (2011), paradigms have elements in common (ontology, epistemology, axiology, methodology and rhetoric), but each worldview takes a different stance regarding these elements, and these stances influence the way researchers deliver and report their research. Postpositivist, constructivist,

participatory and pragmatist worldviews are recognised as the main paradigms used in the social research field (Creswell & Plano Clark, 2011). The latter (pragmatist paradigm) has been adopted in the current research.

The pragmatist worldview is sometimes considered the 'third paradigm', bridging the gap between postpositivism and constructivism (Johnson et al., 2007). One of the assumptions of postpositivism is that there is an objective truth and that knowledge develops based on careful measurement and observation of reality (Creswell, 2014). Postpositivists also study the causes that influence outcomes (Creswell, 2014). Top-down postpositivism is based on deductive reasoning, which is compatible with quantitative research methods (Creswell & Plano Clark, 2011). On the other hand, constructivism assumes that individuals develop subjective meanings of experiences, which can be varied and multiple (Creswell, 2013). Bottom-up constructivism is associated with qualitative methods as it considers individuals' experiences (Creswell & Plano Clark, 2011). Postpositivist and constructivist paradigms have been previously seen as separate, un-bridgeable and incompatible (Creswell & Plano Clark, 2007). Pragmatism brings elements of both of these paradigms together in a unique way. As Creswell and Plano Clark stated, pragmatism frees the researcher of practical and mental constraints imposed by the 'forced choice dichotomy between postpositivism and constructivism' (2007, p.27).

The pragmatic worldview is seen as arising out of situations, actions and consequences and is often used as the philosophical theory underpinning mixed method designs that allow multiple methods of collecting and analysing data (Creswell, 2014). The way to acquire knowledge is through the combination of action and reflection within the pragmatist paradigm (Biesta, 2010), and it focuses

on the consequences of research and practice (Creswell & Plano Clark, 2011). Pragmatism allows quantitative and qualitative methods to be used in a single research (Creswell & Plano Clark, 2011), uniquely combining methods from both paradigms. Questions such as ‘what’ and ‘how’ can be asked as part of the qualitative enquiry to understand the subjective insights of participants, while questions related to ‘how many’ can be asked to measure variables objectively. Several authors embrace pragmatism as the paradigm for mixed research methods (Tashakkori & Teddlie, 2003).

3.1.1 Rationale for adopting a mixed methods design in the current research

Bryman (2016) highlighted that quantitative and qualitative methods could generate a complete answer to a research question. Mixed method approaches have many advantages and can compensate for each method’s limitations, i.e., not enough depth of quantitative methods or small sample sizes of qualitative designs (Creswell & Plano Clark, 2011). The current FT research utilised a real-life intervention and was practice-based. Due to this and the diversity of research objectives, mixed methods were considered the most appropriate approach.
It was also believed that the mixed method approach employed is in line with the updated Medical Research Council’s complex intervention development and evaluation framework, which underscores the significance of process evaluation. (Skivington et al., 2021). It was believed that quantitative and qualitative methods were necessary to understand the impact of FTs on the intervention outcomes, the relationship between variables of interest and participants’ experiences. The research objectives and the corresponding methodology employed to address them are presented in the next section.

3.1.2 Methodological approaches

The next part of this section outlines the methodological approaches employed to address Objectives 1-4. Since the scoping review was treated as a separate study and conducted to provide context for the main study, it was included in a dedicated chapter (2) and is not described in this section.

Objective 1

The main research objective was to assess the effectiveness of FTs when used in addition to the standard weight management intervention (HH). It explored whether FTs impacted upon weight management intervention outcomes in those at risk of CVD. It was of interest whether the intervention with FTs and the intervention as usual had different weight management intervention outcomes. A quantitative approach was used as it was considered the most appropriate to address this objective because the differences between groups were explored on a large scale over time; thus, quantitative instruments and FTs data were utilised to answer this research objective.

Objective 2

The second research objective was to assess the psychological factors associated with successful weight loss and test whether they differ across the study conditions (FTs versus control) over time. It assessed differences in key variables such as TPB, WLOC, Anxiety, Depression, Patient Activation levels and Motivation. It was of interest to examine whether these differ over time, and quantitative instruments were used to measure these variables.

Objective 3

The third objective was to examine the psychological factors associated with successful weight loss and other intervention outcomes. It explored the relative importance of psychological predictors of weight management intervention outcomes. A quantitative approach was used to measure the relationships between variables on a large scale. The use of FT data supported this approach.

Objective 4

The fourth objective was to explore service users' experiences participating in the weight management programme utilising FTs. It also explored the subjective experiences and perceptions of health professionals delivering weight management interventions utilising FTs. A qualitative approach was appropriate since the objective was to gather individuals' experiences.

3.2 Research setting: Healthy Hearts weight management intervention

3.2.1 Background

The HH weight management intervention was used in the current research (Healthy Hearts, 2023). HH was delivered across three Central London boroughs. Healthy Hearts provided 10-week weight management programmes delivered as part of a 6-month intervention to support individuals in losing weight (the intervention was considered successful if clients lost at least 5% of their body weight). This intervention was classified as a tier-two face-to-face lifestyle intervention within the broader obesity care pathway (NICE, 2014b). A definition of each tier can be found in Table 3.1.

Table 3.1. *UK Weight Management Strategy tiers*

Tier 1	Tier 2	Tier 3	Tier 4
Universal prevention interventions reinforcing healthy eating and PA messages. This may involve health professionals across various settings providing brief advice and delivering national campaigns to identify people who are gaining weight to provide them with tools and motivation to reduce it.	Offers multi-component, lifestyle weight management services that are typically time-limited and delivered face-to-face in the community, providing nutrition, PA and behaviour change advice. Since 2021, a digital weight management programme has also been available.	Offers more specialised and clinical but non-surgical support for very obese or morbidly obese individuals; a multidisciplinary and medically led team delivers this.	Provides support to morbidly obese individuals through surgical and non-surgical bariatric surgery supported by a multidisciplinary clinical team.

Key. PA=Physical Activity; *(NICE, 2014b)*

While tiers one and two interventions are usually commissioned by Local Authorities and supported by OHID, tiers three and four interventions tend to be delivered by the NHS as they require clinical input from multidisciplinary teams (Obesity Empowerment Network, 2017). HH is no longer delivered at the time of writing the thesis (2023). The programme ceased its delivery in the City of Westminster and the Royal Borough of Kensington and Chelsea Local Authority areas in 2019 and in the London Borough of Hammersmith and Fulham (LBHF) in 2021. Due to changes in the commissioning strategies in these areas, programmes

were either completely discontinued (LBHF) or replaced with an alternative service offered by the same provider (ONE YOU) in the other two areas. Most of the data in this research were collected from the residents of LBHF, where the recruitment of participants was possible for a more extended period (the recruitment for the quantitative study ceased in January 2020, while the recruitment for the qualitative study ceased in September 2020).

LBHF is one of the 33 London Local Authorities. According to the 2021 Census, LBHF has 183,200 residents (Office for National Statistics, 2022b), with a population density twice that of London as a whole (LBHF, 2018). The North part of LBHF is more deprived than the South part, and higher percentages of residents suffering from limiting long-term illness are present (15.8% in Wormholt & White City versus 9.9% in Parsons Green in the South) (LBHF, 2018).

There are slightly more females (53%) than males (47%) in the borough, and according to the 2021 Census (Office for National Statistics, 2022b), 63.2% of the total population were from the ethnic group within the 'White' category. Other ethnic groups in LBHF in 2021 were Black (12.3%), Asian (10.5%) and other (7.3%) (Office for National Statistics, 2022b).

CVD and cancer are the leading causes of death among LBHF residents, while the major risk factors are alcohol misuse, smoking and obesity (LBHF, 2018). In 2021, the rate of 'under 75 mortality from all CVD diseases' showed that 73.4 people per 100,000 died in LBHF (compared with 74.3 and 76.0 in London and England, respectively)(OHID, 2023b).

The HH intervention was delivered by Thrive Tribe - a Healthy Lifestyle interventions provider (*Thrive Tribe*, 2023) delivering an array of prevention

programmes across England (including, e.g., weight management interventions for adults and children, MAN v FAT football programme tailored for men, stop smoking interventions, health checks and the National Diabetes Prevention Programme). Local Authorities commissioned the HH programme as a CVD prevention programme focusing on key risk factors such as obesity. The programme's main objective was to attract the residents identified as being at risk of CVD who came from the most deprived borough wards and to help them reduce their CVD risks. Some service users might have seemed relatively healthy but had an elevated risk of certain illnesses (e.g., due to age/ethnicity and being overweight or obese). In this case, HH intervention was seen as primary prevention. On the other hand, the other group of service users might have had some pre-symptomatic diseases already detected, for instance, atrial fibrillation, high blood pressure or high cholesterol levels. Providing the weight management programme to this service user group was considered secondary prevention. HH did not routinely engage with service users with symptomatic CVD (tertiary prevention).

HH service users accessed the service free of charge. They either self-referred or were signposted to the service by professionals from primary care, for instance, General Practitioners (GPs), or secondary care, for example, specialised consultants. HH data showed that 59% of all programme service user referrals were from primary care, while 21% were self-referred; the remaining referrals came from secondary care, community services or outreach (confidential HH reports for 2018/19).

3.2.2 Healthy Hearts intervention delivery

The programme was delivered by HH health professionals who had various backgrounds in e.g., nutrition, physical activity, health psychology, behaviour change, public health etc. Once part of HH, all staff completed a range of mandatory training including behavioural change levels 1 and 2, group facilitation, understanding health improvement, exercise, sleep and alcohol misuse awareness, fitness instructor training, and mental health first aid among other training modules. The fostering of good relationships with service users was seen as a key aspect of the programme (e.g., positive group dynamics were facilitated rather than sharing information only). Health professionals were, therefore, trained in motivational interviewing and equipped with good interpersonal and group facilitation skills to deliver successful one-to-one and group sessions. The clinical team at Thrive Tribe ensured all staff were trained in relevant behaviour change theory and BCTs. The supervision and observations (of individual and group sessions) were carried out by members of the Thrive Tribe clinical team on a routine basis at least once a year as part of HH clinical and training procedures. These observations assessed the competencies of each staff member to ensure intervention fidelity. Observations were conducted as part of the service delivery. No observations were carried out specifically for the study.

Following a referral, eligible service users were booked to attend a care planning session with HH health professionals. These sessions initially took place across a network of 24 clinics (approx. 8 per borough), but from January 2019, the number of clinics was reduced to eight in LBHF. Since the HH programme was mainly community-based, most of these clinics were delivered in community and leisure centres located in areas of the highest deprivation, for example, in White

City. These deprivation areas were consistent with the Lower Layer Super Output Areas (LSOA), which are geographic hierarchies built from contiguous output areas based on postcodes (Office for National Statistics, 2010).

Each service user accessing the programme started with a one-to-one care planning session where the health professional took all the necessary measurements in line with the national guidance for weight management services (e.g., weight, waist circumference, glucose, cholesterol) (PHE, 2017d). The key risk factors of CVD were identified using physical and psychological measurements (e.g., blood pressure and self-reported depression and anxiety, alcohol intake, weekly minutes of moderate PA) to identify priority areas to address (a complete list is provided in the materials section 3.3.3.3). Following the first one-to-one session, most service users presenting with obesity/being overweight were channelled to the weight management intervention. There were additional programmes service users could benefit from (including PA and ‘cook & eat’ sessions). Figure 3.1 below shows some examples of how sessions looked like. All programmes were delivered on a face-to-face basis before March 2020.

Figure 3.1. *Visual examples of Healthy Hearts sessions*

Adult Weight Management session

Physical Activity session

'Cook and Eat' session

Care Planning session

The main goals service users were encouraged to work towards during the HH weight management programme were to eat three regular meals a day, reduce snacking, reduce screen time to two hours a day, eat five portions of fruit and vegetables a day, manage portion sizes, have a good sleep routine and aim to achieve 150 active minutes a week. The PA recommendation was for health benefits, rather than weight loss and this was in line with the LA service delivery specification. These objectives were aligned with the government recommendations, for example, the 'Eatwell Guide' (PHE, 2016b). Sessions lasted 90 minutes, were free of charge and delivered in mixed-gender group format across community settings. Each session included a 30-minute

exercise component consisting of low-impact activities such as stretching, chair-based exercises and walking suitable for the cohort of obese service users with mobility issues. The increase in active minutes and steps was emphasised each week. While service users were encouraged to aim for 10,000 steps per day, it was recognised that graduated stepping based on baseline activity levels would be more suitable for some.

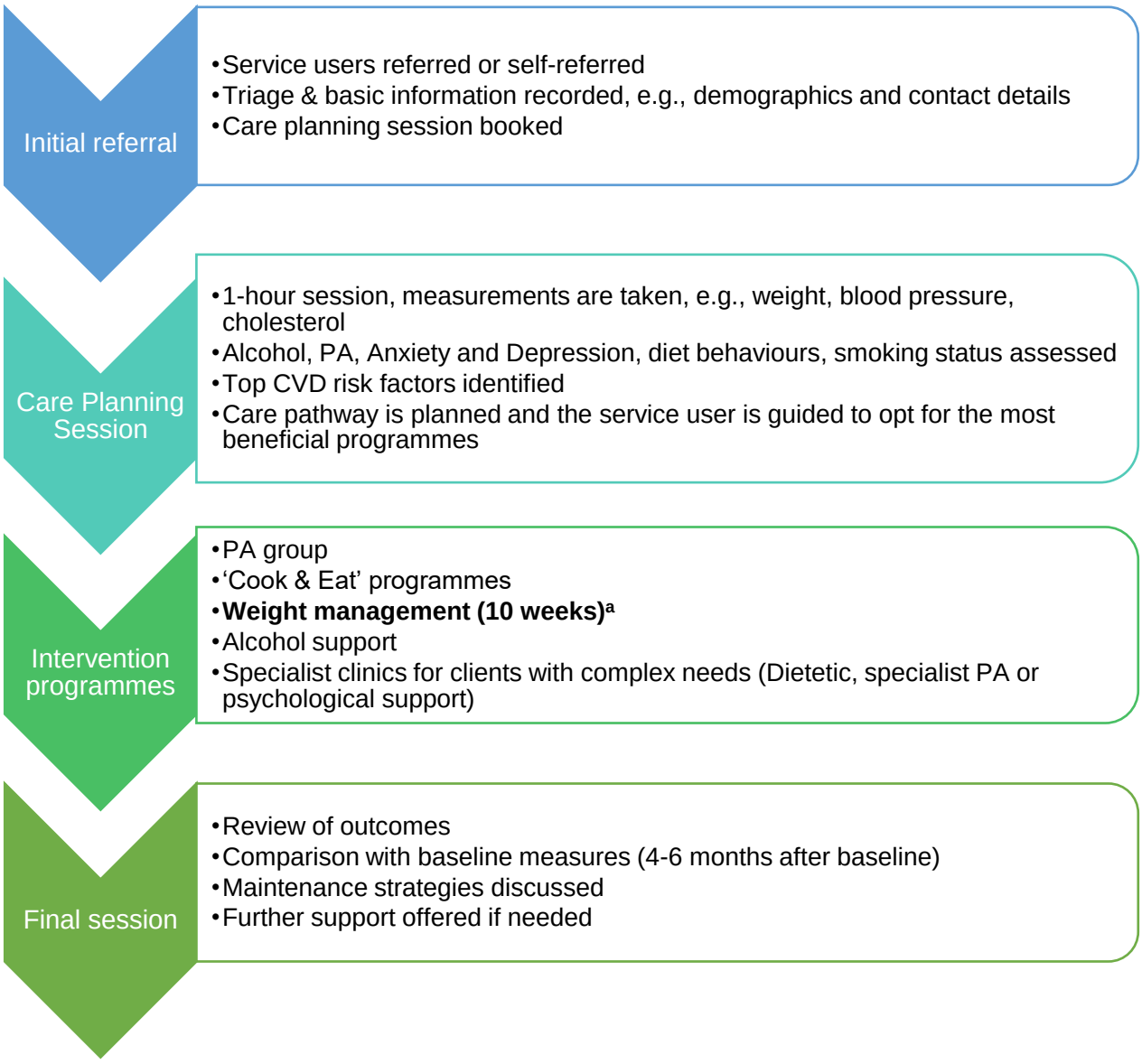
The programme looked at different weekly topics such as drinks, sedentary behaviours (e.g., sitting time), food label reading, sugar and fats. Whenever possible, practical and visual tools were used to improve information delivery; these included cubes of sugar or fat blocks to demonstrate sugar/fat content in drinks and foods, the Eatwell plate or food label reading cards. PHE (2016b) suggest that educational components empower service users by increasing knowledge and promoting programme retention.

During the programme, the emphasis was put on setting SMART goals (Specific, Measurable, Attainable, Realistic and Timely) (Locke & Latham, 1990), practical action planning, identifying barriers to change, feedback and positive reinforcement, social support and encouraging self-monitoring of behaviour. The programme also emphasised social support and encouraged family members to attend group sessions. Several techniques were also used during the service user journey through HH to reduce drop-out rates, for example, appointment letters/text reminder prompts providing cues to action.

Once the weight management programme and any other additional interventions were completed, each service user was invited back for a final one-to-one session with the same health professional to review their progress against

the goals they initially set, repeat the measurements taken in the first session, boost their motivation to continue behavioural change, provide feedback and assess whether further support was needed. The final session usually took place 4-6 months after the initial session. The programme had signposting mechanisms in place (e.g., mental health services, substance misuse services, and housing support) to provide additional support to address wider determinants of health. Service users were also encouraged to take advantage of recommended, free resources such as apps based on national campaigns, e.g., ONE YOU (NHS, 2021b), Couch to 5K (NHS, 2018b), Change4life (NHS, 2021a) and Better Health (NHS, 2020). A typical journey service users had through HH is demonstrated in Figure 3.2 below.

Figure 3.2. *The typical progression through the Healthy Hearts intervention*



Key. PA=Physical Activity, CVD=Cardiovascular Disease; [a] The current research focused on the use of FTs as part of the HH weight management programme

In order to access HH weight management intervention, service users had to be 18 years old or over, be obese or overweight and have identified 'being above the healthy weight threshold' as a priority issue to address during the care planning session. The BMI (NHS, 2019) was used to assess the programme's eligibility. Obese service users (BMI of 30 or over) were channelled to the

programmes directly. For overweight service users who had a BMI between 25 and 29.9, there was an additional requirement to either have an existing medical condition increasing the risk of CVD (e.g., diabetes, pre-diabetes, transient ischaemic attack, HIV, chronic kidney disease, peripheral vascular disease, erectile dysfunction) or a 10% risk of developing CVD. In line with NICE (2023a), the QRisk tool (Hippisley-Cox et al., 2007), which is recommended to assess eligibility for CVD prevention programmes, was used to identify the risk of having a heart attack or stroke in the next 10 years. A slight difference in BMI thresholds was applied to Asian groups, where 27.6 for obese and 23 for overweight thresholds were used in line with NICE recommendations (NICE, 2013) (as outlined in section 1.1.2).

Permission to exercise was needed from the service user's GP if any underlying concerns regarding PA were highlighted through the Physical Activity Readiness Questionnaire (PAR-Q+; Warburton et al., 2011) administered during the care planning session. PAR-Q+ is a 7-item tool used to assess whether there are any underlying risks associated with exercise. Only participants who had their GPs' permission to exercise were able to access the weight management programmes, and thus, only those were eligible to participate in the study.

In addition to the generic health-related eligibility criteria (specified above) to access HH, service users had to be residents of LBHF (or the City of Westminster/ the Royal Borough of Kensington and Chelsea Local Authorities prior to January 2019). The service also required 70% of programme users to reside in the most deprived areas, assessed according to the ONS classification of LSOAs (Office for National Statistics, 2010).

Exclusion criteria to access HH intervention included having experienced an acute cardiovascular event such as stroke or heart attack (as then the service was no longer about prevention). People with severe mental health issues were also excluded from the weight management intervention as a separate one-to-one pathway was delivered by a clinical psychologist to those individuals instead (as assessed using HADs and HH internal mental health pathway). Pregnant individuals and people diagnosed with eating disorders were also not eligible to access HH.

3.2.3 Healthy Hearts and behavioural change

When looking closely at the HH intervention (the setting of the current study), it needs to be pointed out that this intervention was not based on a single behavioural change theory. Instead, it drew on BCTs from various models. It can be seen that the TPB provided a helpful framework in which the intervention components could be viewed. The intentions to make positive changes were reviewed regularly during the intervention duration. Service users' attitudes towards losing weight were explored during the first (one-to-one) session with the HH professional. This aimed to assess the degree to which an individual had a favourable or unfavourable evaluation of their behavioural goal. Subjective norms were often discussed when social pressures were explored during group sessions, and service users were encouraged to bring significant others to sessions for support. PBC was related to the perceived ease or difficulty of performing a behaviour, for example, losing weight and the perception of control individuals had over performing that behaviour (Ajzen, 1998). Strategies to lose weight discussed during HH sessions were linked to PBC, e.g., controlling portion sizes or tracking

exercise sessions. It was argued that these could also be linked to key BCTs, e.g., self-monitoring of weight management behaviour.

Throughout their journey on the HH programme, service users were prompted to set goals and plan for the best outcomes; they were also assisted in developing action plans and coping plans to prevent relapses, in line with PHE recommendations (2017d). HH health professionals made each service user aware of what their individual 5% weight loss goal was for the programme, and clear, bespoke guidance around PA goals was issued. Widely endorsed guidelines state that weight loss greater than 5 % of body weight reduces blood pressure, cholesterol and blood glucose levels, which are important in managing risk for CVD, such as heart disease and stroke, and a range of co-morbidities (Jensen & Ryan, 2014). Additionally, setting SMART goals was emphasised during weekly sessions and service users were encouraged to share these with other group attendees. Group-based delivery of HH programmes facilitated social support when goals were set and the progress was shared. These techniques were in line with PHE recommendations (PHE, 2017c). Setting SMART goals and receiving incentives for their achievement and social support could also be potentially aided by FTs.

HH embraced feedback provision and encouraged self-monitoring of various weight management behaviours (e.g., PA, sleep, weight, dietary intake etc.) in line with PHE recommendations (2018b). In terms of feedback, service users were provided with comprehensive feedback in both one-to-one sessions with their health professionals, mainly concerning their core programme goals around their risk factors that were set individually. During the 10-week weight management programme, feedback was provided in the group session, and attendees' weight

was measured weekly. Self-monitoring of weight-related behaviours was highly encouraged, and this came in many different formats. Service users were asked to keep a weekly food diary that was subsequently reviewed in the group session, track their alcohol units and break down their day into sitting, standing, lying and being active. Service users were encouraged to monitor their sitting patterns and aim to break the sedentary periods and reduce screen time to 2 hours per day. A meta-analysis by Chasting et al. (2015) reported that evidence supports the idea that breaking up periods of sedentary behaviour with light-intensity activity may help manage obesity.

Participants were also encouraged to keep track of their weekly active minutes and write this down in a diary. As individuals lived diverse lives and had different work patterns and sleep habits, self-monitoring of various weight management behaviours was seen as providing helpful feedback, bringing structure into their lives, and contributing to general well-being and improved physical outcomes. FTs can provide a unique opportunity to support self-monitoring of PA and other weight management-related metrics (through automation) and many other BCTs. These could have been particularly useful during weight management programmes such as HH but were not routinely utilised as part of this intervention.

FTs can greatly enhance goal-setting and planning as an online platform that complements the device offers a wide range of support around, for example, goal-setting for steps, hours of sleep or minutes of exercise. Planning can be enhanced to a certain degree as users can introduce improved routines by setting reminders to, for instance, sleep or build exercise into their daily schedules, set weight loss goals, and plan to achieve their targets within a specified timeframe. It

was believed that FTs could fit within the weight management intervention framework to enhance certain aspects of its delivery. While the HH programme has ceased to be delivered, it was thought that FTs could be utilised in similar programmes.

3.2.4 Rationale for recruiting participants from Healthy Hearts

The funding for the study was made available across the three Local Authority areas (the City of Westminster, the Royal Borough of Kensington and Chelsea, and LBHF), where there was an interest in testing innovative technology as an addition to weight management interventions. Thrive Tribe (*Thrive Tribe*, 2023) is a Private Limited Company providing Healthy Lifestyle interventions, including tier-two weight management services across England. While it delivered HH, Thrive Tribe agreed to invite their service users to the study, and all procedures were designed with the already established intervention in mind. This design ensured that the study was ecologically valid and that findings could be generalised to other real-life settings.

Additionally, during the current study's planning phase, many studies used White, middle-class female participants likely to be already fitness-oriented (Lewis et al., 2015). As 70-75% of HH service users came from the most deprived wards of LBHF (October 2015 - March 2020, confidential HH reports, 2020), participants taking part in the study were anticipated to come from less privileged backgrounds – which was vital given that low income and social deprivation are strongly associated with CVD (Lewer et al., 2020). Also, as approximately 75% of service users came from ethnic minority groups (confidential HH reports, 2018), the

majority of participants were anticipated to come from these groups (recognised to be at higher risk of CVD) (British Heart Foundation, 2021c). It was thought that studying this population in an ecologically valid setting would result in an important contribution to this field of knowledge. Another rationale for using HH as an intervention in the current research was its accessibility to the researcher. Daily, the researcher works for Thrive Tribe (the provider of HH), but her role involves managing one of their other programmes (Stop Smoking Services).

The following section focuses on the quantitative research conducted within the HH setting.

3.3 Quantitative research

Objectives 1-3 of the research were addressed using quantitative methodologies, which followed the same procedures; therefore, the methods employed to address these objectives are presented together in the sections below (3.3.1 to 3.3.6).

3.3.1 Research design

Objectives 1-3 of the research were intended to ascertain whether the use of FTs impacts weight management intervention outcomes over six months and to examine the psychological factors associated with successful weight loss. A prospective design was considered suitable as participants' situation with regards to weight loss was assessed pre-HH intervention and at two post-intervention points in time (repeated measures). Participants were asked to complete three study questionnaires [at baseline (wave 1), immediately after their 10-week weight management programme (wave 2) and at the final session at six months (wave 3)]. Following the questionnaire's first wave (baseline), participants were randomised

into one of the two study conditions (the intervention with FTs or the intervention as usual/control). A simple, computer-based randomisation method utilising an online randomiser website (https://www.randomizer.org/) was employed to ensure fair and equal allocation to study groups. This randomisation method was considered the best and fairest technique to fit around the active HH intervention as it provided an opportunity to conduct allocation discretely, decreasing the chances for participants' disappointment in the control condition.

3.3.2 Sampling

The quantitative part of the study focused on service users accessing HH weight management interventions. The sampling process took place within the ecologically valid setting described earlier.

The G*Power programme, version 3.1.9.4 (Faul et al., 2007), was used to calculate the sample sizes needed for the study based on tests of differences, analyses of variance (repeated measures) and the regression analysis. Sample size calculations are always necessary before data collection (Field, 2018) to achieve the required statistical power. Using a significance level of 0.05 (5% probability that the result is due to chance), a level of power set at 0.80 (20% risk of committing false negative error) and an effect size of 0.25 (difference between groups), the required total sample size for Analysis of Variance (2 X 2 repeated measures, within-between interaction) was calculated to be 34 (completed at wave 2 of the questionnaire). Using the same parameters (significance level, power strength and effect size), the calculations were also carried out for the hierarchical regression analysis with 11 predictors and the total sample size was calculated as 78. It was unlikely all 11 predictors were to be used as the analysis was due to be guided by the results of the correlation analysis.

In order to be eligible to participate in the study, participants first had to meet the generic HH programme eligibility criteria described in section 3.2.2. In addition, participants needed access to a computer, a laptop, a tablet, or a smartphone with an internet connection to view their progress on the accompanying website/app. They also had to have no objections to using FTs if provided with one as part of the study.

Service users able to access the HH programme but with specific medical conditions (e.g., epilepsy-assessed on a one-to-one basis by the service GP) and people with pacemakers (due to potential electromagnetic interference caused by FTs) were excluded from the study. Those already using FTs were also not invited to participate.

3.3.3 Materials

The questionnaires used in the three study waves included the same scales (outlined below). The wave one questionnaire also included questions to establish how technology-savvy participants were. The third questionnaire included additional questions about participants' experience with the HH programmes. All three questionnaires can be viewed in Appendices I-III.

3.3.3.1 Behaviour change measures

Control over one's health

The Weight Locus of Control scale - WLOC (Saltzer, 1982) was used to measure locus of control related to weight. WLOC is the first weight-specific measure of LOC developed to predict weight-related behaviours (Saltzer, 1982). It consists of 4-items, two internally and two externally worded, e.g., 'being the right weight is largely a matter of good luck' (external). All items are rated on a 6-point

Likert scale from ‘Strongly disagree’ (1) to ‘Strongly agree’ (6). The measure is scored in an external direction (with internally worded questions reversed for scoring), which means that the higher the score, the more external the WLOC is or, in other words, the more participants are likely to attribute their failures and successes to external factors (e.g., bad luck). The scoring ranges from 4 (indicating internality) to 24 (indicating externality). Previously reported Cronbach’s alpha values to assess internal reliability for this measure were .58 and .56 on two administration occasions (Saltzer, 1982), indicating acceptable levels. The WLOC questionnaire was selected to be used in the current study as it is short, designed for convenient administration and is among the most commonly used instruments for measuring WLOC in the field of obesity (Lazzeretti et al., 2015).

The *Patient Activation Measure-short version* (PAM-13) (Hibbard et al., 2005) was used to measure continuous and categorical Patient Activation variables. The PAM questionnaire has 13 items. Questions include statements such as: ‘I am confident that I can tell a doctor or nurse concerns I have even when he or she does not ask’ or ‘I am confident I can work out solutions when new problems arise with my health’. All items are rated on a 4-point Likert scale ranging from ‘Strongly disagree’ (1) to ‘Agree strongly’ (4) with an additional option to indicate that the question is ‘Not Applicable’. This measure has good psychometric properties and previously reported Cronbach’s alpha values were between .81 and .83 (Alegría et al., 2009).

All items are added and normalised to a 100-point scale using an automated tool that calculates one score per participant considering all 13 items. The potential range of scores is between 0 and 100. The tool also calculates which PAM level (between one and four) participants can be categorised into. Higher PAM scores

and levels indicate higher activation and ability to self-manage; lower scores reflect lower activation and ability to self-manage (Hibbard et al., 2015). Each activation level reveals insight into an array of health-related characteristics, including attitudes, motivators, behaviours, and outcomes. It is also viewed as a powerful mechanism for tackling health inequalities (Hibbard & Gilburt, 2014), as patients can be helped to develop confidence and learn new skills to increase their activation levels.

The use of the PAM tool was secured from the NHS North West London Clinical Commissioning Group in 2016. This area used this tool routinely in GP settings with patients and was keen to share the questionnaire licence with the researcher for the study. In exchange, they were offered a summary of research findings once the study was completed.

Theory of Planned Behaviour

The current study used *TPB measures* to explore variables within the TPB framework. As discussed in the introduction, the TPB has been extensively used to predict and explain health behaviours (McEachan et al., 2011). It has been stated that there is no standard questionnaire measuring variables within the TPB model as it is applied to many various behaviours (Ajzen, 2020). It was recommended that questionnaires are developed for the specific research using the Theory of Planned Behaviour manual (Francis et al., 2004). In the current research, the variables within the TPB were measured using a set of questions initially developed by Schifter and Ajzen (1985) as, at the time of designing this study, it was the only questionnaire available that had been used to assess attitudes towards losing weight within the TPB model. Schifter and Ajzen's scale was

adopted for this study using the recommended manual (Francis et al., 2004). The resulting questionnaire had 18 items measuring four variables: attitudes, subjective norm, intention and PBC (these were assessed by 6, 4, 4 and 4 questions, respectively). Potential ranges for the subscales were either 6-42 (attitudes) or 4-28 (the other three variables). Each question was scored on a 7-point semantic differential scale, e.g., 'I am confident that I would reduce weight if I wanted to'. The 7-point answer scale ranged from 'Strongly agree' (1) to 'Strongly disagree' (7). The responses for each subscale were averaged (mean scores for each subscale were calculated by adding all scores and dividing by the number of items to obtain the subscale score). Higher values indicated stronger intention and positive attitudes towards performing the behaviour, stronger control over the behaviour and more supportive subjective norms. This measure's Cronbach's alpha was previously reported to be .82 (the attitudes scale), .88 (the subjective norms and intention scales) and .63 (the PBC scale) (Ajzen & Shifter, 1985).

Motivation

An adapted version of the *Treatment Self-Regulation Questionnaire* (Levesque et al., 2007) was selected to assess motivation. The 14-item version adapted by Hartmann et al. (2015) is based on the Self Determination Theory approach (Deci & Ryan, 1985; Deci & Ryan, 2000) (see chapter 1, section 1.2.3). While this research does not focus specifically on this particular theory, this instrument was considered the most appropriate as it was tailored explicitly for assessing healthy weight motivation (as opposed to focusing on dieting behaviours). The questionnaire has a filter question assessing motivation by asking, 'would you like to have or maintain a healthy body weight?' and participants are given 'yes', 'no' and 'it does not matter to me' options. The central

part of the instrument measures three subscales, namely autonomous motivation (6 items), introjected motivation (4 items) and external motivation (4 items). This instrument does not distinguish subscales of autonomous motivation (intrinsic, identified and integrated) as within the domain of health research, these are rarely assessed (Levesque et al., 2007).

Responses to questions across all three scales are rated on a 7-point Likert scale from ‘Do not agree at all’ (1) to ‘Totally agree’ (7). In order to score responses, each subscale’s scores are averaged, with higher scores representing greater motivation. Each scale’s range is 1-7. This measure displays high alpha values reported in previous research; Hartmann and colleagues reported Cronbach’s alpha ranging from 0.80 to 0.91 (2015), demonstrating good internal consistency of items within subscales. The questionnaire's motivation section also has a free text field to let participants describe in their own words why they would like to have or maintain a healthy body weight.

3.3.3.2 Physical activity questionnaires

The questionnaire also contained PA measures. The *International Physical Activity Questionnaire* – short version – IPAQ short (IPAQ International Consensus Group, 2005) was chosen as the current study also aimed to explore self-reported PA levels. This instrument is an internationally-used measure of PA (Cleland et al., 2018). It assesses participants' sitting and walking time and the time spent on moderate and vigorous intensity activities. Participants are asked to recall the last seven days and provide information about their activity levels and inactivity. There are seven questions in total (vigorous and moderate activity and walking, which are assessed by 2 questions each, while sitting is assessed by 1 question). Participants are asked to specify how many days and minutes they engaged in the

described activities e.g., moderate activity examples included carrying light loads and bicycling at a regular pace. Separate scores are calculated for vigorous activity, moderate activity, walking and sitting by the summation of the duration and frequency of activity (minutes and days provided) according to the IPAQ scoring protocol (IPAQ International Consensus Group, 2005). The scale enables the continuous scores to be calculated using the formula that converts activity minutes to MET (Metabolic Equivalent of Tasks) minutes.

3.3.3.3 Healthy Hearts programme data

The standard HH programme routinely gathered information about service users during the triage and care planning sessions. These variables were also used in the study and are listed below with information regarding the data source.

- Age, Sex, Ethnicity, Occupation (self-reported or GP records)
- Disability, Educational needs (self-reported or GP records)
- Medical Conditions and medications (self-reported or GP records)
- Method of referral (established at triage)
- Experience of a Mental Health condition in the last five years (self-reported or GP records)
- Weight and Height (Electronic scale & tape measure)
- BMI - chart (calculated using weight and height)
- Waist Circumference (Tape measure)
- Blood pressure (Blood pressure machine-systolic and diastolic)
- Cholesterol levels (Finger prick blood test for Non-HDL cholesterol)
- Glucose levels (Finger prick blood test for non-fasting glucose levels)
- Alcohol Intake (Weekly alcohol units, self-report)

- Smoking Status (self-report, GP record)
- QRisk (CVD risk) - A calculator available online: https://qrisk.org/2016/ (Hippisley-Cox et al., 2007)
- Physical Activity Readiness- The Physical Activity Readiness Questionnaire, PAR-Q+ (Warburton et al., 2011), which is different to the IPAQ measure used as part of the study; PAR-Q+ was used to establish whether participants can exercise as part of the HH programme
- Mediterranean Diet - Mediterranean Diet Adherence Screener (Papadaki et al., 2018)
- Mental well-being - The Hospital Anxiety and Depression Scale – HADs, 14 items – 7 for anxiety and 7 for depression (Zigmond & Snaith, 1983), available through the HH data recorded during the initial and final consultations, can be viewed in Appendix IV
- Main Risk Factors for CVD (NHS, 2017)
- Self-reported minutes of moderate PA in the past 7 days

3.3.3.4 Fitness trackers devices and obtained data

The Fitbit Charge 2 device used in the study was selected after a rigorous comparison of devices available on the UK market in 2017 (at the start of the research). Various aspects were taken into account; this included the battery life, feedback variables available to participants and the ease of data access for self-monitoring purposes (the data needed to be presented in a user-friendly format). Additionally, reported accuracy and validity, ease of operation and the security of data extraction for research purposes were considered. Participants also needed to have access to their data through the accompanying app. The other devices that

were considered were Garmin and Samsung, and Fitbit Charge 2 ranked favourably against them at the affordable price; therefore, it was selected as the most appropriate FT for this study.

Once the devices were obtained through funding from Thrive Tribe Ltd., they were set up and linked with the online research management site 'Fitabase' (available at: https://www.fitabase.com/) so the researcher could access the data. Each participant was provided with a unique email address (e.g., healthy.hearts.study+p2, etc.) and a password to enable them to log in and access their data online. Participants were also instructed that this email address should not be changed while participating in the study (for six months). All participants were informed that once their study participation concluded, this email address could be changed to their own so they could personalise their accounts. Written instructions on how to achieve this were also provided.

The downloadable Fitbit data comprised various measurements and logs, such as the daily activity log, step count, calorie expenditure, heart rate, exercise intensity, sleep duration, sleep quality, synchronisation events, and battery charging patterns. The same variables were visible to all Fitbit users. For the data to be visible to participants on the accompanying Fitbit website/app, the trackers had to be correctly set up and synchronised frequently (i.e., at least once a week) via Bluetooth or Wi-Fi. In order to help participants remember to synchronise their devices, text reminders were sent up to 2 times to each participant during the study.

3.3.4 Procedure

As the study was designed with the standard HH weight management intervention at its core, participants from both conditions (the intervention with FTs and the intervention as usual) followed a standard weight management pathway consisting of 10 structured sessions. Participants were identified from the pool of eligible HH service users. The HH administrative team performed the initial screening of participants at the triage stage. Those deemed eligible to participate in the study (e.g., BMI within specified thresholds, no medical conditions that would exclude them) were flagged up by the administrative team for care planners to screen during their clinics within the community and primary care settings. Following the initial recruitment period, the researcher worked with the database provider to develop an automated screening tool for the HH database system. This helped to flag eligible participants based on the inclusion/exclusion criteria and complimented the administration team's screening work.

Most eligible service users were informed about the study during the care planning clinics (time permitting). As the study recruitment process relied on care planners providing an introduction to the study, this was initially perceived as an extra task. To standardise the information about the study and alleviate the burden placed on the care planning team, the researcher recorded a short video introducing the study to bring the same standard level to the message being conveyed and encourage staff to conduct the screening.

Participants eligible to take part in the study were given the study information sheet (Appendix V), FT study information handout (Appendix VI) and the informed consent form (Appendix VII) and asked to take the time to consider whether they wanted to participate. Participants were encouraged to contact the

researcher for any study-related questions. All aspects of the data collection process are discussed in the following sections.

As stated earlier, the data collection process was spread out over approximately six months for each participant in the quantitative empirical work. The researcher managed each study step, and various steps were taken to minimise potential barriers to engagement and to promote survey completion. For example, participants met with the researcher at a convenient time for them, and they received text reminders to meet. The terminology used in the questionnaires was as clear as possible, and participants were supported and given enough time for each study wave.

3.3.4.1 Wave 1 (baseline), randomisation to conditions and fitness trackers provision

Participants were contacted approximately one week before the weight management programme and reminded that if they were interested in taking part, they needed to arrive 45 minutes before their session. On arrival, consent forms were collected, and participants were asked to complete a paper questionnaire (wave 1, Appendix I). The researcher assisted participants when they had questions. On average, the completion of questionnaires took 25 minutes, but extra time was given if needed. Participants were thanked and informed that they would be notified shortly about their randomly assigned study condition (by phone or text message). The randomisation took place between the first and second weight management sessions. Participants were made aware that they had an equal chance of allocation to either study condition. This was done to reassure participants about the fairness of the process. Participants were informed about the potential benefits of taking part in the study. This included providing FTs worth

approximately £100 per piece if allocated to the experimental study condition (the intervention with FTs).

Participants allocated to the intervention with FT condition were asked to meet the researcher within the first two weeks of their weight management programme to obtain the device and the device's manual (Fitbit Charge 2, manual version 1.3, 2019). Participants were also instructed on how to set up their Fitbit account and given access to the login page (https://www.fitbit.com/uk/app). Whenever possible, participants were helped to set up the account (if participants had access to the internet and the time). The researcher also explained how to synchronise their activity data between the device and the online account.

Participants were asked to use their FTs for six months to self-monitor their behaviours, for instance, the number of steps, sleep patterns, and heart rate and encouraged to set personal reminders and goals. Participants were asked to use the device daily and encouraged to wear it at night to benefit from the sleep pattern monitoring feature. Good sleep quality was highlighted as one of the pillars of wellbeing during the standard HH programme. Participants were also informed that the device is not waterproof and should not be used in water. Participants were reminded that FTs were an addition to the weight management programme and that they needed to attend their sessions as planned. Participants in the control group were asked to attend the intervention as usual.

3.3.4.2 Wave 2 (10 weeks from baseline)

All participants enrolled on the study received wave two questionnaires (Appendix II), similar to the questionnaire from the first wave, one week before the end of the intervention (week 9). HH practitioners gave out the questionnaires, and

participants were asked to bring the completed forms back to the final session, where the researcher was present to collect them and provide assistance if needed. An online version of this questionnaire was also offered on the Qualtrics survey platform as an alternative (a data collection tool available on mobile and computer where a website link can retrieve the survey). An online survey was thought to offer participants a convenient option, improving response rates and data accuracy. Only one participant completed the second questionnaire online.

3.3.4.3 Wave 3 (6 months from baseline)

Following the weight management intervention, some participants progressed to other programmes, for instance, 'Cook & Eat' or various PA classes. The final care planning session usually took place approximately 4-6 months after the initial care planning session and was treated as the programme sign-off point. The final questionnaire (wave 3, Appendix III) had the same primary content as questionnaires in waves one and two. In addition, all participants were asked whether they attended other interventions or had any changes to their medications. Participants in the FTs condition were also asked to share their experiences of using their devices as part of their programme.

Wave three questionnaires were posted to participants independently of the final care planning session. Participants were provided with a prepaid, addressed envelope to return the survey. They were also reassured that they could contact the researcher if they required assistance with the survey completion. As with the wave two questionnaires, participants were given the option to complete an online version, and 12 participants chose this option (mainly when programmes were disrupted due to the pandemic). Participants also had the option to express their interest in participating in the qualitative part of the study (if they were allocated to

the FT condition) and leave their contact details if they wished to receive a summary of research findings.

3.3.5 Ethical considerations

As some HH service users got referred by NHS health professionals and due to some clinics being run within NHS settings (e.g., GP surgeries), ethical approval for the study from the Health Research Authority was necessary. It was received in February 2018 (17/LO/1932, Integrated Research Application System Project ID: 225481). Additionally, the study obtained ethical approval from the School of Human and Social Sciences Ethics Committee at the University of West London in April 2018 (UWL/REC/PSW-00760). The ethical aspects of the study are outlined below. This includes necessary patient information sheets, consents and data handling issues. The potential for distress, physical harm, debriefing, and conflict of interest are also outlined.

3.3.5.1 Consents

Participant Study Information Sheets (Appendix V) provided all necessary information about the study and were given to all eligible service users. Participants were given the time to familiarise themselves with their content and decide whether they were interested in participating in the study. In line with the British Psychological Society's guidelines, principles and code of conduct (British Psychological Society, 2018), participants were notified about their rights to withdraw from the study, confidentiality and data protection arrangements. Additionally, written informed consent (Appendix VII) to participate in the study was obtained from all participants and collected by the researcher. All documents provided clear information written in simple language. Participants were able to keep copies of both documents for their reference.

When participants agreed to share their FT data for this study, the data (outlined above) became visible to the researcher. This was available through the Fitbit app/website (https://www.fitbit.com/uk/home) and the Fitabase cloud storage system (https://www.fitabase.com/). The researcher considered the security of data storage and sharing (with the research team) when a review of potential devices to be used in the study was conducted. Participants were reassured that these data would remain confidential and be only used for the study. Only data from participants who provided consent to share their activity data through Fitabase were utilised. All participants were set up and given access to their password-protected accounts from which they could access these data.

One crucial ethical consideration was that using the FT may provide insights into participants' lifestyles. While this was useful for the study and educational for participants, there was a chance that it could make participants feel uncomfortable. Therefore, participants were informed that they could contact the researcher with any concerns or withdraw from the study at any point.

Participants consented to their anonymised weight management programme data (outlined above) being used in the study. Participants in the FTs condition were made aware that for their Fitbit devices to be set up correctly, their weight, height, and sex information (all obtained during the weight management programme) had to be registered on their Fitbit account while the account remained anonymous. The researcher and members of the supervisory team had access to participants' HH anonymised data.

3.3.5.2 Data management and storage

Printed consent forms and questionnaires collected from participants were transported in a sealed envelope, entered into SPSS and placed in locked filing cabinets on Thrive Tribe's premises. When it comes to the data collected through Qualtrics, participants' anonymity and the protection of collected data were prioritised. The guidelines for internet-mediated research (British Psychological Society, 2017) were followed, e.g., IP addresses stored alongside online survey responses can be linked to an individual respondent (British Psychological Society, 2017), so IP addresses were removed from survey responses after the download to ensure anonymity. All participants were made aware of the data storage processes. All electronic data were protected with a password, and folders used to store data were encrypted. All data were handled securely, and the study complied with the Data Protection Act (2018).

3.3.5.3 Acknowledging the potential for distress

One of the project's difficulties related to ethical issues was the potential upset caused to participants randomly assigned to the intervention as usual condition (control condition). When participants learnt they were not getting the FT, they could have felt disappointed and lost interest in the study or dropped out of the weight management programme, especially if there was an interaction between participants from both study conditions (those in the FT condition could keep their devices after the study was completed). This was a potential problem as some participants could have felt left out when other participants talked about the devices they had received. Participants could have felt that they were not given an

equally valid intervention and could have believed their chances of success diminished.

To address these issues, participants were assured that both groups were crucial to the study and that the participation of all was equally valued. Most importantly, it was explained to all participants that the impact of FTs was still to be proven in this setting. At the same time, the HH programmes had been shown to be successful without the use of FTs, and many service users lost weight and reduced their CVD risk factors. For instance, 96% of those attending the HH weight management programme reduced their BMI and 40% reduced their weight by 5% (HH internal reports). It was emphasised to participants in the 'intervention as usual' group that the intervention they were getting was no different to the high quality of care in the standard HH programme. In addition, the researcher ensured that the provision of Fitbit devices took place away from participants from the control group whenever possible. In terms of participants in the FT condition, it was made clear to them at the beginning of the study that they would be able to keep their devices once the study concluded.

Another potential for distress could be linked to the awareness that the researcher could track participants in the FTs condition and that their data were recorded all the time. To ensure that participants were comfortable with this, participants in the FT condition were reassured that their data would be anonymised and that only basic data would be used for the study. Participants were also reminded that they might withdraw from the study at any point should they feel uncomfortable or distressed.

Another ethical consideration related to the care and protection of participants was the possibility of injury when participants tried to reach the required number of steps/other goals. To minimise the risks, all participants taking part in the study were asked to complete a PAR-Q questionnaire to assess whether there are any underlying risks associated with exercise. Participants across both study conditions were advised to work towards 150 active minutes a week and encouraged to engage in activities such as brisk walking, cycling, dancing and swimming. However, the potential likelihood of over-exercising was greater among participants in the FTs condition as in addition to HH goals, they also had FT-specific goals to achieve. To minimise the risks associated with this situation, all participants in the FT condition were strongly advised to exercise caution when setting goals in their Fitbit accounts. It was emphasised that each participant should set goals based on their comfort level and ability.

The study also considered that the self-monitoring of PA or other weight management-related metrics carried out by participants in the FT condition could cause distress. It was anticipated that some participants might experience disappointment if they did not meet the prescribed step count or other goals. To address this concern, participants were reassured that the goals were merely guidelines and not strict requirements. It was also made clear to all participants that their goals could be customised and that they could decide on the frequency of notifications (nudges). Moreover, all participants were given the contact details of the researcher and the members of the supervisory team and reassured that they could talk to their care planner in case of distress.

All participants were thanked for participating in the study and given an opportunity to ask questions about the project. A study debrief document was shared with all participants; they could keep it for their records (Appendix VIII).

3.3.5.4 Conflict of interest

Neither the researcher nor the supervisory team benefited from the study financially or by receiving any other forms of compensation, for instance, from Fitbit manufacturers, which was made clear to participants. Thrive Tribe employs the researcher as the Head of Stop Smoking Services operating in central London (overlapping areas where HH was delivered), which could have been viewed as a potential conflict of interest. In order to emphasise the absence of any conflict of interest, it is essential to highlight that the primary objective of this study was not to evaluate the HH intervention.

Instead, the study aimed to test whether the intervention produced different results when FTs were added to the standard intervention. At all stages of the study, professional boundaries were maintained, for instance, clear communication and correct expectation setting to ensure all staff were clear about procedures to follow. Staff were also encouraged to approach the researcher for clarifications if needed. The supervisory team played a role in ensuring all standards were upheld.

3.3.6 Data analysis and statistical tests

To address objective 1 (i.e., to test whether the intervention with FTs and the intervention as usual have different weight management intervention outcomes), a mixed ANOVA (Analysis of Variance) was chosen to test for differences in outcome between the two study groups (the between-subjects variable). The test was run to evaluate the repeated element at the baseline, the

10-week and 6-month follow-up points (waves 1, 2 and 3). The primary outcome was weight loss, and the secondary outcomes included a range of measures as outlined earlier (Sections 3.3.3.1-3.3.3.3). The attendance rates of the weight management programme were also investigated. Where appropriate, independent samples and repeated-measures t-tests (or their non-parametric equivalent) were employed.

To address objective 2 (i.e., to test whether health beliefs as defined by the Theory of Planned Behaviour, WLOC, Anxiety, Depression, Patient Activation levels and Motivation differ between FTs and the intervention as usual conditions and change over time), a mixed ANOVA was chosen to be utilised. As mentioned above, t-tests were also employed where necessary.

The third objective was addressed in two steps. Firstly, a correlation analysis was employed to identify relationships between the key variables in a bid to select suitable predictors for the second step – the regression analysis. Hierarchical regression was selected as most appropriate (i.e., exploring predictors of weight management intervention outcomes, controlling for each at the same time. Additionally, hierarchical regression enabled the entry of predictors in a specific order that the researcher determined based on previous research and correlation outcomes. Up to 11 predictors were intended to be investigated [Health beliefs within the Theory of Planned Behaviours (4), WLOC (1), Depression (1), Anxiety (1), Patient Activation level (1) and Motivation to change (3)]. Again, the primary outcome considered was weight loss.

3.4 Qualitative research

Objective 4 (i.e., exploring the experiences of service users and health professionals of taking part in/facilitating the weight management programme utilising FTs) was addressed using qualitative methodologies, described in the following sections (3.4.1 – 3.4.3). While some methods employed in both of these studies are identical, they are presented separately below due to the difference in participant cohorts.

3.4.1 Service users' study

This phase of the research partly addressed objective 4 and explored the experiences of service user participants taking part in the HH weight management programmes utilising FTs. The study setting was the same as described in detail above (section 3.2). All methodologies introduced at this stage are an addition to already described methodologies (as participants already followed quantitative procedures to be eligible for the qualitative part of the study).

3.4.1.1 Participants

Inclusion and exclusion criteria

A selection of participants from the FTs condition who expressed an interest in taking part in the qualitative part of the study (at the end of wave 3) was invited using purposeful sampling. In order to ensure a diverse representation of experiences, a wide range of FT users were invited. Participants of various ages, ethnic backgrounds, weight management programme outcomes (those who lost weight and those who did not), and engagement levels with the FT devices were carefully selected. Participants who did not complete the HH weight management

programme and/or did not attend the final care planning session (or were in the control condition) were excluded.

Sample size

It was hypothesised that a sample of nine to ten participants was going to be sufficient for this phase of the study to obtain a range of views representing different experiences. However, the final sample size was left open depending on how quickly data saturation was reached.

Participant recruitment

All service user participants from the FT condition who completed their final study questionnaire (n=21 in total) – at the end of the programme (roughly 6 months after the start of the intervention or W3) - and who initially expressed an interest in this phase of the research (15 out of 21 in total), were contacted. Two were no longer interested, and four were not reachable at the time of data collection. Nine participants agreed to participate (38% of the total number of participants in the FTs condition - 24). Those who agreed to participate were sent the qualitative study information sheet (Appendix IX) and the consent form (Appendix X) by post and asked to take time to decide whether they wanted to participate.

3.4.1.2 Procedure

Topic guide

All questions in the topic guide were open-ended and explored participants' experiences of the weight management programme that utilised FTs. Questions included: 'How would you describe your experiences of using a Fitbit FT as part of

the HH programme?', 'Which aspects of the Fitbit have you found the most and least useful and why?', 'How do you think the Fitbit contributed to your overall experience on the programme?' and 'What barriers to wearing your Fitbit did you experience (if any)?'. The topic guide, including a complete list of questions, is included in Appendix XI.

Data collection procedure

The lead researcher conducted semi-structured interviews with participants. Five interviews took place in person, while four were conducted over the phone due to the pandemic. Convenient locations and time slots were offered to participants. The interviews took place in confidence either at the office premises of HH, in West London, at community centres (the choice of location most convenient for participants) or over the phone. Interviews lasted approximately 20-30 minutes, were recorded and transcribed from a Dictaphone into Word by the researcher. The transcripts were checked for any inconsistencies and prepared for analysis.

Ethics

Participants were informed that they could withdraw from the study without providing a reason. Once participants' consents were obtained, semi-structured interviews were conducted with service user participants, and these interviews were recorded. The participants also provided consent for the use of quotations from the interviews. After the interview transcription, only anonymised direct quotes were used in the analysis.

3.4.2 Health professionals' study

This part of the research also addressed objective 4, and it looked at the experiences and perceptions of health professionals delivering HH weight management interventions utilising FTs.

3.4.2.1 Participants

Inclusion and exclusion criteria

HH health professionals who delivered the weight management programme to FT condition participants and expressed an interest in participating in the qualitative study were invited. Participants had to be employed to deliver HH weight management interventions and have at least six months of exposure to the study process. Participants with insufficient exposure to the study process were excluded.

Sample size

Due to the discontinuation of the Local Authority contracts, staff turnover and the requirement of the minimum exposure to the study procedures being six months, the available cohort of health professionals to recruit from was small (n=8). Four health professionals agreed to participate in the study, and they were interviewed within their working hours.

Participant recruitment

Participants were approached by the researcher and invited for an interview at a convenient time within their working hours. Participants were provided with the study information sheet (Appendix XII) and the consent form (Appendix XIII) before the interview. The consent forms were collected, and any study-related questions were answered. The interviews were subsequently scheduled.

3.4.2.2 Procedure

Topic guide

The qualitative topic guide included open-ended questions about participants' experiences of working with HH service users who used FTs as part of the programme they delivered. Questions included: "How (if at all) did FTs influence the weight management programme outcomes of your clients?", "Were there any barriers to FT use among participants that you observed?", "How was the dynamic of running the HH weight management programme changed when the devices were added (if it was changed at all)?" The topic guide, including a complete list of questions, is included in Appendix XIV.

Data collection procedure

The interviews took part in confidence in the office premises of HH, in West London and over the phone. Three interviews were conducted in person, but one of them needed to be repeated with the same participant after a period of time because the participant had not had enough exposure to the study (despite delivering HH interventions for 6 months). Two interviews were conducted over the phone (including the repeated one). Interviews lasted approximately 10-20 minutes and were conducted by a supervisory team member to avoid conflicts of interest between the lead researcher and her colleagues. The interviews were transcribed verbatim and prepared for analysis.

Ethics

The same ethical considerations as for the study with service users were considered. In addition, participants were informed that they could withdraw from the study without providing a reason or without affecting their work or working

relationships. It was emphasised to participants that the study was not an assessment of their practice but an exploration of their observations of how service users experienced the weight management programme that utilised FTs. The research team emphasised that they did not intend to make participants feel like their work was being evaluated. Semi-structured interviews were conducted and recorded by a supervisory team member after gaining participants' consent to record (the use of quotations was also consented to). After the interview transcription, only anonymised direct quotes were used in the analysis.

The study concentrated on evaluating the effectiveness of FTs when used in addition to the standard HH intervention instead of concentrating on the evaluation of the HH programme itself, which could have created a potential for bias. Additionally, the BPS code of ethics and conduct (British Psychological Society BPS, 2018) was followed to ensure that the study was independent and unbiased. The interaction with HH health professionals delivering the programme was always conducted professionally. The researcher strived to be as honest and objective as possible and acted with integrity, maintaining personal and professional boundaries. In the eventuality that some issues with HH practice were highlighted during the study, it was agreed that these would be constructively communicated to HH management for improvements.

3.4.3 Researcher Reflexivity

In reflecting on the research process for this study, consideration must be given to how the lead researcher's personal characteristics, experiences, and dual role as both a PhD student researcher and employee within the service provider organisation (Thrive Tribe) may have influenced data generation and analysis. As a user of FTs, the researcher's familiarity with the technology may have resulted in

a positive bias towards its effectiveness. This potential bias could have influenced the interpretation of data, with a tendency to emphasise benefits over drawbacks. To mitigate this, diverse perspectives were consciously sought from the participants, and attention was given to both positive and negative aspects of FTs use during data analysis. Additionally, the mitigation was further reinforced through supervision, ensuring that the data interpretation was balanced and critically assessed.

The researcher's dual role provided valuable access to data and facilitated trust with participants. However, potential conflicts of interest and power dynamics may have also been introduced, as participants might have viewed the researcher as an authority figure within the organisation. To address this, transparency about the researcher's dual role was maintained, confidentiality was assured to participants, and the academic nature of the research was emphasised. Regular reflection on positionality was conducted to ensure a critical and balanced approach. During data analysis, the researcher's background may have influenced interpretations. To ensure credibility, triangulation and checks with the supervisory team were employed, seeking feedback on the accuracy of interpretations.

3.4.4 Data analysis

To enhance rigour, the qualitative elements of the project were aligned with the Consolidated Criteria for Reporting Qualitative Research (COREQ) framework (Tong et al, 2007). COREQ was used for reporting purposes, as it enables detailed reporting and ensures transparency. The COREQ framework is a comprehensive set of guidelines designed to enhance the quality of reporting in qualitative research. It comprises a 32-item checklist covering three main domains: research team and reflexivity, study design, and data analysis and reporting. This covered

everything from the personal characteristics of the research team to the data analysis methods and presentation of findings. The checklist is presented in Appendix XV.

The qualitative analysis followed the six steps of Thematic Analysis (TA) as outlined by Braun and Clarke (2006). This method was chosen for its flexibility and its ability to highlight key features and identify patterns within the dataset. Here is a detailed description of how each stage was utilised in this research.

Familiarisation with the Data

The lead researcher transcribed all interviews verbatim to ensure an accurate representation of participants' responses. All interviews were pseudonymised (using random names in alphabetical order) by the lead researcher. Safeguarding measures e.g., data encryption and strict data access controls were employed to protect unintentional disclosure and/or identification of participants. The lead researcher repeatedly read the transcripts to become deeply familiar with the content, taking detailed notes to capture initial thoughts and observations about the data.

Generation of Codes

Using the open-source qualitative data analysis tool Taguette (https://app.taguette.org/, 2022), the lead researcher coded the data. Tags were applied to highlight important segments of text, with each code representing a specific idea or concept relevant to the research questions. Codes were created inductively from the data, ensuring they reflected the participants' actual responses. This process resulted in a comprehensive list of codes that captured a wide range of experiences and perceptions of the participants.

Searching for Themes

The generated codes were examined for patterns and similarities. Codes were grouped into broader categories or themes that encapsulated related ideas. This involved iterative reviewing and refining to ensure themes accurately represented the data. Initial themes were identified, providing a structured way to understand the data.

Reviewing Themes

The initial themes were reviewed and refined by the lead researcher and the supervisory team. This involved checking if the themes worked in relation to the coded extracts and the entire dataset. Any discrepancies or inconsistencies were discussed and resolved collaboratively, resulting in a set of coherent and meaningful themes that were internally consistent and distinct from each other.

Defining and Naming Themes

Each theme was clearly defined, outlining what aspect of the data it captured and why it was relevant. Sub-themes were identified where necessary to provide additional structure and detail. Labels for the themes were created to be concise, informative, and reflective of the content. This resulted in well-defined themes and sub-themes that provided a detailed understanding of participants' experiences and perceptions.

Reporting of Findings

The findings were written up, with each theme supported by direct quotations from the participants to illustrate and substantiate the analysis. Efforts were made to ensure that both positive and negative aspects were represented to

provide a balanced view. This comprehensive report of the findings highlighted key themes and sub-themes with supporting evidence from the data.

The following two chapters provide a quantitative (Chapter 4) and qualitative (Chapter 5) overview of the empirical work conducted in the current research

Chapter 4 – Assessing the impact of fitness trackers on weight management programme outcomes (quantitative study)

This chapter outlines the quantitative study conducted as part of the research. It includes a description of the methods employed, an overview of the statistical analysis, and the steps taken to assess the psychometric properties of the measures used. The chapter also presents the characteristics of the study sample. To address the initial three research objectives, the chapter provides the results of tests for differences, correlations, and regression analyses. Additionally, it includes an analysis of the Fitbit data, offering insights into device usage patterns and their relationships with other study variables. The chapter concludes with a discussion summarising the key findings, strengths, limitations, and implications for the thesis.

4.1 Introduction

The quantitative analysis included in this chapter addressed the first three research objectives. The analysis assessed whether the 'intervention with FTs condition' and the 'intervention as usual condition' (control) had different weight management intervention outcomes (objective 1). It also assessed the factors associated with successful weight loss and tested whether they differed across the study conditions (FTs versus control) over time (objective 2). Finally, it examined the factors associated with successful weight loss and other intervention outcomes (objective 3).

The study took place in Central London and utilised an established weight management intervention - HH (described in detail in section 1.5).

4.2 Methods

The first participant was invited to participate in the study as part of the HH programme on 18/04/2018, and the last was invited on 15/01/2020, meaning that participants were recruited over 21 months. In total, 22 participants (38.6%) were recruited in 2018, 32 (56.1%) in 2019 and only three in 2020 (5.3%) due to the pandemic. Participants were invited to complete three study waves spanning six months (57 completed wave 1, 34 wave 2 and 21 wave 3, as illustrated in Figure 4.4 later in the chapter). The details of the methods employed in the current study were provided in Chapter 3.

4.3 Statistical analysis overview

To test whether the intervention with FTs (FT condition) and the intervention as usual (control condition) have different weight management programme outcomes, a two-way [intervention condition over time (study waves)] mixed model Analysis of Variance (ANOVA) was run to test for main effects and any interaction of these independent variables on dependent variables, for instance, weight.

T-tests (or their alternatives) were also employed to examine the differences between groups (independent) and study waves (paired-samples) on several key variables, e.g., weight management sessions attended and PA. The study and HH data from the initial and final assessments were included. The results were grouped into physical and psychological measures. Correlation and regression analyses are also presented. The following section focuses on the data screening procedures.

4.4 Data screening

Questionnaire data were entered into SPSS (Statistics Package for the Social Sciences, Release Version 25, www.spss.com, 2017). The data were transferred from paper questionnaires and Qualtrics (an online survey platform). During the data entry process, all variable names were checked and relabelled in the case of online questionnaires.

The data set was cleaned, and any missing values were coded in SPSS as 'missing'. All reversed scored items were appropriately recoded, and new variables were created (e.g., subscales). Total scale scores were calculated where appropriate. Steps were taken to examine each study scale in terms of internal reliability and distribution of scores. T-tests (or their non-parametric alternatives) were utilised. To test the normality of distribution, skewness and kurtosis were computed and converted to z-scores. Due to skewed distributions in some scales, Spearman and Pearson's correlations were used to assess their test-retest reliability. The findings are presented later in the chapter (section 4.5.2).

Additionally, continuous variables such as age and Body Mass Index (BMI) were divided into categories (age groups and overweight/obese/severely obese) for further analysis.

4.5 Results

4.5.1 Sample profile

Demographic information

The study sample comprised 57 participants, 45 females and 12 males (79% females). The ratio of females and males mirrored the ratio typically seen on HH programmes, as most men opted for an alternative weight management

programme provision specifically designed for men (MAN v FAT football). There were 22 females and two males in the FT condition, while the control condition had 23 females and 10 males.

The slightly uneven spread of participants between study conditions (n=24 in the FT group and n=33 in the control group, respectively) was due to the randomisation tool (https://www.randomizer.org/) being initially set up to consider a larger group of participants. While the expected total number of participants (n=100) entered in the calculation was defined to be split equally between the two conditions, initially, the tool randomly allocated more participants into the control group. This was on track to be levelled as the number of participants increased. However, unfortunately, the recruitment of participants had to be stopped due to the pandemic in March 2020, and the intended (even) allocation was not achieved.

The age range of participants was 25-84, with a mean age of 52.9 years old [Standard Deviation (SD)=12.07]. The mean age and SDs for each condition split by sex are provided in Table 4.1 below. The mean age in the control condition was slightly higher than in the FTs condition. However, this difference was not statistically significant at the overall level or by sex.

Table 4.1. *Participants mean age (and SDs) split by sex and study conditions*

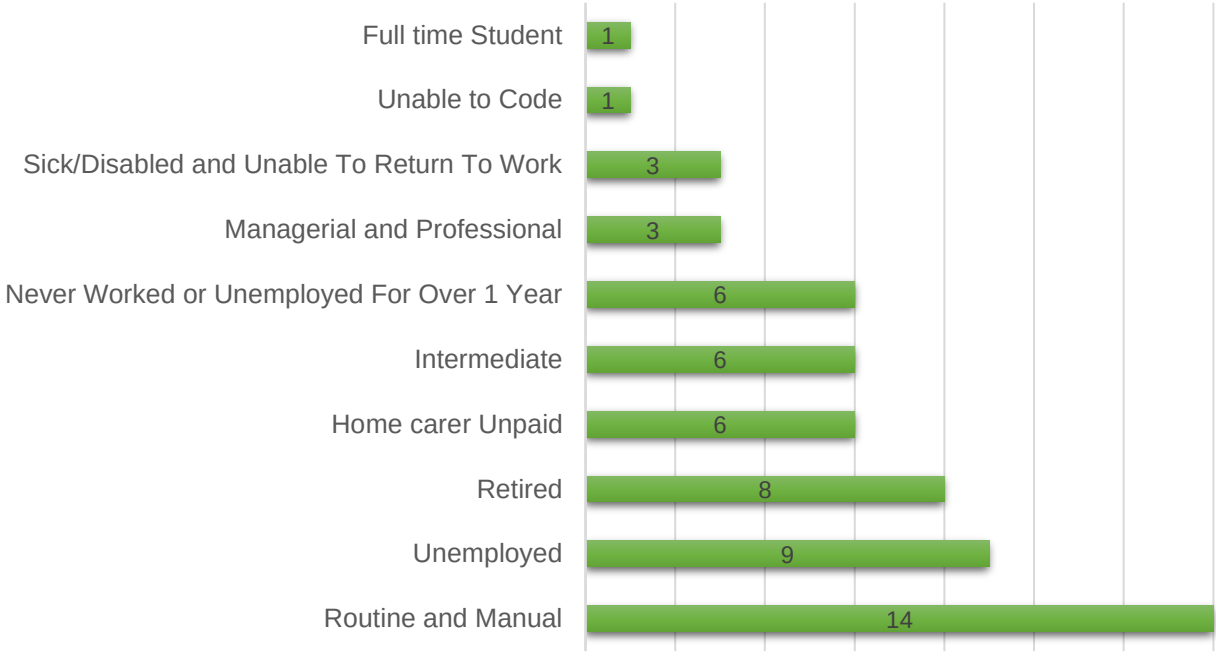
Sex	FTs condition age mean (SD)	Control condition age mean (SD)	Total
Female n=45	49.09 (12.08) n=22	54.91 (10.67) n=23	52.07 (11.63)
Male n=12	64.00 (8.49) n=2	54.60 (14.25) n=10	56.17 (13.64)
Total n=57	50.33 (12.41) n=24	54.82 (11.63) n=33	52.93 (12.07)

Key. SD = Standard Deviation, FT = Fitness Tracker, n = number of participants

Of the total sample, 63.2% of participants came from the two most deprived Lower Layer Super Output Areas (LSOA, 2010; defined in Chapter 3, subsection 3.2.2), slightly less than the 70% of service users from these categories typically seen on HH programmes. 59.6% of participants (n=34) were from ethnic minority backgrounds, slightly lower than the 75% usually seen on HH programmes.

In terms of occupation status, 57.9% of the sample (n=33) were not employed, classified as either unemployed, unpaid home carer, retired, never worked or unemployed for over one year, sick/disabled and unable to return to work, or as full-time students. This breakdown was in line with the 57% of service users from these categories typically seen on HH programmes. The breakdown of socioeconomic status is provided in Figure 4.1 below.

Figure 4.1. *Number of participants within various socioeconomic categories (n=57)*

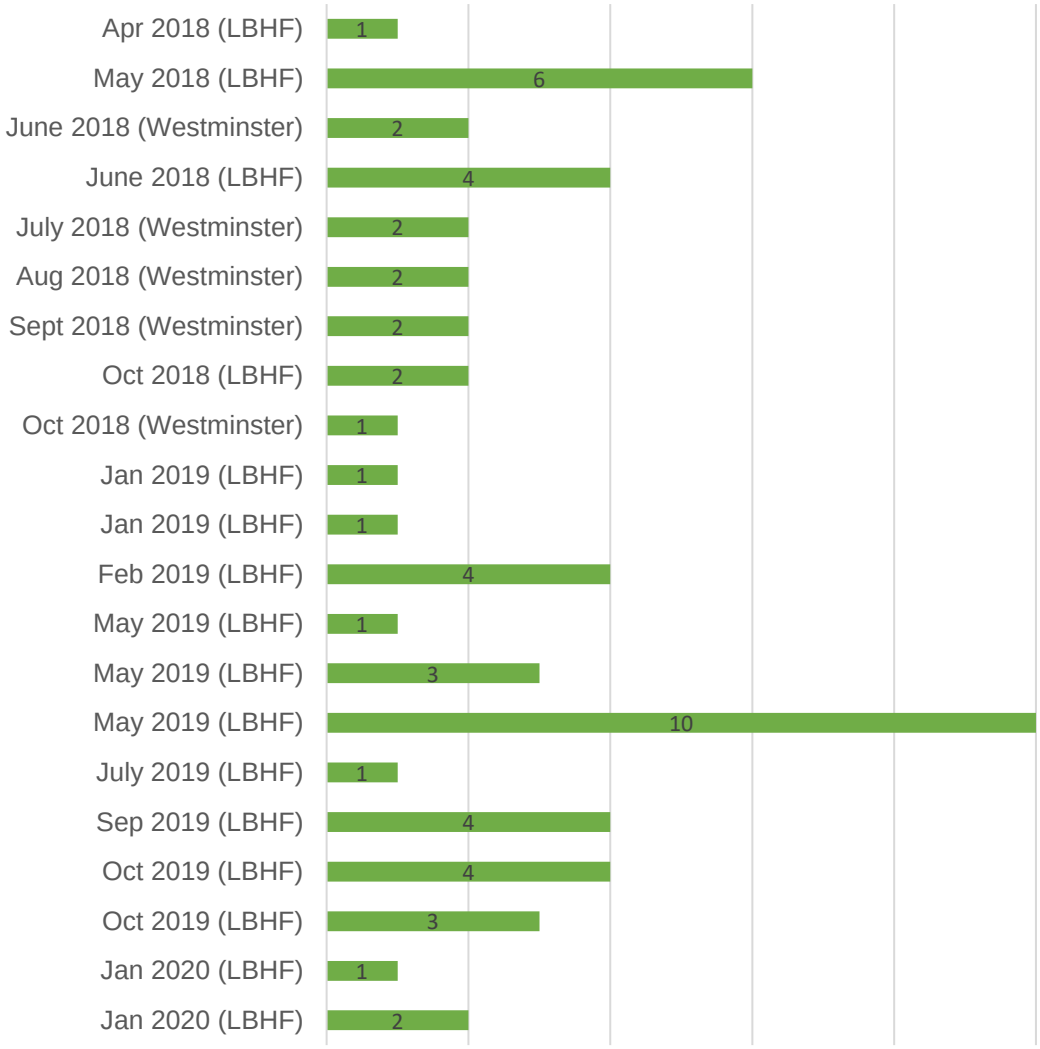


Regarding participant confidence in using technology, 34 participants (59.6%) rated themselves as confident with technology, five (8.8%) as not confident and 18 (31.6%) as somewhere in between (average). Most participants (n=37, 64.9%) were Facebook users.

Healthy Hearts-related information

Participants were recruited from 21 different weight management groups. Regarding geographical location, 48 participants (84.2%) were from the LBHF, and nine (15.8%) were from the City of Westminster. The number of recruited participants can be seen visually in Figure 4.2 below.

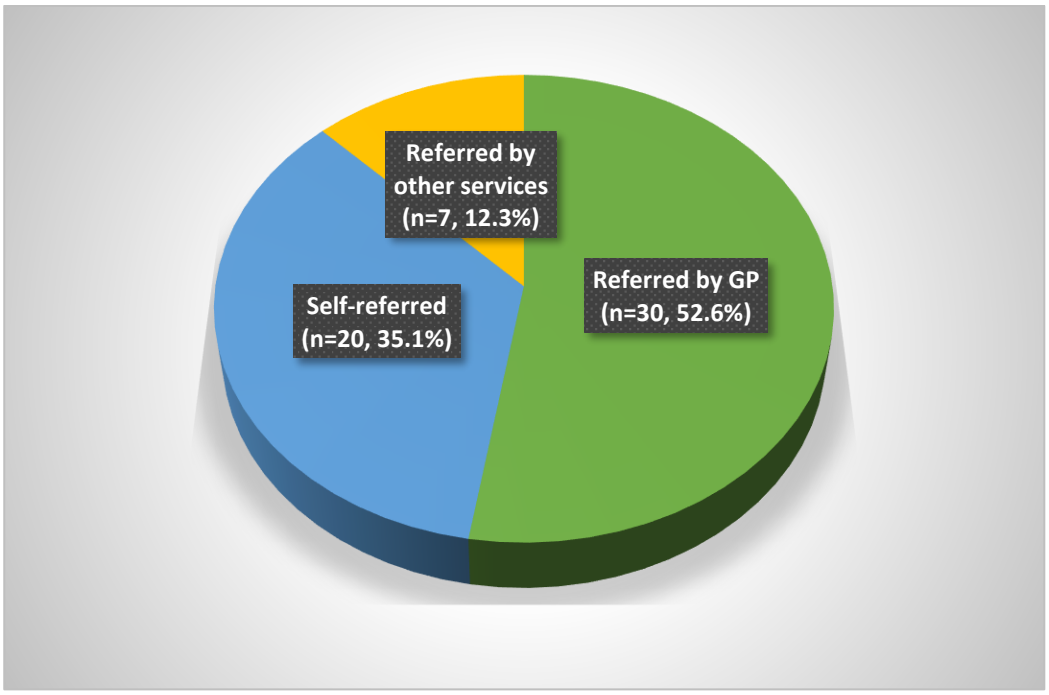
Figure 4.2. *Number of participants recruited across the London Borough of Hammersmith and Fulham and the City of Westminster (n=57)*



Key. LBHF=London Borough of Hammersmith & Fulham

The minimum number of months participants were enrolled on the HH programme was two months, while the maximum was 18 months. The mean number of months on the programme was 5.86 (SD=3.55), which was typical of the average service user. As seen in Figure 4.3 below, most participants were referred to the HH programme by their GP.

Figure 4.3. *The referral routes participants used to access the Healthy Hearts service (n=57)*

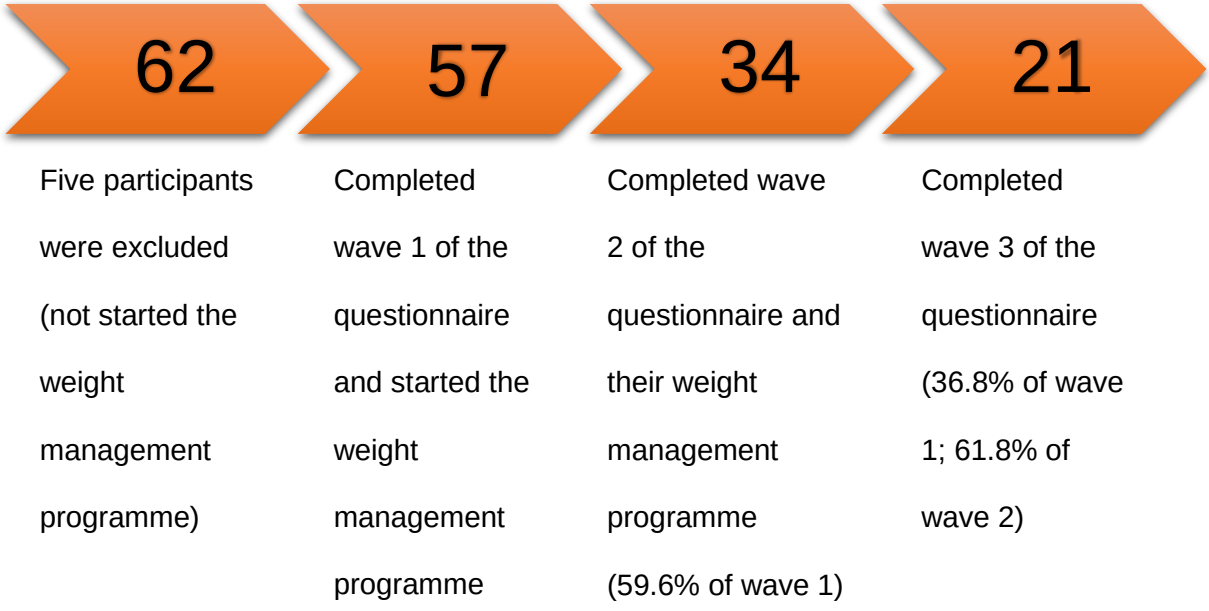


Key. GP=General Practitioner

Eleven participants (19.3%) enrolled on the programme with other family members, while 46 (80.7%) attended the programme alone. A total of 62 participants were initially recruited for the study, but on completion of the data collection (March 2020), the data from 57 participants were analysed (the breakdown is provided in Figure 4.4). Five additional participants initially consented to participate in the study and completed the first questionnaire wave (W1)

(bringing the total number of participants to 62) but could not continue their participation. Of those five, one participant's health deteriorated in the initial stages, so they could not start the weight management programme. Four other participants were prevented from starting their intervention because all HH programmes had to be suspended due to the pandemic. None of these additional participants were randomised into the study conditions nor provided with FTs. All five participants were informed that their participation in the study ceased due to circumstances outside of the researcher's control.

Figure 4.4. *The number of participants completing different stages of the study*



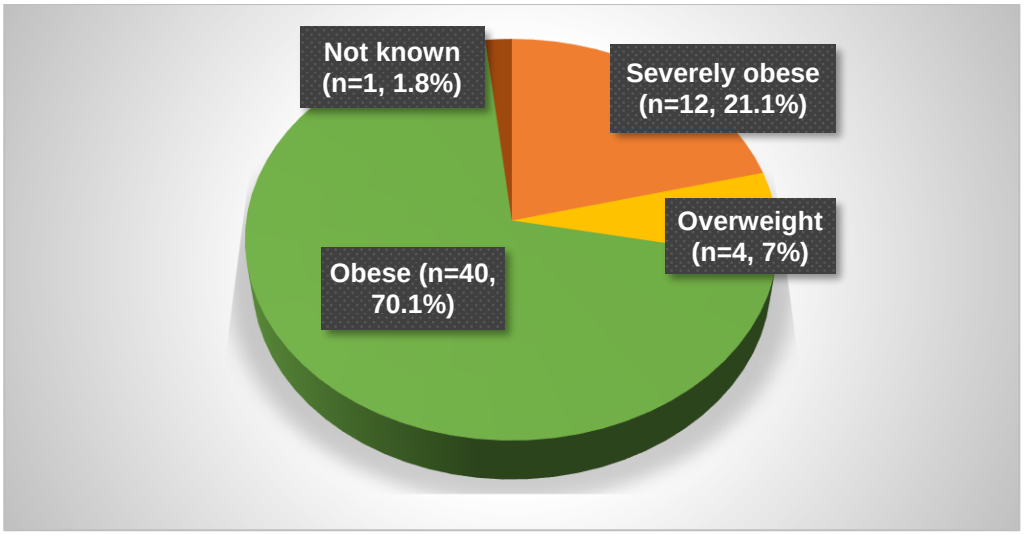
All 57 participants included in the study completed the initial and final HH care planning sessions. However, some participants did not have final session measurements recorded, i.e., weight (n=3), waist circumference (n=14), BMI (n=4), anxiety (n=14), depression (n=14), Alcohol units (n=4), QRisk score (n=16),

systolic blood pressure (n=11), diastolic blood pressure (n=11), LDL cholesterol (n=11), total cholesterol (n=11), blood glucose (n=12), Mediterranean diet score (n=4) and minutes of moderate activity (n=3). This mainly affected participants whose programmes were disrupted by the pandemic.

In terms of diagnosed medical conditions, of the 57 participants, six (10.5%) had a diagnosis of type 2 diabetes, while thirteen participants (22.8%) were diagnosed with pre-diabetes. Additionally, 24 participants (42.1%) had a diagnosis of hypertension, and ten participants (17.5%) had a diagnosis of mental health conditions. Some of these conditions overlapped. More than half of the sample (32 participants, 56.1%) were on regular medications for various medical conditions. Five participants (8.8%) were current cigarette smokers, fourteen (24.6%) were ex-smokers, and 38 had never smoked (66.7%).

Participants were grouped into three BMI categories according to the NHS BMI classification (NHS, 2018a), where a BMI between 25 and 29.9 is classed as overweight, a BMI between 30 and 39.9 as obese, and a BMI over 40 as severely obese [thresholds of 27.6 for obese and 23 for overweight were applied to Asian groups in line with NICE recommendations (NICE, 2013)]. The BMI categories breakdown in the current study can be seen in Figure 4.5 below.

Figure 4.5. *Participant BMI category breakdown (n=57)*



Key. BMI=Body Mass Index

Additionally, the BMI and weight mean values (with SD) and ranges (broken down by sex) are presented in Table 4.2.

Table 4.2. *Participant BMI and weight mean values (with SD) and ranges at the initial care planning sessions broken down by sex*

	Mean (SD)	Range
BMI Total Sample	36.33 (6.43)	27.9 – 58.8
BMI Females	36.51 (6.66)	28 – 58.8
BMI Males	35.68 (5.67)	27.9 – 48.4
Weight (kilograms) Total Sample	100.14 (18.58)	71 – 143.8
Weight Females	96.23 (17.14)	71 – 143
Weight Males	114.82 (16.89)	93 – 143.8

Key. BMI=Body Mass Index, SD=Standard Deviation

As seen above, the mean weight of males was higher than for females, which was expected. Nevertheless, it is noteworthy that the BMI of females exceeded that of males, implying that, within the sample, females exhibited a relatively higher degree of overweightness compared to males.

4.5.2 Study scale diagnostics

All scale variables were explored individually to check whether they were suitable for analysis. Some steps specific to each measure had to be taken (e.g., calculating total scores for each subscale), and these are outlined below. Subsequently, scale reliability and distribution of scores were examined for each, and these are also presented in the latter part of the section. The results are grouped into physical and psychological scales.

4.5.2.1 Distribution of scores

The distribution of scores within each of the study scales/subscales was examined. Skewness and Kurtosis of distributions were calculated and converted to z scores. They are presented in Table 4.3 below.

Table 4.3. *Skewness, Kurtosis and Standard Error values (with z scores) for all subscales across the three study waves*

Subscale	Study Wave	Skewness (Standard Error)	z score (Skewness)	Kurtosis (Standard Error)	z score (Kurtosis)
WLOC	1	.11 (.32)	.34	-.85 (.63)	-1.35
	2	.67 (.40)	1.67	-.33 (.79)	-.42
	3	.13 (.50)	.26	-.77 (.97)	-.79
Attitudes (TPB)	1	-2.35 (.32)	-7.34***	4.94 (.63)	7.84***
	2	-2.81 (.40)	-7.03***	7.79 (.79)	9.86***
	3	-2.94 (.50)	-5.88***	10.26 (.97)	10.58***
Subjective Norms (TPB)	1	-1.58 (.32)	-4.94***	2.83 (.63)	4.49***
	2	-1.82 (.40)	-4.55***	3.50 (.79)	4.43***
	3	-.38 (.50)	-.76	-1.22 (.97)	-1.26
Intention (TPB)	1	-3.36 (.32)	-10.5***	15.86 (.63)	25.17***
	2	-3.35 (.40)	-8.38***	14.44 (.79)	18.28***
	3	-1.00 (.50)	-2	-.20 (.97)	-.21
Perceived Behavioural Control (PBC, TPB)	1	-.58 (.32)	-1.81	.09 (.63)	.14
	2	-.09 (.40)	-.23	-.15 (.79)	-.19
	3	-.39 (.50)	-.78	-.41 (.97)	-.42
Patient Activation Measure	1	.85 (.32)	2.66**	.36 (.62)	.58
	2	.85 (.40)	2.13*	.96 (.79)	1.22
	3	.48 (.50)	.96	.12 (.97)	.12
Autonomous Motivation	1	-3.44 (.32)	-10.75***	15.90 (.63)	25.24***
	2	-2.59 (.41)	-6.32***	7.81 (.80)	9.76***
	3	-2.38 (.51)	-4.67***	5.19 (.99)	5.24***
Introjected Motivation	1	-.62 (.32)	-1.94	-.07 (.63)	-.11
	2	-.75 (.41)	-1.83	.15 (.80)	.19
	3	-.66 (.51)	-1.29	.40 (.99)	.40
External Motivation	1	.23 (.32)	.72	.13 (.63)	.21
	2	.38 (.40)	.95	-.28 (.79)	-.35
	3	.18 (.51)	.35	-.79 (.99)	-.80

Key. WLOC=Weight Locus of Control, TPB=Theory of Planned Behaviour;

**p<.05, **p<.01, ***p<.001; (significant z score values are highlighted in grey)*

As Field (2018) pointed out, skewness and kurtosis z scores can be classified as significant when they meet certain thresholds (above 1.96 significant at $p < .05$, above 2.58 significant at $p < .01$ and above 3.29 significant at $p < .001$ level). Scales whose scores were not evenly distributed are highlighted in grey in the table, demonstrating skewness/kurtosis. Attitudes, subjective norm, intention, and autonomous motivation were negatively skewed (at almost all study waves), indicating a build-up of high scores. The same subscales had significant kurtosis z scores indicating leptokurtic distributions (higher than normal peaks). This suggests that distributions were skewed towards high scores on attitudes, subjective norm, intention, and autonomous motivation, which to some extent is to be expected on a weight management programme where service users intend to participate to lose weight. As suggested by the creators of the TPB questionnaire construction manual (Francis et al., 2004), nonparametric tests may be required in case of highly skewed distributions.

The PAM's distribution skewness was also significant, but in contrast to other skewed scales, it showed a build-up of low scores (positively skewed). In this case, more participants were clustering to the left of the scale (less engaged in their health and healthcare). This distribution aligns with the score distribution observed in HH programmes.

Despite these uneven distributions of scores, parametric tests such as ANOVA were utilised as they are particularly robust against irregularities in distribution. For instance, Glass and colleagues (1972) suggested that under skew, kurtosis and non-normality conditions, *F* controls well for Type I error (accepting an effect in the population if there is not one/false positive) in ANOVA. In a systematic

review, Blanca and colleagues (2017) concluded that the *F*-test is a valid statistical procedure under the non-normality of score distribution.

4.5.2.2 Test-retest reliability

As some scales had skewed distribution, Spearman's correlation (rs) was employed to examine their test-retest reliability, and Pearson's correlation (r) was performed to test the remaining measures.

Physical activity scale

International Physical Activity Questionnaire (IPAQ)

Responses to the questions provided in hours were first converted to minutes in line with the 'Guidelines for the data processing and analysis of the International Physical Activity Questionnaire' (IPAQ International Consensus Group, 2005). Subsequently, the total number of weekly minutes for vigorous and moderate activity and walking were calculated. These were later multiplied by 3.3, 4.0 and 8.0, respectively, to calculate MET minutes (Metabolic Equivalent of Tasks) in line with the IPAQ manual. Next, total IPAQ PA scores were calculated by summing MET minutes of the three activity intensities for each study wave. This calculation enabled the production of continuous PA scores comparable across study waves.

The distribution of IPAQ subscales was visually assessed by looking at histograms. The positive skewness was observed in the case of vigorous and moderate activity and walking variables while the sedentary minutes variable was negatively skewed. This was in line with what was previously reported in literature e.g., Cleland et al, 2018.

Additionally, IPAQ PA categories were created in line with the IPAQ manual by including all scores below 600 MET minutes in the low PA category, scores between 600 and 2999 MET minutes in the moderate category and scores over 3000 MET minutes in the high PA category. Levels of PA fluctuated between study waves.

Correlation analyses between total PA continuous MET scores between waves revealed significant positive relationships. Wave 1 (W1) and wave 2 (W2) PA scores correlated with each other ($r = .86$, $p < .001$, $n = 34$), W2 and wave 3 (W3) had a correlation of $r = .69$ ($p < .01$, $n = 18$), and W1 and W3 also correlated ($r = .73$, $p < .001$, $n = 18$), indicating that there were positive relationships between these activity levels across all study waves. This indicates that people who were more physically active in one wave tended to maintain their activity levels in the following waves, suggesting a consistent pattern of PA over time.

Psychological scales

The Weight Locus of Control measure (WLOC)

Total WLOC scores ranged from four (high internality) to 14-15 (the middle of the scale), and no scores clustered within the top end of the scale (nearer to score 24, which would have indicated high externality) in any of the study waves. The WLOC test-retest reliability between two waves (W1 and W2) was $r = .42$ ($p < .05$, $n = 34$) and between W2 and W3, it was $r = .52$ ($p < .05$, $n = 21$). Any coefficient between .4 and .59 can be classified as having fair clinical significance (Cicchetti, 1994). In Saltzer's original study (1982), the test-retest reliability was $r = .67$, but the test was done within a 24-day interval. The current study had W2 and W3 repeated at 10 weeks and six months intervals from the initial baseline, which

may explain the difference between Saltzer's scores and those from the present study. As the coefficient values had a fair clinical significance in the current study, this scale was considered suitable for further analysis.

The Theory of Planned Behaviour (TPB) measures

The TPB scale was divided into four subscales (attitudes, subjective norm, PBC and intention), and the responses to each were averaged. When the test-retest reliability of these subscales was considered, the attitudes subscale at W1 correlated positively with the attitudes subscale at W2 (Spearman's correlation, rs = .45, $p < .01$, n = 33). At the same time, correlations between the other waves (W1 and W3 or W2 and W3) were not statistically significant. In terms of the subjective norms subscales, all correlated strongly with each other at each study wave: W1 and W2: rs = .64 ($p < .001$, n = 33), W1 and W3 correlated rs = .80 ($p < .001$, n = 20) while W2 and W3 correlated rs = .71 ($p < .001$, n = 21). PBC subscales also correlated with each other at each wave. W1 and W2 had a correlation of r = .56 ($p < .001$, n = 33), W1 and W3 had a correlation of r = .52 ($p < .05$, n = 20) and W2 and W3 had a correlation of r = .61 ($p < .01$, n = 21). The intention subscales also correlated strongly. W1 and W2 had a correlation of rs = .60 ($p < .001$, n = 33), W1 and W3 had a correlation of rs = .59 ($p < .01$, n = 20) and W2 and W3 had a correlation of rs = .76 ($p < .001$, n = 21). The reliability coefficient for this measure has ranged from fair (r = .44) to excellent (r = .82), as defined by Cicchetti (1994). These scales exhibited a good test-retest validity and thus were deemed appropriate for further use.

The Patient Activation Measure (PAM)

Total PAM scores were automatically computed using an algorithm developed by Insignia Health (the company licencing the PAM tool). These scores were explored to examine test-retest reliability. It was shown that this scale correlated positively between W1 and W2 (rs = .35, $p < .05$, n = 34) and between

W2 and W3, where the positive correlation was rs = .46 ($p < .05$, n = 21). W1 and W3 did not show any statistically significant correlations. Overall, the test-retest coefficient values were low or not significant, suggesting poor clinical significance. One reason could be linked to the change in reported activation levels. Hibbard and colleagues (2007) noted that an intervention may lead to increased activation. As PAM is a well-established and validated research tool (Greene & Hibbard, 2012), this measure was deemed appropriate for this study.

Motivation measure

The test-retest reliability was explored after the creation of the subscales (for autonomous, introjected and external motivation types). Autonomous motivation subscales correlated positively at each application occasion. W1 and W2 had a positive correlation of rs = .52 ($p < .01$, n = 32), W1 and W3 had a positive correlation of rs = .61 ($p < .01$, n = 19) while W2 and W3 had a correlation of rs = .63 ($p < .01$, n = 19). When the introjected motivation subscales were analysed, similar trends were observed. W1 and W2 had a positive correlation of r = .54 ($p < .01$, n = 32), W2 and W3 had a positive correlation of r = .86 ($p < .001$, n = 19) and W1 and W3 had a positive correlation of r = .64 ($p < .01$, n = 19).

The correlation analysis was also conducted for the external motivation subscale, and once again, similar patterns were observed. Scores for W1 and W2 showed a positive correlation of r = .74 ($p < .001$, n = 33), and those between W2 and W3 had a correlation of r = .69 ($p < .001$, n = 20) and W1 and W3 had a correlation of r = .53 ($p < .05$, n = 19). As the reliability coefficient has ranged from fair (r = .50) to excellent (r = .86), as defined by Cicchetti (1994), these scales were also deemed suitable to be used in the current study.

Hospital Anxiety and Depression scale (HADs)

Unlike the measures reported above, the HADs scores were available to the researcher through the HH data recorded during the initial and final consultations with participants (as opposed to being included in the study materials). This is important because the reported test-retest reliability was calculated for two (not three) time points. This exploration showed that there was a positive correlation between the two administrations of the anxiety scale (r = .72, $p < .001$, n = 43) and the depression scale (r=.67, $p<.001$, n=43). These test-retest results are slightly lower than results presented in previous studies, e.g., Spinhoven and colleagues (Spinhoven et al., 1997) reported a total HADs test-retest value of r = .86 ($p < .001$). The HADs measure is a validated and reliable instrument (Herrmann, 1997), but it lacks psychometric evaluations in non-clinical samples, especially in older people (Djukanovic et al., 2017). The slightly lower test-retest value can be partly attributed to the general population nature of the current sample (as opposed to clinical populations), and the measure was considered adequate to be used.

Most scales presented above were deemed suitable to use as their coefficient values were considered to have fair significance over time. PAM scale was an exception, but as pointed out above, PAM was also regarded as suitable to use in the current study due to the variable nature of the activation concept.

4.5.2.3 Scale reliability

All the scales' dimensions used in the study also had their Cronbach's alpha calculated to check their reliability across all three study waves. The results are presented in Table 4.4 below.

Table 4.4. *Cronbach's alpha values calculated for all subscales across the three study waves*

Subscale	Study Wave	Cronbach's alpha value (with the item removed)
Weight Locus of Control (WLOC)	1	.16 (.24)
	2	.44 (.47)
	3	.46 (.47)
Attitudes (TPB)	1	.87
	2	.95
	3	.79
Subjective Norms (TPB)	1	.90
	2	.90
	3	.88
Intention (TPB)	1	.92
	2	.95
	3	.94
Perceived Behavioural Control (PBC, TPB)	1	.24 (.33)
	2	.44 (.64)
	3	.65 (.68)
Patient Activation Measure	1	.85
	2	.86
	3	.86
Autonomous Motivation	1	.95
	2	.90
	3	.96
Introjected Motivation	1	.94
	2	.85
	3	.96
External Motivation	1	.74
	2	.83
	3	.86

Key. Traffic Light rating system: values below .5 = Red; between .5 and .7 = Amber; above .7 = Green; TPB=Theory of Planned Behaviour

Cronbach's alpha values were colour-coded to demonstrate reliability thresholds. All values below .5 were highlighted in red as they were considered to

have poor internal reliability. Values above .5 and below .7 were marked in amber, indicating acceptable alpha levels. Nunnally (1967) stated that values as low as .5 might be suitable for exploratory research. Alpha values above .7 were marked in green as they were considered to have good reliability.

Table 4.4 shows that Cronbach's alpha values of the WLOC scale across the three study waves were very low, especially in W1. These values were lower than those reported by Saltzer in the original study (1982), which were .58 and .56 on two administration occasions. The low level of reliability can be potentially attributed to the small number of items in this scale. It was also highlighted that while the measure is simple and easy to administer, it might be complex for someone without good verbal skills to answer (Lefcourt, 1991). When an 'alpha value when item deleted' function was explored, this did not increase the alpha value significantly (as shown in the table). Due to the low alpha value of this scale, a decision was made not to utilise the WLOC scale in the current study.

The Cronbach's alpha values for the attitudes, subjective norms, and intention subscales of the TPB measure were high and in line with values initially reported by Ajzen and Shifter (1985), where the attitudes subscale had an alpha value of .82, the subjective norms subscale had a value of .88, and the intention subscale had a value of .88. The PBC subscale was adjusted in line with the recommendation in the TPB manual (Francis et al., 2004), two items measuring controllability and two measuring self-efficacy were utilised. The manual advised removing items that significantly decrease the alpha value. As a result of removing the item measuring controllability ('*The decision to lose weight is beyond my control*'), there was an increase in an alpha value from .33 in W1 to .64 in W2 and to .68 in W3.

As Ajzen (1991) pointed out, there is no standard TPB questionnaire for any health behaviour, and tailored scales are recommended to be developed for the behaviour of interest in the studied population. Due to the PBC scale being constructed for this study according to the recommended manual (Francis et al., 2004), there were no norms for comparing these alpha values. Similar to the WLOC subscale, this measure was not analysed due to the PBC scale's low alpha value. It also must be pointed out that for both scales (WLOC and PBC), the alpha value was lower in the first wave compared to subsequent ones. This might indicate that as participants progressed through the study, they were perhaps more familiar with the wording used and understood questions better at successive scale administrations.

PAM's subscales had high alpha values across all three study waves. These were in line with previous research done with immigrant populations in the USA (Alegría et al., 2009) and in older adults with multimorbidity, also in the USA (Skolasky et al., 2011), where Cronbach's alphas were reported to be 0.83 in both studies. Prey and colleagues (2016) also reported Cronbach's alpha of 0.81 in their sample of hospitalised patients. PAM is a well-validated and reliable measure (Skolasky et al., 2011), and its validity and reliability are well-established (Greene & Hibbard, 2012).

Motivation subscales also had high alpha values indicating good reliability of scales, which were in line with previous research. For instance, Hartmann and colleagues reported Cronbach's alpha ranging from 0.80 to 0.91 (2015), demonstrating good internal consistency of items within subscales.

Overall, except for the WLOC and PBC, all measures demonstrated good internal consistency and were deemed suitable to be used in the current study.

The sections below address specific research objectives. Sections 4.5.3 and 4.5.5 address the first research objective, section 4.5.4 addresses the second objective, and the third objective is addressed in section 4.5.6. This is supplemented by the analysis of the FT data presented in section 4.5.7.

4.5.3 Physical measures over time by study conditions

The physical measures, mainly gathered during the initial and final HH sessions, were analysed to address the first research objective, i.e., to assess the effectiveness of FTs when used in addition to the standard weight management intervention. It assessed whether the 'intervention with FTs condition' (FT condition) and the 'intervention as usual condition' (control condition) have different weight management intervention outcomes (primary outcome – weight and secondary outcomes - waist circumference and BMI) that are presented in this section. PA and programme attendance have dedicated sections that follow.

Mean values, SD, and significance levels (*t* values calculated using paired-samples t-tests) for these measures are presented in Table 4.5 below. They have been divided into categories (weight, PA, physiological measures and others) and colour-coded.

Table 4.5. *Means and SDs of Healthy Hearts outcome variables at W1 and W3 for the total sample and by study conditions*

Measure	Total Initial Mean (SD)	Total Final Mean (SD)	FT Condition Initial Mean (SD)	FT Condition Final Mean (SD)	Control Condition Initial Mean (SD)	Control Condition Final Mean (SD)
Weight	100.14 (18.58)	98.62** (19.52)	98.79 (16.35)	95.83** (18.51)	101.12 (20.24)	100.54 (20.25)
% Total Weight Loss		-1.64 (3.92)		-3.05 (4.18)		-.67 (3.47)
Waist Circumference	112.77 (14.36)	111.72** (15.13)	112.64 (13.69)	109.05** (15)	112.87 (15.04)	113.83 (15.22)
BMI	36.33 (6.43)	35.86 **(6.59)	36.83 (5.26)	35.83** (6.11)	35.96 (7.24)	35.88 (7.01)
Moderate Activity (self-reported)	40.96 (54.23)	105.96*** (85.90)	28.54 (40.79)	113.73*** (82.19)	50.00 (61.24)	100.63** (89.26)
Systolic Blood Pressure	129.11 (13.88)	127.76 (13.74)	126.58 (14.72)	126.52 (15.40)	130.94 (13.16)	128.80 (12.40)
Diastolic Blood Pressure	79.77 (9.08)	79.48 (9.21)	77.67 (10.37)	79.57 (11.07)	81.30 (7.83)	79.40 (7.55)
LDL Cholesterol	3.51 (1.24)	3.46 (1.15)	3.18 (1.39)	3.01 (1.17)	3.73 (1.09)	3.84 (1.01)
Cholesterol Total	4.87 (1.13)	4.91 (.92)	4.67 (1.07)	4.61 (.80)	5.00 (1.16)	5.15 (.95)
Blood Glucose	5.90 (1.56)	5.52** (1.26)	6.14 (1.44)	5.64 (1.19)	5.74 (1.64)	5.42* (1.33)
Mediterranean Diet	8.46 (2.57)	10.04*** (2.55)	8.42 (2.84)	10.05*** (3.12)	8.48 (2.40)	10.03*** (2.11)
Alcohol Intake Units	2.95 (6.79)	3.79 (14.17)	.67 (1.37)	1.09 (3.13)	4.61 (8.52)	5.71 (18.22)
QRisk Score	10.10 (10.14)	8.98*(9.09)	8.57 (9.18)	7.33 (7.86)	11.20 (10.78)	10.26 (9.92)

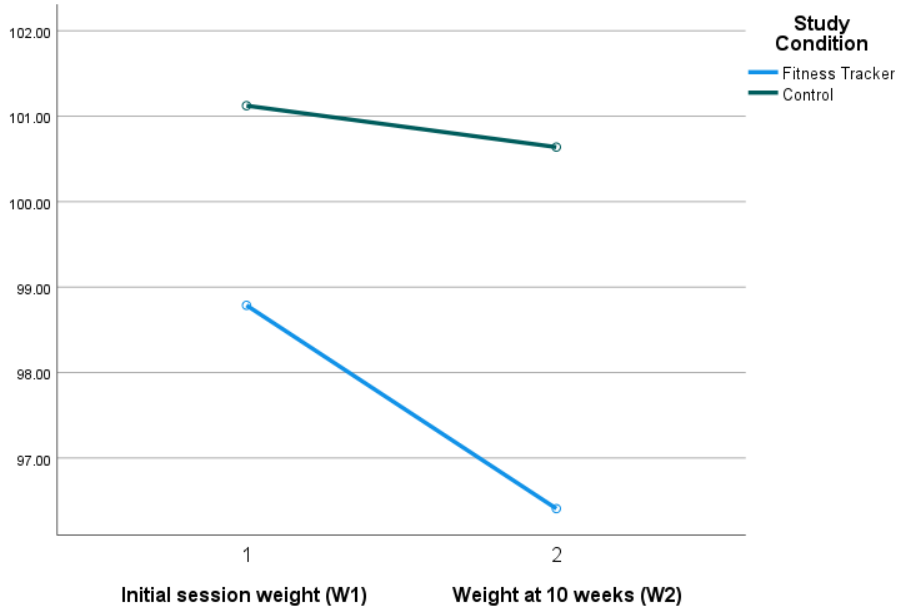
Key. BMI=Body Mass Index, SD=Standard Deviation, FT=Fitness Tracker, LDL=Low Density Lipoprotein, Qrisk=Cardiovascular Risk; Variable categories: weight (yellow), physical activity (blue), physiological measures (green) and other (pink); significant differences are highlighted in grey; *$p < .05$, **$p < .01$, ***$p < .001$

Weight measures

Weight loss

To begin with, a mixed (2X2) ANOVA was employed to examine the difference between the initial weight (W1) and the weight recorded at the end of the 10-week weight management intervention (W2). The study condition was used as a between-subjects variable (FT vs. control). Weight was used as the repeated measure variable (time factor: W1 and W2). Possible interactions between weight over time and study conditions were of interest. The analysis revealed that there was no significant main effect of the study condition [F (1, 55) = .42, p > .05], but there was a significant main effect of time, with lower weight recorded at W2 than W1 [F (1, 55) = 9.29, p <.01, r =.14]. There was also a significant interaction between the study condition and weight over time [F (1, 55) = 4.06, p <.05, r = .07], showing that the effect of the study condition on weight depended on the specific time point with lower weight seen in the FT condition over time. Levene's test was not significant for the weight measure at W1 [F (1, 55) = .63, p > .05] and at W2 [F (1, 55) = .07, p > .05], indicating that the homogeneity criteria were met. The interaction can be seen visually in Figure 4.6 below.

Figure 4.6. *The interaction between study conditions and weight at W1 and W2*



Key. W1=Wave 1 (initial session), W2=Wave 2 (weight at 10 weeks)

The mean weight at the initial session (W1) in the FTs condition was 98.79 (SD=16.35); in the control condition, it was 101.12 (SD=20.24). Immediately after the 10-week weight management programme ended (W2), the mean weight in the FTs condition was 96.41 (SD=17.95); in the control condition, it was 100.64 (SD=19.85). Paired-samples t-tests were also employed to examine weight differences separately for the total sample, FTs, and control conditions. There was a significant decrease in weight following the 10-week weight management intervention in the total sample [t (56) = 2.69, p < .01, d =.36] and the FTs condition [t (23) = 3.09, p < .01, d =.63] but not in the control condition [t (32) = .85, p > .05]. This provides evidence that the intervention was more effective (when weight is considered) in the cohort of participants utilising FTs.

A mixed (2X2) ANOVA was subsequently employed to examine weight differences over six months across both study groups and check for possible interactions between these variables. The study condition was used as a between-subjects variable. The intervention outcomes (weight) recorded at W1 and W3 were used as the repeated measures variables (time factor). There was no significant main effect of the study condition [F (1, 52) =.48, p >.05], but there was a significant main effect of time, with lower weight observed at W3 than W1 [F (1, 52) = 10.28, p < .01, r =.17]. There was no significant interaction observed between the study condition and weight over time [F (1, 52) = 3.26, p >.05]. Levene's test was not significant for the weight measure at W1 [F (1, 52) = .48, p > .05] and at W3 [F (1, 52) = .01, p > .05], indicating that the criteria for homogeneity were met.

Paired-samples t-tests were utilised to explore initial (W1) and final intervention (W3) weight measures separately for the total sample, FT, and control conditions. The repeated variable consisted of the weight outcome measure over time (measured six months apart). The results showed that the reduction in weight after six months of the intervention was significant in the total sample [t (53) = 2.86, p < .01, d =.39] and in the FTs condition [t (21) = 3.38, p < .01, d =.72] but not in the control condition [t (31) = 1.07, p >.05], see Table 4.5. for means and SDs.

Percentage weight loss

Additionally, the weight variables were converted to show the 'percentage 10-week programme weight difference' (between the initial session – W1 - and the end of the 10-week weight management programme – W2; subsequently called 'W1 & W2 weight difference %') and the 'percentage total weight difference'

(showing the difference between the initial – W1 - and final HH sessions approximately six months apart – W3; subsequently called ‘W1 & W3 weight difference %). These conversions addressed a commonly occurring problem related to heavier people losing more weight than people of lighter weight. As Bray and colleagues (2009) pointed out, using a percentage of the initial weight to demonstrate weight difference/weight loss mitigates drawing an incorrect interpretation that heavier people are considered more successful. ‘Body weight loss percentage’ is commonly used in weight management programmes, including HH.

A (2X2) mixed ANOVA was performed to explore the W1 & W2 and the W1 & W3 weight difference % across both study groups. The results showed that there was a significant main effect of the study condition [F (1, 52) = 6.21, p < .05, r = .11], with the FT group losing more weight than the control group at both time points (W1 vs W2, and W1 vs, W3). There was no main effect of time for weight difference % [F (1, 52) = .30, p > .05] and no interaction between the study condition and time for weight difference % [F (1, 52) = .12, p >.05]. Levene’s test was performed and was once again non-significant for the weight difference % at W2 [F (1, 52) = 2.19, p > .05] and at W3 [F (1, 52) = .51, p > .05].

Paired-samples t-tests were also utilised to look at the differences in W1 & W2 weight difference % and W1 & W3 weight difference % separately for the total sample, FT and control conditions. No significant differences in weight percentage between these two waves were found in the total sample [t (53) = .62, p > .05], the FT condition [t (21) = .20, p > .05] or the control condition [t (31) = .59, p > .05].

Independent samples t-tests were also performed to examine the differences in weight percentage between the study conditions (run separately for

the weight difference % variables specified above); the results are shown in Table 4.6 below. Levene's tests were not significant for weight difference % at W2 [F (52) = 2.49, p > .05] and at W3 [F (52) = .51, p > .05].

Table 4.6. *T-test results showing differences in weight percentage outcomes between study conditions*

	FT condition Mean (SD)	Control condition Mean (SD)	t value (df) and Cohen's *d*
W1 & W2 weight difference % (10-week weight management intervention)	-2.65 (4.20)	-.39 (3.19)	-2.31 (55)*, *d*= -.62
W1 & W3 weight difference % (6-months intervention)	-3.05 (4.18)	-.67 (3.47)	-2.27 (1, 52)*, *d*= -.63

Key. W1=Wave 1, W2=Wave 2, W3=Wave 3, FT=Fitness Tracker, SD=Standard Deviation, df=Degrees of Freedom; *p<.05

As seen above, individuals in the FTs condition had a significantly higher reduction in body weight percentage when compared with the control group. This reduction was significant across both periods (W1 & W2 weight difference % and W1 & W3 weight difference %).

Subsequently, other weight-related measures were looked at, namely waist circumference and BMI. First, paired-samples t-tests were utilised to explore W1 and W3 waist circumference separately for the total sample, FT, and control conditions. The results showed that the waist circumference was significantly

reduced in the total sample [t (42) = 3.12, p < .01, d =.48] and the FTs condition [t (18) = 3.03, p < .01, d =.69] but not in the control condition [t (23) = 1.42, p > .05].

Similarly, the results of the paired-samples t-test showed that the reduction in BMI at W3 was significant in the total sample [t (52) = 3.07, p < .01, d =.42] and the FTs condition [t (21) = 3.43, p < .01, d =.73], but not in the control condition [t (30) = 1.20, p > .05]. As outlined previously for the weight variable, the results were once again driven by the FT group.

Overall, the intervention with FTs showed significantly improved weight, waist circumference, and BMI compared to the control group. Following the weight and weight-related measures analysis, the focus turned to PA.

Physical activity over time by study conditions

A 2X2 mixed ANOVA was employed to examine the minutes of moderate activity variable recorded at the initial (W1) and final HH sessions (W3) across both study groups. Due to Levene's test being significant at W1 [F (1, 52) = 9.85, p < .05], which meant that the assumptions for homogeneity of variance were not met, the minutes of moderate activity scores at W1 were first ranked in SPSS. Levene's test result at W3 was not significant [F (1, 52) = 1.21, p > .05]. The subsequent results showed that there was no significant main effect of the study condition [F (1, 52) = .13, p > .05]. There was a significant effect of time [F (1, 52) = 46.86, p < .001] with an increase in the minutes of moderate activity across both study groups. There was no significant interaction between the minutes of moderate activity and study conditions [F (1, 52) = .56, p > .05].

The minutes of moderate activity variables at W1 and W3 were also examined using paired-samples t-tests run separately for the total sample, FT and control conditions. Significant increases were observed between initial and final

measures across the total sample and both study conditions. Moderate activity levels significantly improved over time in the total sample [t (53) = -5.49, p < .001, d = -.75], FTs condition [t (21) = -4.40, p < .001, d = -.94] and the control condition [t (31) = -3.50, p < .001, d = -.62]. The effect size was more prominent in the FTs condition (d = -.94 versus d = -.62), indicating that the FT condition performed better.

In addition to the self-reported moderate activity measures discussed above (obtained by HH staff in the initial and final intervention sessions), IPAQ outcomes (PA assessed through the International Physical Activity Questionnaire-IPAQ at W1, W2 and W3) were also explored. Vigorous and moderate activity, walking and sitting variables were investigated separately in this order. Total self-reported MET-minutes have been also calculated by combining vigorous, moderate and walking variables. All of these are presented below.

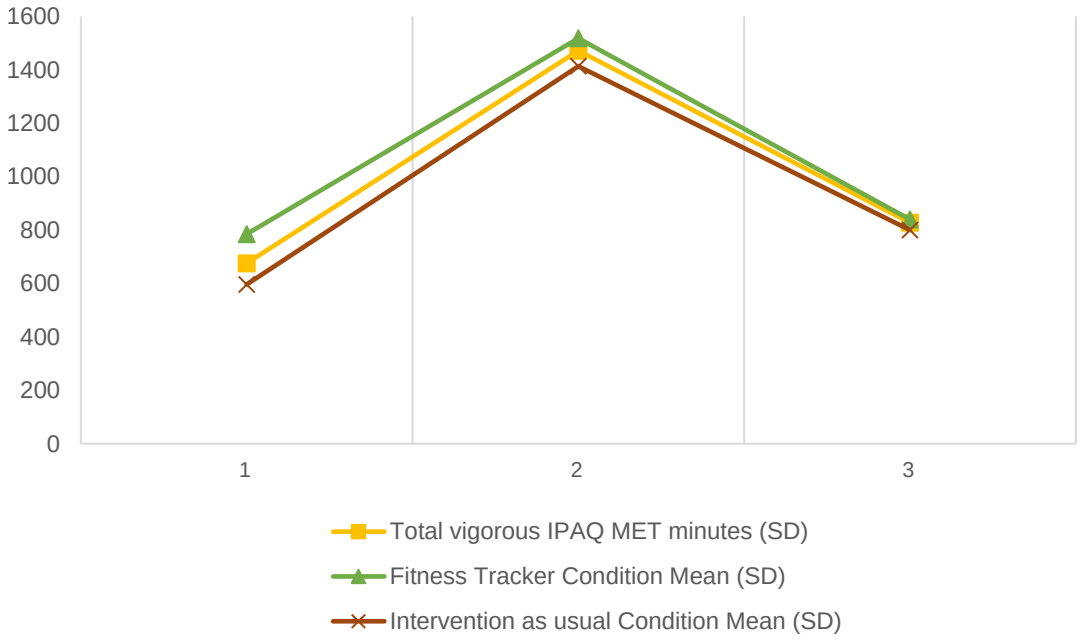
Once vigorous IPAQ scores were converted to MET minutes, the means (and SD) were calculated. These are presented in Table 4.7 and Figure 4.7.

Table 4.7. *Means and SDs of the vigorous IPAQ MET minutes over time (for the total sample and by study conditions)*

Study Wave	Total vigorous IPAQ MET minutes (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	675.79 (1115.06)	785.00 (1134.55)	596.36 (1111.41)
2	1471.76 (1737.76)	1517.89 (1977.58)	1413.33 (1443.38)
3	828.00 (1282.96)	840.00 (1333.77)	800.00 (1275.99)

Key. SD=Standard Deviation, IPAQ = International Physical Activity Questionnaire, MET = Metabolic Equivalent of Tasks, FT = Fitness Tracker

Figure 4.7. *Mean values of the vigorous IPAQ MET minutes across three study waves (for the total sample and by study conditions)*



As seen above, the vigorous PA level increased in W2 and then decreased in W3 but remained higher than the W1 level. A 2X3 mixed ANOVA model (vigorous IPAQ MET minutes variable in two study conditions repeated at W1, W2 and W3) was utilised to test whether these differences were significant. Levene's test results were not significant [F (1, 18) = .45, p > .05 at W1; F (1, 18) = .03, p > .05 at W2; F (1, 18) = .06, p > .05 at W3]; therefore, the equality of variances could be assumed. Mauchly's test of sphericity of variance was non-significant (p > .05), indicating that the variances of differences were roughly equal. The mixed ANOVA test revealed that there was no effect of the study condition [F (1, 18) = .02, p > .05] and no effect of time [F (2, 36) = 3.26, p > .05]. There was also no significant interaction between the study condition and time for the vigorous IPAQ MET minutes variable [F (2, 36) = .11, p > .05].

After a visual inspection of Figure 4.7, it was felt that significant differences between vigorous PA mean might be present between the study waves. Paired-samples t-tests were run for each study condition, looking separately at W1 and W2, W2 and W3, and W1 and W3. The vigorous PA differences were significant between W1 and W2 in the FT condition [t (18) = -2.82, p < .01, d = -.65] and in the control condition [t (14) = -2.37, p < .05, d = -.61]. FT condition had, therefore, a slightly larger effect size (d = -.65 versus d = -.61). No significant differences in vigorous PA were found between W2 and W3 in the FT condition [t (13) = 1.07, p > .05] or the control condition [t (5) = 1.45, p > .05]. There were no significant differences in vigorous PA between W1 and W3 in the FT condition [t (13) = -.54, p > .05] or the control condition [t (5) = -.22, p > .05].

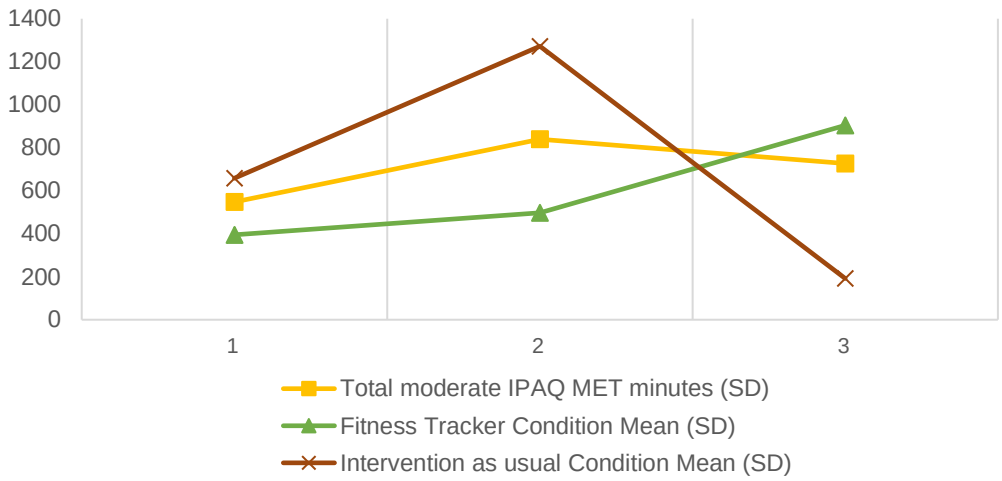
The same steps were repeated to analyse moderate IPAQ MET minutes. The means and SDs are provided in Table 4.8, while trends are shown visually in Figure 4.8.

Table 4.8. *Means and SDs of the moderate IPAQ MET minutes over time (for the total sample and by study conditions)*

Study Wave	Total moderate IPAQ MET minutes (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	547.72 (1253.73)	395.00 (1000.07)	658.79 (1414.80)
2	839.41 (1687.40)	497.89 (973.54)	1272.00 (2265.88)
3	726.00 (1165.54)	904.00 (1298.49)	192.00 (276.26)

Key. SD=Standard Deviation, IPAQ = International Physical Activity Questionnaire, MET = Metabolic Equivalent of Tasks, FT = Fitness Tracker

Figure 4.8. *Mean values of the moderate IPAQ MET minutes across three study waves (for the total sample and by study conditions)*



As seen above, the moderate activity level increased in W2 across both study groups and continued to increase in the FT condition in W3. There was, however, a sharp decrease in moderate activity levels in the control condition in W3. Participants in the FT condition steadily increased and did not decrease their activity as in the control condition. This implies that their exercising habit might be more likely to continue than those in the control group, potentially due to the impact of the FT. Notably, participants in the control group had slightly higher scores than those in the FT condition, but these were not significantly different.

These trends were explored using a 2X3 mixed ANOVA model (moderate IPAQ MET minutes variable in two study conditions repeated at W1, W2 and W3), but while Levene's test results were not significant [F (1, 18) = .84, p > .05 at W1; F (1, 18) = .06, p > .05 at W2; F (1, 18) = 4.55, p > .05 at W3], Mauchly's test of sphericity was significant [W (2) = .40, p <.001], indicating that the variances of differences were not equal. Considering this, the F-ratios were intended to be treated cautiously, and adjusted values were reported. The mixed ANOVA test

revealed that there was no main effect of the study condition [F (1, 18) = .60, p > .05]. There was also no significant effect of time [F (1.25, 22.53) = .20, p > .05]. No significant interaction was present between the study condition and the time for the moderate IPAQ MET minutes variable [F (1.25, 22.53) = .77, p > .05].

Similarly to vigorous activity, paired-samples t-tests were also performed for each study condition, looking at moderate IPAQ MET minutes variable separately in W1 and W2, W2 and W3, and W1 and W3. There were no significant differences in moderate PA detected between W1 and W2 in the FT condition [t (18) = -.40, p > .05] or the control condition [t (14) = -1.22, p > .05]. No differences were detected in moderate PA between W2 and W3 in the FT condition [t (14) = -1.25, p > .05] or the control condition [t (4) = 1.12, p > .05]. The same was observed when moderate PA in W1 and W3 were compared in the FT condition [t (14) = -1.08, p > .05] and the control condition [t (4) = 1.63, p > .05].

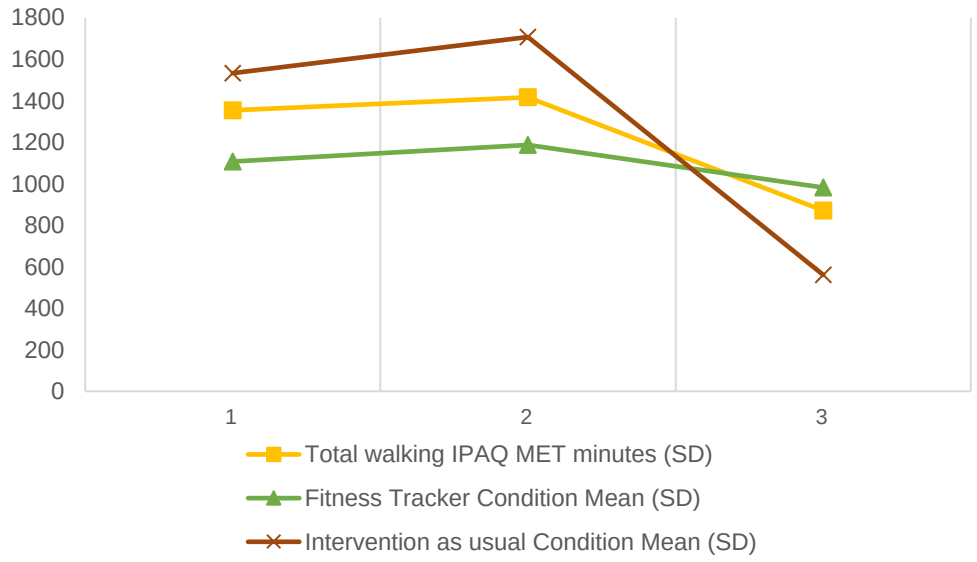
Regarding walking activity, again, the same steps were taken to analyse walking IPAQ MET minutes. The means and SDs are provided in Table 4.9, while trends are shown visually in Figure 4.9.

Table 4.9. *Means and SDs of the walking IPAQ MET minutes over time (for the total sample and by study conditions)*

Study Wave	Total walking IPAQ MET minutes (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	1353.87 (2342.17)	1106.88 (1999.51)	1533.50 (2578.26)
2	1416.57 (1928.57)	1187.13 (1993.17)	1707.20 (1870.12)
3	871.03 (1192.58)	981.75 (1366.81)	561.00 (406.85)

Key. SD=Standard Deviation, IPAQ = International Physical Activity Questionnaire, MET = Metabolic Equivalent of Tasks, FT = Fitness Tracker

Figure 4.9. *Mean values of the walking IPAQ MET minutes across three study waves (for the total sample and by study conditions)*



As seen above, the level of walking increased in W2 and then decreased in W3. To test whether any of these differences were significant, a 2X3 mixed ANOVA model was utilised (walking IPAQ MET minutes variable in two study conditions repeated at W1, W2 and W3). Levene's test was not significant [F (1, 17) = 1.61, p > .05 at W1; F (1, 17) = 1.01, p > .05 at W2; F (1, 17) = 2.72, p > .05 at W3]; therefore, the equality of variances could be assumed. Mauchly's test of sphericity of variance was not significant (p > .05), indicating that the variances of differences were roughly equal. The mixed ANOVA test revealed that there was no main effect of the study condition [F (1, 17) = .48, p > .05]. There was no significant effect of time [F (1, 17) = .89, p > .05] and no significant interaction between the study condition and time for walking IPAQ MET minutes variable [F (1, 17) = 1.05, p > .05].

As above, paired-samples t-tests were also performed for each study condition, looking at the walking measure separately in W1 and W2, W2 and W3,

and W1 and W3. There were no significant differences in walking detected between W1 and W2 in the FT condition [t (18) = .31, p > .05] or the control condition [t (14) = -.63, p > .05]. No differences in walking were detected between W2 and W3 in the FT condition [t (13) = 1.18, p > .05] or the control condition [t (4) = 1.12, p > .05]. The same was observed when walking variables in W1 and W3 were compared in the FT condition [t (13) = 1.83, p > .05] and the control condition [t (4) = -.06, p > .05].

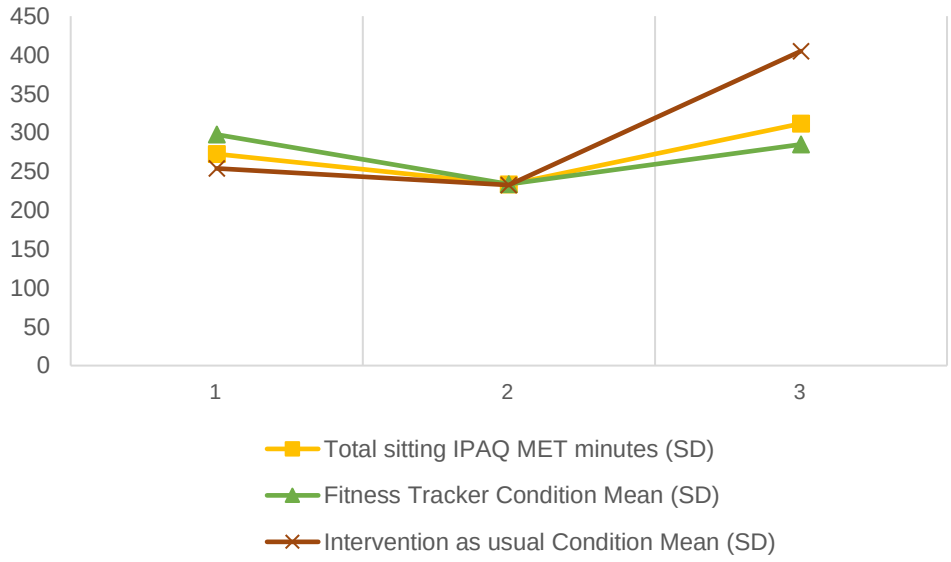
The same statistical tests were employed to examine sitting patterns. This variable was not converted into MET minutes, as instructed in the IPAQ manual (IPAQ International Consensus Group, 2005). The means and SDs are provided in Table 4.10, while trends are shown visually in Figure 4.10.

Table 4.10. *Means and SDs of the sitting IPAQ minutes over time (for the total sample and by study conditions)*

Study Wave	Total sitting IPAQ minutes (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	272.28 (228.16)	297.50 (237.20)	253.94 (223.24)
2	233.23 (156.60)	233.68 (165.10)	232.50 (149.25)
3	311.67 (207.88)	285.00 (226.27)	405.00 (90.00)

Key. SD=Standard Deviation, IPAQ = International Physical Activity Questionnaire, FT = Fitness Tracker

Figure 4.10. *Mean values of the sitting IPAQ minutes across three study waves (for the total sample and by study conditions)*



As seen above, the sitting level decreased across both study conditions in W2. Subsequently, in W3, it increased in the control condition to a higher level than in W1, whereas in the FTs condition, although it increased, it was lower than in W1. A 2X3 mixed ANOVA model was utilised (sitting variable in two study conditions repeated at W1, W2 and W3). Levene's test was not significant [F (1, 14) = .58, p > .05 at W1; F (1, 14) = 2.37, p > .05 at W2; F (1, 14) = .66, p > .05 at W3]; Mauchly's tests was also not significant (p > .05). The mixed ANOVA test revealed that there was no main effect of the study condition [F (1, 14) = .02, p > .05]. There was no significant main effect of time for sitting minutes [F (1, 14) = .74, p > .05] and no significant interaction between the study condition and sitting minutes variable over time [F (1, 14) = 2.00, p > .05].

Paired-samples t-tests were also performed for each study condition, looking at the sitting measure separately in W1 and W2, W2 and W3, and W1 and

W3. The only significant difference in sitting was between W1 and W2 in the FT condition [t (18) = 2.39, p < .05, d =.55], which saw a decrease between the two time periods. This reduction was not significant in the control condition [t (11) = .18, p >.05]. No differences in sitting were detected between W2 and W3 in the FT condition [t (13) = -1.37, p > .05] or the control condition [t (1) = -7.00, p > .05]. The same was observed when the sitting variable in W1 and W3 were compared in the FT condition [t (13) = .85, p > .05] and the control condition [t (3) = - 1.67, p > .05].

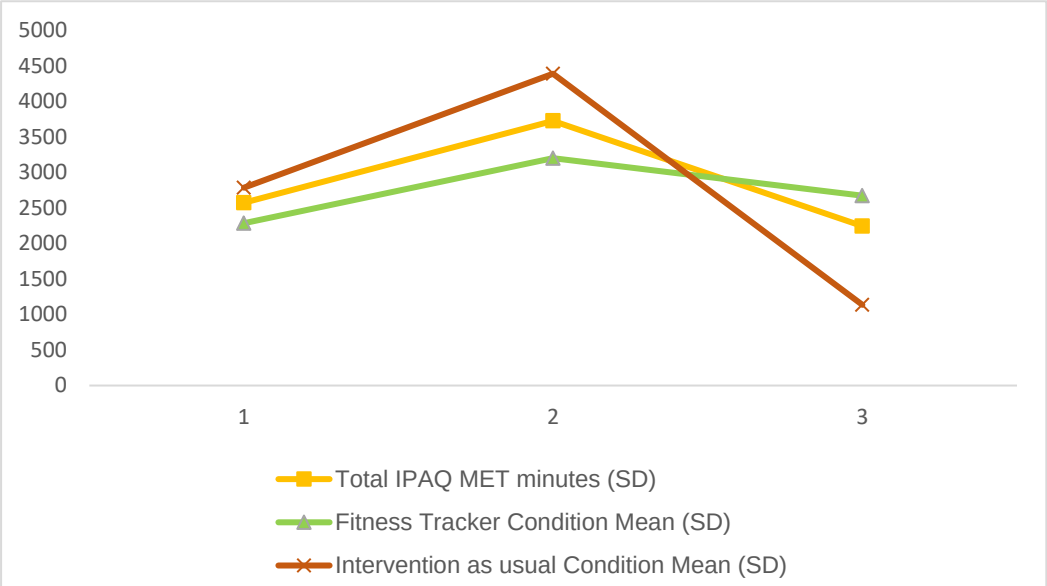
Total self-reported MET-minutes have been also calculated by combining vigorous, moderate and walking variables. These are presented in Table 4.11 and Figure 4.11.

Table 4.11. *Means and SDs of the total IPAQ MET minutes over time (for the total sample and by study conditions)*

Study Wave	Total IPAQ MET minutes (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	2577.38 (3397.16)	2286.88 (3182.86)	2788.65 (3578.48)
2	3727.75 (3763.47)	3202.92 (3840.70)	4392.53 (3684.14)
3	2246.08 (2965.18)	2672.65 (3370.75)	1137.00 (1072.86)

Key. SD=Standard Deviation, IPAQ = International Physical Activity Questionnaire, MET = Metabolic Equivalent of Tasks, FT = Fitness Tracker

Figure 4.11. *Mean values of the total IPAQ MET minutes across three study waves (for the total sample and by study conditions)*



As seen above, the total PA level increased in W2 and then decreased in W3. A 2X3 mixed ANOVA model (total IPAQ MET minutes variable in two study conditions repeated at W1, W2 and W3) was utilised to test whether these differences were significant. Levene's test results were not significant [F (1, 16) = .62, p > .05 at W1; F (1, 16) = .41, p > .05 at W2; F (1, 16) = 2.71, p > .05 at W3]; therefore, the equality of variances could be assumed. Mauchly's test of sphericity of variance was non-significant (p > .05), indicating that the variances of differences were roughly equal. The mixed ANOVA test revealed that there was no effect of the study condition [F (1, 16) = .41, p > .05] and no effect of time [F (2, 32) = 1.42, p > .05]. There was also no significant interaction between the study condition and time for the total IPAQ MET minutes variable [F (2, 32) = .53, p > .05].

After a visual inspection of Figure 4.11, it was felt that significant differences between total PA mean might be present between the study waves. Paired-samples t-tests were run for each study condition, looking separately at W1 and

W2, W2 and W3, and W1 and W3. The total PA difference was not significant between W1 and W2 in the FT condition [t (18) = -1.70, p > .05] but it was significant in the control condition [t (14) = -2.57, p < .05, d = -.66]. No significant difference in total PA was found between W2 and W3 in the FT condition [t (12) = .46, p > .05] but there was a significant difference in the control condition [t (4) = 2.31, p < .05, d = 1.03]. There were no significant differences in total PA between W1 and W3 in the FT condition [t (12) = .45, p > .05] or the control condition [t (4) = .34, p > .05].

To summarise, none of the four self-reported PA variables recorded using IPAQ questionnaires produced significant differences between study conditions or study waves in the mixed model ANOVA tests. However, when paired-samples t-tests were employed, the increase in vigorous PA was significant between W1 and W2 in both study conditions (with a slightly larger effect size and significance level in the FT condition). The reduction in sitting minutes was significant only in the FT condition between W1 and W2. When total IPAQ scores were tested, the differences between W1 and W2 as well as between W2 and W3 were significant only in the control condition.

Interestingly, when moderate PA levels recorded as part of HH (six months apart) were examined, both study groups significantly improved PA over time (with a more prominent effect size in the FT condition). These results show that the FT group had better PA outcomes than the control condition.

In addition to the PA results presented above, the data obtained through FTs have also been analysed and are presented in section 4.5.7. The analysis of physiological and other measures is presented next.

Physiological and other measures over time by study conditions

As seen in Table 4.5, some significant results were observed when physiological measures obtained in initial (W1) and final HH sessions (W3) were analysed. A 2X2 mixed ANOVA test looking at blood glucose results between study groups and over time (W1 and W3) showed that there was no significant main effect of the study condition [F (1, 40) = .41, p > .05]. However, there was a significant main effect of time [F (1, 40) = 7.61, p < .01, r=.16] with lower blood glucose readings recorded at W3. There was no significant interaction between blood glucose and study conditions [F (1, 40) = .04, p > .05]. Levene's tests were not significant [F (1, 40) = .67, p > .05 at W1; F (1, 40) = .02, p > .05 at W3].

When the paired-samples t-test was employed, it showed that the decrease in blood glucose was significant in the total sample [t (41) = 2.85, p < .01, d =.44] and in the control condition [t (23) = 2.37, p < .05, d =.48]. This difference was not significant in the FTs condition [t (17) = 1.60, p > .05].

When it came to the Mediterranean diet scores, a 2X2 mixed ANOVA test showed that there was no significant main effect of the study condition [F (1, 51) =.00, p > .05]. However, there was a significant main effect of time [F (1, 51) = 32.72, p < .001, r =.39] with higher Mediterranean diet scores reported at W3 in comparison with W1. No significant interaction was observed [F (1, 51) = .00, p > .05]. Levene's tests were not significant [F (1, 51) = .37, p > .05 at W1; F (1, 51) = 1.52, p > .05 at W3].

Paired-samples t-tests were also explored to look at each group separately. Significant improvements in the Mediterranean diet score were observed in the total sample over time [t (52) = -5.85, p < .001, d = -.80], the FTs condition [t (21) = -4.93, p < .001, d = -1.05] and the control condition [t (30) = -3.88, p < .001, d

=.70]. It is important to mention that the most prominent effect size was in the FTs condition (*d* = -1.05).

A 2X2 mixed ANOVA was also run to examine cardiovascular risk factor measure (QRisk) at W1 and W3 across both study groups. No main effect of the study condition was identified [*F* (1, 38) = .67, *p*>.05], but there was a significant main effect of time [*F* (1, 38) = 5.69, *p* < .05, *r* =.13] showing a reduction in both groups at W3. No significant interaction between study conditions and QRisk across time was identified [*F* (1, 38) = .32, *p* > .05].

When paired-samples t-tests were applied, the differences were significant only in the total sample [*t* (39) = 2.35, *p* < .05, *d* =.37]. This difference was not significant in the FT condition [*t* (16) = 1.48, *p* > .05] or the control condition [*t* (22) = 2.03, *p* > .05].

To summarise, blood glucose measure decreased in the total sample, driven by the reduction observed in the control condition. The Mediterranean diet scores improved across both conditions over time, with a more prominent effect size in the FT condition. The QRisk score significantly decreased in the total sample over time, but these differences were not significant when individual study groups were examined. No significant differences were identified in blood pressure and cholesterol measures or the alcohol intake units (*p* > .05). The following section focuses on the psychological measures used in this research.

4.5.4 Psychological measures over time by study conditions

The following section addresses the second research objective, which assessed the factors associated with successful weight loss and tested whether they differ across the study conditions (FTs versus control) over time. The analysis

results for the TPB, WLOC, anxiety, depression, PAM and motivation measures are presented below.

Theory of planned behaviour measures over time and by study conditions

The TPB subscales were scrutinised, and their means and standard deviations (SDs) across all three study waves are presented in Table 4.12 below.

Table 4.12. *Means and SDs for TPB subscales at three study waves (for the total sample and by study conditions)*

TPB Subscale	Study Wave	Total Mean (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
Attitudes	1	6.35 (1.17)	6.41 (1.23)	6.30 (1.14)
	2	6.37 (1.40)	6.49 (1.18)	6.21 (1.67)
	3	6.25 (1.35)	6.18 (1.56)	6.44 (.65)
Subjective Norm	1	6.04 (1.11)	6.14 (.78)	5.97 (1.30)
	2	5.79 (1.46)	6.12 (.77)	5.37 (1.98)
	3	5.68 (1.05)	6.03 (.84)	4.79 (1.05)
Intention	1	6.56 (.74)	6.58 (.49)	6.55 (.88)
	2	6.25 (1.12)	6.29 (.72)	6.20 (1.52)
	3	5.85 (1.35)	6.13 (.88)	5.13 (2.06)
PBC	1	4.69 (1.09)	4.74 (1.06)	4.66 (1.12)
	2	4.76 (1.13)	5.04 (1.13)	4.40 (1.05)
	3	4.95 (1.14)	5.13 (.96)	4.50 (1.52)

Key. TPB=Theory of Planned Behaviour; SD=Standard Deviation; PBC=Perceived Behavioural Control; Higher values indicated stronger intentions and positive attitudes towards performing the behaviour, stronger control over the behaviour and more supportive subjective norm

Some minor changes between study waves and conditions were observed. These were tested using a mixed 2X3 ANOVA model. The intervention group (the FT versus the control conditions) was used as a between-subjects variable. The TPB subscales were used as repeated measures over time (within-subject) at W1, W2 and W3, and each was run separately.

When the attitudes scale was explored, the analysis revealed no main effect of the study condition [F (1, 18) = 1.39, p > .05]. There was also no main effect of time [F (2, 36) =.87, p > .05] and no significant interaction between the study condition and attitudes scores over time [F (2, 36) = 1.52, p > .05]. Levene's tests were not significant at any study waves ([F (1, 18) =.15, p > .05; F (1, 18) = 2.09, p > .05; F (1, 18) = 1.08, p > .05]. Mauchly's test was also non-significant (p > .05).

Regarding the subjective norms scale, Levene's test for homogeneity of variance was significant at W1 [F (1, 18) = 6.25, p < .05] and at W2 [F (1, 18) = 18.34, p < .001] but not at W3 [F (1, 18) = .54, p > .05]. Mauchly's test result was also significant [W (2) = .53, p < .01]. As a result, ranked scores for W1 and W2 subjective norms scales were used in the mixed 2X3 ANOVA analysis. The test revealed that there was no main effect of the study condition [F (1, 18) = 1.30, p > .05]. There was, however, a significant effect of time [F (1.42, 25.59) = 20.20, p < .001, r = .53] with a significant decrease in subjective norms scores. There was no significant interaction between the study conditions and subjective norms over time [F (1.42, 25.59) = .69, p > .05]. Paired-samples t-tests using ranked variables confirmed that the differences across all waves were significant (W1 & W2 and W1 & W3 at p < *.001*, and W2 & W3 at p < *.01*). The subjective norms scores went down at each study wave, indicating less supportive subjective norms towards weight loss.

Regarding intention, ranked scores were also used due to Levene's tests being significant at all study waves [F (1, 18) = 5.52, p < .05 at W1; F (1, 18) = 4.69, p < .05 at W2; F (1, 18) = 32.49, p < .001 at W3]. Mauchly's test result was not significant. The results of a 2X3 mixed ANOVA showed no main effect of the study condition [F (1, 18) = .01, p > .05]. However, there was a main effect of time [F (1.33, 23.85) = 19.17, p < .001, r = .52], indicating that there was a meaningful relationship between time passing and the changes in people's intentions. All paired-sample t-tests were significant at p < .001 level, indicating that scores in intention differed across all study waves. There was no significant interaction between the study conditions and intention over time [F (1.33, 23.85) = .27, p > .05]. As PBC had a low alpha value (discussed earlier), it was not included in this analysis.

To summarise, significant decreases in subjective norms and intentions to lose weight were found, indicating less supportive subjective norms towards weight loss and deteriorating intentions to lose weight as time progressed. These decreases were not driven by any specific study condition.

Weight Locus of Control over time

WLOC mean scores (and SDs) for the three study waves were calculated and are shown in Table 4.13 below.

Table 4.13. *Means and SDs for the WLOC scale at three study waves (for the total sample and by study conditions)*

Study Wave	Total WLOC Mean (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	8.04 (2.68)	7.46 (2.75)	8.47 (2.59)
2	7.56 (3.16)	7.05 (3.37)	8.20 (2.83)
3	8.62 (3.12)	8.07 (3.17)	10.00 (2.76)

Key. SD=Standard Deviation; WLOC=Weight Locus of Control; higher scores indicated more external weight locus of control

These results indicated that the average WLOC score decreased in W2 (at the end of the 10-week weight management programme) and then increased in W3 at the HH programme sign-off point. As pointed out earlier, due to the low reliability of the WLOC scale, no further analysis was conducted on this measure.

Hospital Anxiety and Depression scale over time and by study conditions

When HADs mean values (and SDs) were considered (shown in Table 4.14 below), the analysis showed that the means for both scales were lower at W3 (final care planner session), indicating a reduction in anxiety and depression scores.

Table 4.14. *Means and SDs for Anxiety and Depression scales at the initial (W1) and final care planning sessions (W3)*

Measure	Total Initial Mean (SD)	Total Final Mean (SD)	FT Condition Initial Mean (SD)	FT Condition Final Mean (SD)	Control Condition Initial Mean (SD)	Control Condition Final Mean (SD)
Anxiety	8.07 (5.13)	6.02*** (3.67)	8.04 (4.17)	5.50** (3.69)	8.10 (5.81)	6.48* (3.68)
Depression	6.44 (4.65)	4.49** (3.45)	6.43 (4.74)	3.80* (3.32)	6.45 (4.65)	5.09 (3.53)

Key. SD=Standard Deviation, W1=Wave 1, W3=Wave 3, FT=Fitness Tracker; significant results are highlighted in grey; **p<.05, **p<.01, ***p<.001*

Ranges for each scale were calculated for the two waves, W1 and W3 (the initial and final care planning sessions). Anxiety scale scores ranged from 0 to 21 in W1 and 0 to 14 in W3. Depression scores ranged from 0 to 15 and 0 to 12, respectively. For both scales, scores were lower when measured on the second occasion. Applying Zigmond and Snaith's cutoff points for the identification of anxiety and depression pathology (1983), individuals with scores of eight and above can be suspected of having anxiety and/or depression, while those scoring 11 or above can be classified as confirmed cases (have anxiety or depression). In line with these thresholds, participants in both study groups met the criteria for suspected anxiety, while no participants met the criteria for depression. There were no significant differences in anxiety or depression scores between the study groups at baseline.

A mixed (2X2) ANOVA was run to test anxiety scores in both study groups across time. The intervention group (FT and control conditions) was used as a

between-subjects variable. Anxiety outcomes recorded at W1 and W3 were used as dependent variables over time (within-subject). The results showed no main effect of the study condition [F (1, 41) = .60, p > .05], but there was a main effect of time [F (1, 41) = 12.76, p < .001, r = .24]. No significant interaction between study conditions and anxiety over time was identified [F (1, 41) = .01, p > .05]. Levene's tests were not significant at W1 [F (1, 41) = 2.70, p > .05] and at W3 [F (1, 41) = .02, p > .05].

Paired-samples t-tests were utilised to explore W1 and W3 anxiety measures separately for the total sample, the FTs, and the control condition. The results showed that the reduction in anxiety scores after six months of the intervention was significant in the total sample [t (42) = 3.62, p < .001, d = .55], the FTs condition [t (19) = 3.05, p < .01, d = .68] and the control condition [t (22) = 2.26, p < .05, d =.47]. It needs to be highlighted that the result in the FT condition was more significant and had a larger effect size.

Similarly, a mixed (2X2) ANOVA was also run to test depression scores in both study groups across time. The results showed no main effect of the study condition [F (1, 41) = 1.08, p > .05], but a main effect of time was detected [F (1, 41) = 10.50, p <. 01, r = .20]. No significant interaction between study conditions and depression over time was identified [F (1, 41) = .07, p > .05]. Levene's tests were not significant at W1 [F (1, 41) = .26, p > .05] and at W3 [F (1, 41) = .02, p > .05].

Paired-samples t-tests were also employed to look at the differences in depression scores in the total sample and each of the study conditions. The reduction in depression scores after six months of the intervention was significant

in the total sample [t (42) = 3.27, p < .01, d = .50] and the FTs condition [t (19) = 2.55, p < .05, d =.57] but not in the control condition [t (22) = 2.08, p > .05].

In summary, the mixed ANOVA tests revealed significant reductions in anxiety and depression scores between W1 and W3 over time. However, there was no difference in the magnitude of the reduction between the two groups. When paired-samples t-tests were performed, the reduction in anxiety scores was significant in both study groups (with more significant results and a larger effect size in the FT condition). The depression scores, however, were only significantly reduced over six months in the FT condition. Once again, these results indicate more favourable results in the FT group.

Patient Activation Measure over time and by study conditions

Continuous PAM scores (automatically categorised by the Insignia Health algorithm tool into four levels) are presented in Table 4.15 below, along with corresponding ranges.

Table 4.15. *The number of participants (including cumulative %) categorised into four PAM levels (and ranges) across the three study waves*

Study Wave	Level 1	Level 2	Level 3	Level 4	Ranges
1	11 (19.3%)	12 (21.1%)	22 (38.6%)	12 (21.1%)	38.1-100
2	2 (5.9%)	10 (29.4%)	13 (38.2%)	9 (26.5%)	38.1-100
3	4 (19%)	7 (33.3%)	7 (33.3%)	3 (14.3%)	35.5-84.8

Key. PAM=Patient Activation Measure

Additionally, the continuous variable's means (and SD) were explored in the total sample and intervention groups, presented in Table 4.16.

Table 4.16. *Means and SDs for PAM scale at three study waves by study conditions*

Study Wave	Total Mean (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
1	60.96 (14.75)	61.28 (17.22)	60.72 (12.94)
2	63.82 (14.27)	61.39 (15.21)	66.90 (12.82)
3	57.27 (11.89)	57.87 (9.98)	55.77 (16.81)

Key: SD=Standard Deviation; PAM=Patient Activation Measure; FT=Fitness Tracker

Higher PAM scores and levels indicated higher activation and ability to self-manage. Lower scores reflected lower activation and ability to self-manage (in line with Hibbard et al., 2015). As seen in Table 4.16, scores were higher in W2 across both conditions. Then, they decreased in W3, indicating that participants' activation levels and ability to self-manage improved when tested directly after the 10-week weight management intervention and subsequently reduced at six months.

Observed differences in means were tested employing a 2X3 mixed ANOVA looking at PAM scores in the two study conditions at W1, W2 and W3. It revealed that there was no effect of the study condition [F (1, 19) = .14, p > .05] or PAM scores over time [F (2, 38) = 1.93, p > .05] and no significant interaction between the study condition and PAM scores [F (2, 38) = .53, p > .05]. Levene's tests were

not significant at W1 [F (1, 19) = 3.05, p > .05], at W2 [F (1, 19) = .62, p > .05] and at W3 [F (1, 19) = 1.32, p > .05].

Paired-samples t-tests were subsequently run to examine the results individually for each study group and two study waves at a time. The results revealed a significant increase in PAM scores between W1 and W2 in the control condition [t (14) = -2.19, p < .05, d = -.57] but not in the FT condition [t (18) = -.53, p > .05]. The differences in PAM scores between W1 and W3 were not significant in the FT condition [t (14) = 1.34, p >.05] or the control condition [t (5) = .18, p >.05]. In terms of the differences in PAM between W2 and W3, only a significant difference in the total sample was observed [t (20) = 2.12, p < .05, d = 46]. The differences between W2 and W3 PAM scores in the FT condition [t (14) = 1.47, p > .05] and the control condition [t (5) = 1.53, p > .05] were not significant.

In summary, PAM scores increased only in the control condition between W1 and W2. A decrease in PAM scores was observed between W2 and W3 in the total sample, indicating that participants were less activated at six months from the start of the intervention.

Motivation over time and by study conditions

The motivation subscales' mean scores (with SDs) are presented in Table 4.17 below.

Table 4.17. *Means and SDs for all motivation subscales at three study waves (for the total sample and by study conditions)*

Motivation Subscale	Study Wave	Total Mean (SD)	FT Condition Mean (SD)	Control Condition Mean (SD)
Autonomous	1	6.46 (1)	6.60 (.73)	6.35 (1.16)
	2	6.57 (.68)	6.47 (.87)	6.69 (.36)
	3	6.53 (.84)	6.67 (.66)	6.13 (1.23)
Introjected	1	4.83 (1.68)	4.75 (1.92)	4.89 (1.49)
	2	5.13 (1.46)	4.92 (1.42)	5.38 (1.50)
	3	4.75 (1.76)	4.60 (1.92)	5.20 (1.19)
External	1	3.64 (1.38)	3.75 (1.70)	3.56 (1.11)
	2	3.47 (1.55)	3.25 (1.56)	3.75 (1.54)
	3	3.68 (1.86)	3.43 (1.90)	4.40 (1.67)

Key. SD=Standard Deviation; FT=Fitness Tracker

Mean values across these scales fluctuated between study waves, with W2 being noticeably different from W1 and W3. These differences in means were tested using a 2X3 mixed ANOVA model with the study condition (the FT and the control conditions) as a between-subjects variable. The motivation subscales were used as repeated measure variables (within-subject, time factor W1, W2 and W3) and analysed separately. The mixed ANOVA exploring the autonomous motivation showed that there was no main effect of the study condition [F (1,16) = .66, p > .05] and no main effect of time on the autonomous motivation scale [F (2, 32) = 2.54, p > .05]. There was also no significant interaction between the study condition and autonomous scale scores over time [F (2, 32) = 3.07, p > .05]. Levene's tests were not significant at W1 [F (1, 16) = .41, p > .05] at W2 [F (1, 16) = .22, p > .05] and at W3 [F (1, 16) = 2.82, p > .05]. Mauchly's test was also not significant (p > .05).

In addition, each subscale was analysed using paired-samples t-tests separately applied to the study groups looking at W1 and W2, W1 and W3 and W2 and W3 in turns. No significant differences were observed in autonomous motivation between W1 and W2, W1 and W3, and W2 and W3 in any study group ($p > .05$).

The same steps were followed to examine the introjected motivation scale. Levene's test was significant at W1 [F (1, 16) = 7.85, $p < .05$] and not significant at W2 [F (1, 16) = 1.31, $p > .05$] and W3 [F (1, 16) = 1.42, $p > .05$]. Mauchly's test was also not significant ($p > .05$). When the 2X3 mixed ANOVA was employed, there was no main effect of the study condition [F (1, 16) = .29, $p > .05$], no main effect of time [F (1.51, 24.11) = .74, $p > .05$], and no significant interaction between the study condition and introjected scale scores over time [F (1.51, 24.11) = .04, $p > .05$]. When the paired-samples t-test was applied, no significant differences were observed in introjected motivation between W1 and W2, W1 and W3, and W2 and W3 in any of the study groups ($p > .05$).

Regarding the external motivation scale, the same steps were followed to examine this scale. Levene's test was significant at W1 [F (1, 17) = 4.75, $p < .05$] and not significant at W2 [F (1, 17) = 1.02, $p > .05$] and at W3 [F (1, 17) = 3.87, $p > .05$]. Mauchly's test was significant [W (2) = .50, $p < .01$], indicating that the variances of differences were not equal. Considering this, the F-ratios were intended to be treated with caution. When the 2X3 mixed ANOVA test was employed, there was no main effect of the study condition [F (1, 17) = .00, $p > .05$], no main effect of time [F (1.34, 22.71) = .77, $p > .05$] and no significant interaction between the study condition and external motivation scale scores over time [F (1.34, 22.71) = .53, $p > .05$]. When the paired-samples t-test was applied,

significant decreases in external motivation were observed between W1 and W2 in the total sample [t (32) = 2.57, p < .05, d =.45] and the FT condition [t (18) = 2.76, p < .05, d = .63] but not in the control group [t (13) = 1.10, p > .05]. When analysing external motivation score differences between W1 and W3 and subsequently between W2 and W3, no significant differences were found in any of the study groups (p > .05).

To summarise, the only significant differences identified in the analysis of the motivation scales were in external motivation between W1 and W2 in the total sample and the FT condition. External motivation (where behaviours are performed in response to external punishment or incentives) decreased following the 10-week weight management intervention.

To sum up, the results obtained from the analysis of the psychological measures over time and by intervention groups were mixed. Anxiety was reduced across both groups, with a slightly larger effect size in the FT condition. The depression scores were significantly reduced only in the FT condition. External motivation scores between W1 and W2 significantly decreased only in the FT condition. The only measure where a more favourable result was found in the control condition was the PAM measure at W2. The control condition had a significantly higher activation level than the FT condition. No other differences in psychological measures were detected.

The analysis of weight management programme attendance rates is presented next.

4.5.5 Intervention attendance by study condition

The number of weight management sessions attended (out of 10) across the two study groups was also examined. An independent samples Mann-Whitney U test was considered the most appropriate as the Kolmogorov–Smirnov test confirmed that the session attendance variable significantly deviated from a normal distribution [D (33) = .16, p < .05]. The means ranks for both study groups and the Mann-Whitney U test value are reported in Table 4.18 below.

Table 4.18. *The results of a Mann-Whitney test showing differences in attendance between study conditions (with mean ranks and the U value included)*

	FT condition Mean rank	Control condition Mean rank	U value
Attendance of sessions	34.77	24.80	257.50*

Key. FT=Fitness Tracker; *p<.05

Common Language Effect Size (CL) was also calculated to examine the effect size, and it was CL=.33, indicating a small effect. On average, participants in the FT condition attended more weight management programme sessions than participants in the control condition. Those who used FTs attended 1.72 sessions more session on average than participants not utilising FTs.

The following section examines the relationships between the study variables.

4.5.6 Investigating relationships between variables

This section addresses the third research objective - examining the factors associated with successful weight loss and other intervention outcomes. Correlation analyses were conducted first to investigate the relationships between the key variables. This was seen as a crucial step in providing the foundation for the regression analysis, as variables significantly correlated at this stage were intended to be used as predictors in future investigations. As Tabachnick and Fidel (2019) pointed out, regression is usually employed after identifying a significant correlation between variables.

Two-tailed Spearman's correlations were performed (due to the skewed distribution of some scales, non-parametric tests were used) to assess whether regression analysis could be employed. The relationships between the key variables from W1 and weight outcomes at 10 weeks (post-weight management programme intervention/W2), the final care planning session (six months/W3), and the weight management programme attendance were explored first. The results of the correlation analysis, including Spearman's *rs* values and significance *p* values, are presented in Table 4.19 below.

Table 4.19. *The relationship between key variables at W1 and weight outcomes (at W2 and W3) and attendance sessions*

	Subjective Norm	Intention	Anxiety	Depression	PAM	Autonomous Motivation	Introjected Motivation	External Motivation	Weight (W1)	Weight (W2)	Weight (W3)	BMI (W1)	BMI (W3)	Weight difference (W1 & W2)	Weight difference % (W1 & W2)	Weight difference (W1 & W3)	Weight difference % (W1 & W3)	Number of Sessions Attended
Attitudes	.36**	.29*	-.28*	-.28*	.14	.17	-.22	-.24	-.06	-.05	-.11	-.07	-.19	-.17	-.14	-.28*	-.29*	-.06
Subjective Norm		.41**	-.03	-.08	-.02	.11	-.06	-.11	.27*	.27*	.25	-.01	-.01	-.13	-.11	-.08	-.08	-.05
Intention			.02	-.02	.38**	.46***	-.11	-.09	.04	.02	.02	-.01	-.06	-.18	-.16	-.08	-.09	-.06
Anxiety				.73***	-.14	.04	.19	.46**	.21	.18	.20	.28*	.23	.08	.06	.31*	.31*	.01
Depression					-.09	-.01	.05	.24	.20	.20	.27	.32*	.32*	.11	.10	.21	.22	-.10
PAM						.28*	-.14	-.23	-.11	-.15	-.15	.05	-.06	-.13	-.11	-.16	-.16	-.08
Autonomous Motivation							.27*	-.17	-.42**	-.42**	-.46**	-.25	-.33*	-.09	-.11	-.12	-.14	.04
Introjected Motivation								.52***	-.34**	-.32*	-.32*	-.25	-.27	.12	.08	.22	.21	.22
External Motivation									.03	.02	.06	.16	.15	.08	.05	.21	.20	.19
Weight (W1)										.97***	.98***	.74***	.76***	-.02	.00	.04	.09	-.08
Weight (W2)											.99***	.68***	.77***	.16	.18	.19	.24	-.15
Weight (W3)												.71***	.79***	.14	.17	.21	.26	-.11
BMI (W1)													.94***	-.09	-.07	-.06	-.02	.06
BMI (W3)														.15	.19	.20	.24	-.03
Weight difference (W1 & W2)															.99***	.75***	.76***	-.30*
Weight difference % (W1 & W2)																.73***	.77***	-.31*
Weight difference (W1 & W3)																	.99***	-.26
Weight difference % (W1 & W3)																		-.27

Key. W1=Wave 1, W2=Wave 2, W3=Wave 3, PAM=Patient Activation Measure, BMI=Body Mass Index; All significant results are highlighted in grey; **p<.05, **p<.01, ***p<.001*

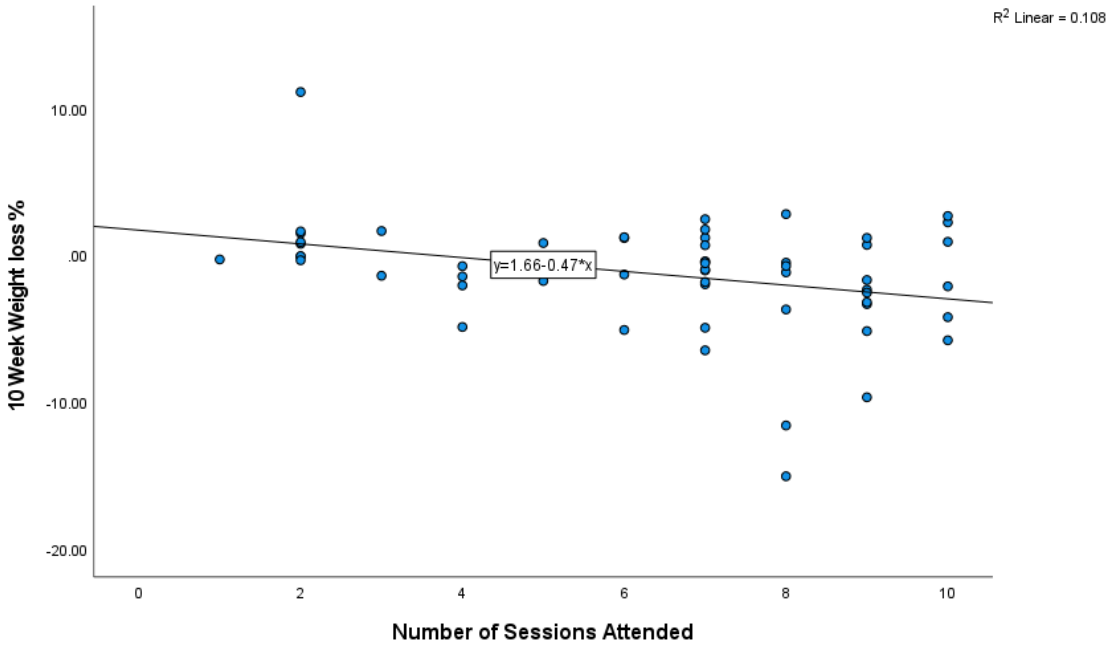
Correlations were performed for all psychological variables except WLOC and PBC, which displayed low internal reliability. All analysed variables within the TPB model (attitudes, subjective norms and intention) correlated with each other. Additionally, attitudes correlated negatively with anxiety and depression, suggesting that the lower the anxiety and depression scores were, the more positive the attitudes towards losing weight. Intention correlated positively with PAM scores, showing that the more activated participants were, the higher their intention to lose weight was. Intention to lose weight also positively correlated with autonomous motivation. Anxiety correlated positively with depression and with external motivation. The higher the anxiety scores, the higher the scores for depression and external motivation. Autonomous and introjected motivation were positively associated, while introjected motivation was also positively correlated with external motivation. Autonomous motivation was also positively correlated with PAM, suggesting that the more activated participants were, the greater their autonomous motivation was.

Some relationships were identified when these psychological measures and weight and weight-related intervention outcomes were considered. Attitudes towards losing weight had a negative relationship with weight difference between the W1, W2 and W3 study waves. This relationship suggested that the more positive participants' attitudes were at W1, the more weight loss they achieved. Subjective norms also positively correlated with weight measures (actual weight) at W1 and W2, suggesting that heavier participants reported more supportive subjective norms at W1 and W2. Anxiety and depression were positively correlated with BMI at W1, suggesting that more anxious and depressed participants had a higher BMI at the start of the weight management intervention. Anxiety also positively correlated with weight difference

(actual and %) between W1 and W3, suggesting that the more anxious participants were, the less weight they lost at the end of the 6-month intervention (more negative weight outcomes indicated greater weight loss). Autonomous and introjected motivation scales were also negatively associated with weight, showing that participants with higher motivation (both types) had lower weight at W1, W2 and W3. Additionally, autonomous motivation was negatively correlated with BMI at W3, suggesting that those with higher motivation had lower BMI at the end of their 6-month intervention. Some weight and weight-related measures correlated with each other as expected.

Additionally, the number of sessions participants attended was considered a potential variable that could correlate with study outcomes. Spearman's correlation analysis revealed a negative correlation between session attendance and the weight difference percentage at W2. The more sessions participants attended, the more weight they lost. This is shown visually in the scatter plot below (Figure 4.12). The total weight difference (at the final session, approximately six months) was no longer significantly correlated with the number of sessions participants attended.

Figure 4.12. *Negative correlation between the number of sessions participants attended and the % weight difference (between W1 and W2)*



A hierarchical regression analysis was planned to address objective 3 (i.e., exploring predictors of weight management intervention outcomes). It was intended that the results of the correlation analysis would guide the number of predictors to be used in the regression model (as recommended by Tabachnick and Fidel, 2019). As anxiety and attitudes (TPB) were related to weight management programme outcomes (6 months weight difference %), only these variables were used in the regression analysis as potential predictors. The multiple regression analysis was performed with two predictors - the anxiety variable (W1) entered into the model first, followed by the attitudes variable (W1). This order was determined by the principle described by Cohen and Cohen (1983) that no variable entered later should be a presumptive cause of the variable entered earlier. As anxiety is seen as potentially affecting attitudes, it was entered into the model first. The weight % difference was selected as the outcome variable. The results can be viewed in Table 4.20.

Table 4.20. *Hierarchical Regression Analysis results for weight % difference with Anxiety and Attitudes used as predictors*

Predictor Variables	F value (df)	Δ R^2	ß
1. Anxiety	3.57 (1, 28)	11.3%	.34
2. Anxiety & Attitudes	1.81 (1, 27)	11.8%	.33 -.07

None of the two models were significant in predicting weight loss % outcomes at six months. No further regression analysis was performed.

The following section presents the results obtained from the analysis of the objective data available through FTs.

4.5.7 Fitness trackers (Fitbit) data analysis

The FT (Fitbit) data were downloaded from the Fitabase research management site (available at https://www.fitabase.com/) in Excel format. Most measures were available in minutes, hours, and days. The data were processed in Excel before being transferred to SPSS. The manipulation involved converting variables from daily to weekly and creating total and average values. As the Fitbit data in the current study complemented the primary data presented above, only a selection of the measures considered the most relevant in terms of their potential relationship with weight outcomes was examined to understand how participants engaged with their devices. Four variables were selected and explored further: the

device synchronisation with the app/website, the number of steps, the types of PA activity, and the sleep minutes. Each of these variables is discussed below. All performed tests have been only run for the cohort of participants using FTs (n = 24).

Fitbit synchronisation information

This information was deemed necessary as it provided insight into how frequently and how long participants engaged with their devices. Synchronising was required to ensure the data gathered by Fitbit were uploaded to the accompanying app and the website. As the device had a limited data storage capacity, synchronising was crucial to prevent the data from being overwritten by newly recorded information. Synchronising allowed users to view their data as summarised trends presented more analytically through the Fitbit app or the website. Table 4.21 below shows a detailed breakdown of each participant's synchronisation episodes (every time they enabled the device to be synchronised with the app/website).

Table 4.21. *The Fitbit synchronisation episodes broken down by months*

Participant number	Months						Total number of synchronising events
	1	2	3	4	5	6	
1	7	22	7		1		37
2	6	30	21				57
3	8	23	13	4		1	49
4	13	31	31	29	28	26	158
5	1						1
6	9	13	4			3	29
7	17	31	30	31	109	31	249
8	3	5		8			16
9	7	28	31	30	30	30	156
10	14	31	29	31	30	18	153
11	9	9	4				22
12	1						1
13	14	24	28	21	10	1	98
14	1						1
15	15	28	22	14	9	9	97
16	1						1
17	1						1
18	5	30	30	31	30	28	154
19	24	28	30	82	30	21	215
20	16	14	11	41	17	9	108
21	1			1			2
22	22	27	49	21	23	22	164
23	7	31	38	31	29	31	167
24	21	28	17	22	12	27	127

Key. Traffic Light rating system:
Low usage = Red; Medium usage = Amber; High usage = Green

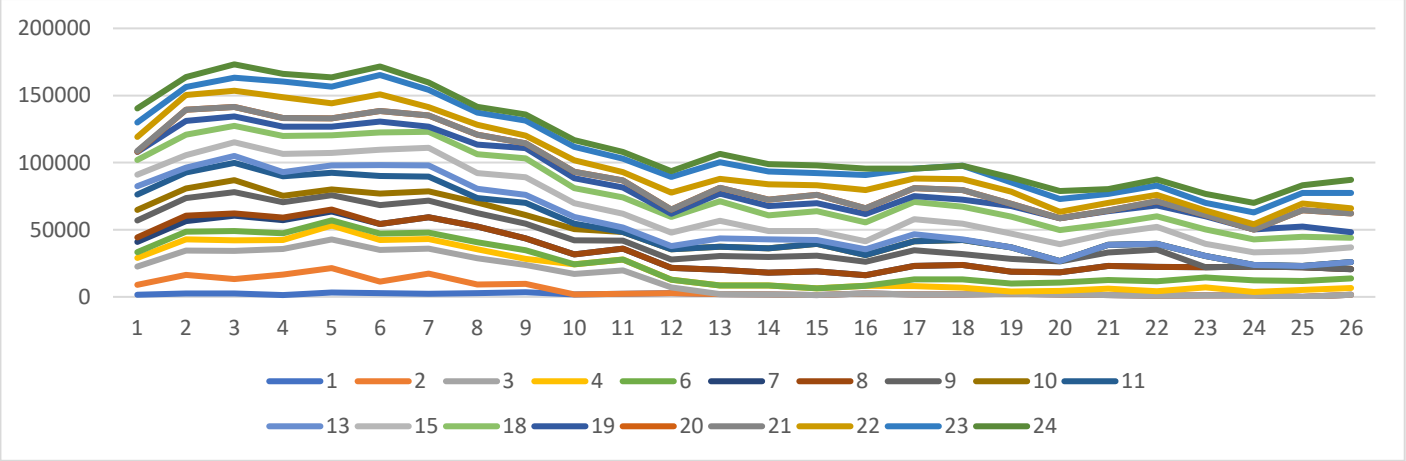
As seen in the table above, the usage of Fitbit devices varied widely. Twelve participants used their FTs for six months (green) – from enrolment to their final HH session. The data from six participants were interpreted as medium usage (amber), while the remaining six participants had not registered the use of their devices (red).

The researcher likely synchronised for the latter group while the device was being set up. It is possible that in this cohort, no service user-initiated synchronisation occurred.

Steps

This variable was available in minutes, hours and days, but for this study, only daily breakdowns were looked at (minute and hour breakdowns were considered too detailed). The daily steps variable provided the total number of steps taken that day, and each participant had approximately 182 measurements recorded. The daily value was zero for days when the device was unused or the data were not uploaded. The daily data were converted to weekly averages. Figure 4.13 below offers a visual representation of the step data.

Figure 4.13. *The breakdown of weekly step averages for each participant over six months*



Note. Participants 5, 12, 14, 16, and 17 were removed due to inactivity; the X axis shows the number of steps, the Y axis shows the number of weeks while the lines represent participants

As seen above, many participants used their FTs regularly during the initial six to seven weeks. After the initial period, which overlapped with the HH intervention, the number of steps recorded by participants declined. The mean number of steps was 7298.53 (SD = 4110.83), ranging between seven and 15854.31 steps across the whole period.

Physical activities

This variable captured different physical activities, with walking, cycling and running being the most popular. Activities were entered manually (through the Fitbit app/website) or automatically detected (by the Fitbit device) as the device registered participants' heart rates, movements, etc. Similarly to steps, for some participants, no activities were recorded. Each participant's total number of activities recorded was calculated to understand their overall engagement. No average measures were calculated as the data had too many missing values. The mean number of activities recorded throughout the six months was 96.44 (SD = 92.71), ranging from 3 to 302. Table 4.22 below presents the breakdown of the types of activities recorded.

Table 4.22. *The types of activities participants recorded through Fitbit (sorted by popularity)*

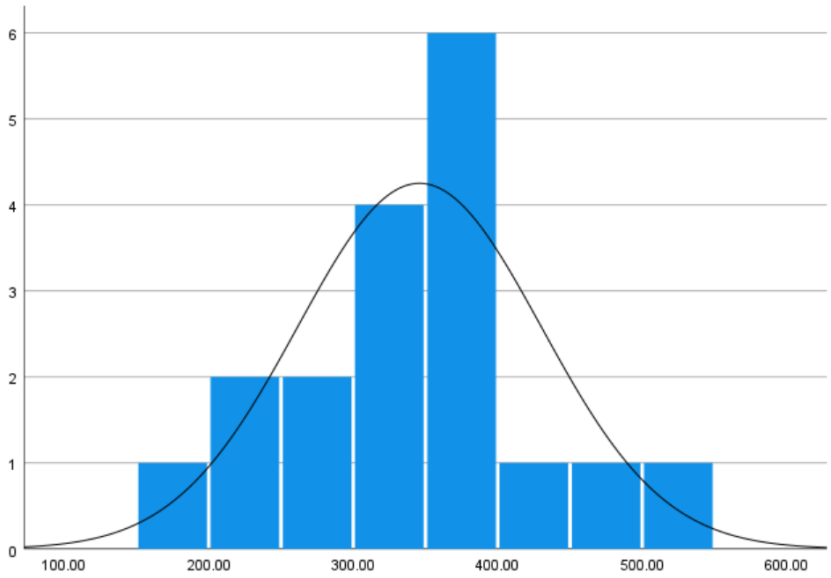
Fitbit activity type	Number of recorded activities
Walk	19856
Bike	2370
Run	2164
Elliptical	849
Sport	805
Weights	678
Outdoor Bike	606
Aerobic Workout	492
Workout	385
Bootcamp	266
Yoga	266
Pilates	182
Circuit Training	152
Treadmill	139
Water aerobics	96
Aerobics	61
Calisthenics	57
Football	57
Swim	37
Fitbit Coach: Personal Trainer	36
Dancing	24
Interval Workout	7
Total number of recorded activities	29585

Sleep

As sleep is one of the pillars of wellbeing looked at during the HH programme, it was considered important to be looked at as part of the analysis. Numerous sleep

variables were available, either automatically detected by the device (if worn at night) or specified by the participant (in the app/on the website). The variables available through Fitbit included sleep stages, Rapid Eye Movement minutes (light sleep), sleep efficiency score and daily sleep minutes. The decision was made that the number of minutes asleep variable was to be used as other measures were deemed unreliable (e.g., due to missing data). Average values were calculated for each participant, ranging from 194.49 to 520.58 minutes, with a mean of 345.85 (SD = 84.44). The spread of scores can be seen in Figure 4.14 below.

Figure 4.14. *A histogram showing the spread of average sleep minutes recorded through the FT*



Note. The X-axis shows the count number, and the Y-axis shows the number of minutes

Correlations were run to assess the relationship between the average number of steps, minutes of sleep, and physical activities with other study variables. Additionally, the steps, sleep and physical activity variables were broken down into three equal intervals to enable the FT data to be mapped against other study variables obtained across the three study waves. The FT values obtained this way were called study intervals to ensure a distinction from the study waves.

The relationships between the three FT measures and other study variables at various time points were explored first. As before, these tests were run only for the cohort of participants using FTs (n = 24). Table 4.23 below shows correlations between steps, activity totals, sleep and other study variables, including weight outcomes, depression, PAM, and intention.

Table 4.23. *Significant correlations between FT variables (steps, activity and sleep) and other study variables*

	FT Activity	FT Sleep	Weight difference % (W1 & W2)	Weight difference % (W1 & W3)	BMI Difference (W1 & W3)	Depression (W2)	PAM (W2)	PAM (W3)	Intention (W2)
FT Steps	.84***	.72***	-.56**	-.40	-.38	.21	.54*	.57*	.64**
FT Activity		.29	-.76**	-.70**	-.62**	.68**	.26	.41	.34
FT Sleep			-.19	-.01	-.00	-.02	.35	.48	.40
Weight difference % (W1 & W2)				.92***	.90***	-.14	-.49*	-.28	-.52*
Weight difference % (W1 & W3)					.99***	-.08	-.51*	-.18	-.36
BMI Difference (W1 & W3)						-.05	-.52*	-.19	-.35
Depression (W2)							.26	.19	-.11
PAM (W2)								.61*	.49*
PAM (W3)									.27

Note. All significant results are shown and highlighted in grey; Key. FT=Fitness Tracker, BMI=Body Mass Index, PAM=Patient Activation Measure, W1, W2 & W3 = study waves; **p<.05, **p<.01, ***p<.001*

As seen above, the total average number of steps recorded through FTs correlated negatively with the weight loss percentage recorded at W2, suggesting that the more steps participants took, the greater the weight loss. This was no longer significant at W3. FT steps also correlated positively with PAM (W2 and W3) and intention (W2). In general, the more steps participants took, the greater their weight loss immediately after their 10-week weight management programme, the higher their PAM activation scores at W2 and W3, and the higher their intention to lose weight at W2.

Regarding recorded physical activities through FTs, the more types of activity participants engaged in and recorded, the greater their weight loss at W2 and W3, and their BMI difference between W1 and W3. Additionally, a positive relationship was identified between depression scores at the end of the study period and the average number of recorded activities. This correlation suggested that the more depressed participants were, the more activities they engaged in. The FT sleep measure was not associated with weight outcomes or other study variables.

In addition to examining the relationship between variables, repeated measures tests were planned to determine whether there were any differences in participant engagement at various time intervals. Examining FT data frequencies led to a decision against conducting these tests, as there were too many missing variables at the second and third intervals. As a result, the data were deemed insufficiently reliable for these tests. Table 4.24 shows the number of missing values per variable.

Table 4.24. *Missing values per participant for each FT variable at the three intervals*

	Interval 1	Interval 2	Interval 3
Steps	5	8	10
Activity	6	10	11
Sleep	6	11	12

In summary, the findings of the FT data analysis indicated that higher levels of recorded steps, as measured through FTs, were associated with greater weight loss, higher PAM activation scores, and stronger intention to lose weight. Engaging in various physical activities also showed positive associations with weight-related outcomes. The positive relationship between depression scores and recorded activities was also identified. These findings are discussed further in the discussion section.

4.6 Discussion

4.6.1 Key findings

This chapter addressed the first three research objectives of the current study, and these have been detailed below.

Research objectives and hypotheses

The current study's first and overarching research objective was to assess the effectiveness of FTs when used in addition to a standard weight management intervention. It assessed whether the ‘intervention with FTs condition’ and the ‘intervention as usual condition’ (control) have different weight management intervention outcomes. The second objective was to assess the factors associated

with successful weight loss and test whether they differ across the study conditions (FTs versus control) over time. The third objective was to examine the factors associated with successful weight loss and other intervention outcomes.

Hypothesis 1 (FTs will impact the weight management intervention outcomes in those at risk of CVD) was accepted. Hypothesis 2 [Health beliefs (TPB), WLOC, Anxiety, Depression, Patient Activation levels and Motivation will differ between conditions and change over time] was partially accepted. Hypothesis 3 [Health beliefs (TPB), WLOC, Anxiety, Depression, Patient Activation levels, and Motivation will predict weight loss outcomes in the weight management intervention] was rejected.

Hypothesis 1 - Physical outcomes

The analysis addressing the first research objective revealed that at the end of the 10-week weight management intervention – W2, weight outcomes were different between the study conditions, as indicated by a significant interaction between the study condition and weight over time. Only participants in the FTs condition showed a significant weight reduction after their intervention. This reduction was significant across both weight variables (the % weight difference between the initial session and the 10-week intervention end and the % weight difference between the initial and final sessions). The reduction in weight after six months of the intervention was significant in the total sample, and the FT condition was driving this reduction. Regarding other weight-related outcomes, the waist circumference and BMI were significantly lower only in the FT condition at the 6-month follow-up (W3).

This result is in line with previous work in this area. For instance, in a systematic review conducted by McDonough and colleagues (2021), it was reported that FTs have proven to be successful intervention tools/strategies in promoting weight and BMI reduction among individuals who were overweight or obese and had chronic comorbidities. In another systematic review (Yen & Chiu, 2019), a meta-analysis of 19 studies found that using FTs resulted in a moderate and statistically significant effect size on body weight and waist circumference and a large and statistically significant effect size on BMI. Bender and colleagues (2017) also reported reductions in these measures in the group of participants utilising FTs.

The more favourable weight-related results in the FT condition obtained in the current study were also in line with the findings reported by Ferguson and his team (2022). In their large-scale umbrella systematic review, the authors reported that weight was the outcome with the most significant improvements in individuals using FTs in a variety of age groups across clinical and non-clinical populations (Ferguson et al., 2022).

In terms of PA recorded as part of the HH sessions, there was a significant increase in PA across time in both groups, with a larger effect size and a higher significance level in the FT condition. The same pattern was observed with vigorous PA levels recorded in this study via IPAQ; the FT condition had a slightly larger effect size than the control condition. The time spent sitting was significantly reduced only in the FT condition. The data gathered via the FTs (steps and activities) also showed an association with weight loss. The more steps and activities recorded, the more weight participants lost. This was in line with previous work conducted in this area. FTs were reported as associated with increased PA in two systematic reviews looking at the use of FTs and their impact on PA levels (Braakhuis et al., 2019 &

Brickwood et al., 2019). Some studies, however, reported mixed findings. For instance, Jakicic and colleagues (2016) reported that PA increased across all study groups (with and without FTs) in their study.

Hypothesis 2 - Psychological outcomes

The analysis addressing the second research objective revealed that amongst the psychological variables tested, depression scores were significantly different across study groups (a significant reduction in depression scores over time in the FT condition but not in the control group, suggesting that FTs contributed to this trend to some extent). As reported by Robinson and colleagues in their recent systematic review, evidence supporting the use of FTs in depression (and other mental conditions) is primarily anecdotal (2023). A previous study looking at FTs and depression reported that 23 out of 36 individuals with depression found their FT (Fitbit) to be advantageous (Chum et al., 2017). Those who reported its usefulness believed that it served as a source of motivation, encouraging them to participate in PA. While anxiety scores significantly reduced over time in the current study, there was no significant difference between the study groups (but the difference in the FT condition was more significant and had a larger effect size).

Subjective norms and intention to lose weight defined by the TPB also displayed significant differences across time (less supportive attitudes and less intention) at W2 and W3. Participants perceived that they had more approval from significant others and greater intention to lose weight at the start of their weight management interventions, but these measures were reduced with time. However, no differences between the study conditions were present. Subjective norms variable was also reported to reduce over time in a study looking at weight change in a 4-

month weight management intervention (not designed to use FTs) for 142 overweight and obese women (Palmeira et al., 2007). Study authors reported that the intention scores were higher at the end of their intervention than at baseline. The current study observed an opposite trend (the intention decreased with time). It is possible that subjective norms became less important over time.

An increase in Patient Activation immediately after the 10-week weight management programme was also observed. However, this was only the case in the control condition and was no longer significant at the final session. No significant differences in PAM in the FT condition were observed. Batsis and colleagues also reported no Patient Activation changes in their cohort of obese, older FT users (Batsis et al., 2016). However, it must be emphasised that the control condition had a slightly lower activation level at W1 than the FT condition (non-significant). While it significantly increased in W2, it subsequently decreased in W3 to lower levels than in the FT group. This suggests that any changes in Patient Activation in the control condition were short-term.

Significant differences in external motivation between W1 and W2 in the total sample were observed, and when explored further, the results showed that the FT condition drove this difference. This is consistent with the statement that external motivation often increases in response to external punishment or incentives (Ryan & Deci, 2000). It can be speculated that external motivation could have increased if the FT provided regular feedback and incentives to exercise and utilised gamification techniques.

Hypothesis 3 – predicting weight loss

Regarding the third research objective, some relationships were identified between psychological measures and weight. Anxiety and attitudes (TPB) were tested as possible predictors of weight outcomes using multiple regression analysis. However, it was revealed that they were not significant, indicating that the model was not a good fit. Anxiety, together with depression, was found to predict between 4% and 6.7% variability in weight loss in previous research (Legenbauer et al., 2009). Limited evidence exists regarding the extent to which baseline anxiety can predict weight management programme outcomes (McLean et al., 2016). It was reported in prior research that anxiety was identified as a negative predictor of weight loss in bariatric patients (de Zwaan et al., 2011). However, in their UK-based study, McLean and colleagues found that anxiety (measured through HADs) did not predict or lead to less favourable weight management results when compared with those without identified anxiety.

In terms of attitudes (TPB), it has been previously reported that while attitudes correlated with the intention to lose weight, this scale was not necessarily associated with final changes in body weight (Schifter & Ajzen, 1985). However, Palmeira (2007) reported that the attitudes scale was linked to a reduction in body weight. These conflicting results could be due to the diverse measurement tools employed to assess attitudes (Chung & Fong, 2015).

Intervention attendance rates

Although this analysis was not part of the hypotheses, it is worth noting that study conditions also seemed to impact the programme's attendance rate. This was in line with earlier studies where lower attrition was reported in FT conditions compared to control groups (e.g., Ashe et al., 2015; Jakicic et al., 2016 & Peyer et al., 2017). In the current study, on average, participants in the FT condition attended 1.72 more sessions than participants in the control group. The higher programme attendance rates demonstrated by the participants with FTs may have positively impacted participant health outcomes. A study by Følling and colleagues reported that participants' experience with their FTs aligned with their adherence to the weight management programme (Følling et al., 2021). As reported by Carpenter and colleagues in their review (Carpenter et al., 2022), studies have shown that when incorporated into a weight management intervention, FTs can enhance adherence to self-monitoring of own behaviours and lead to better weight loss outcomes compared to conventional self-monitoring tools. It can be speculated that the FTs provided to participants in this group contributed to these improvements as increased self-monitoring of own weight management behaviours was enabled. Social desirability bias could also explain the results, and it is possible that the increased attendance could have resulted from participants' desire to be viewed positively or avoid criticism. In a study that utilised FTs (Friel & Garber, 2020), it was highlighted that the self-reported data for PA could have been subject to social desirability bias and, therefore, was deemed as not accurately reflecting FTs' actual use.

It is also possible that participants may have felt thankful for the provision of the tracker and aimed to make the most of the opportunity given to them. Past studies reported that the manner in which the FTs were acquired (e.g., received as a

gift) played a role in determining their usage (Friel & Garber, 2020). Due to the heterogeneity of studies that utilise FTs as an addition to the weight management intervention, comparing attendance/attrition rates across other studies is challenging.

Fitness trackers data insights

When the data obtained through FTs (steps, physical activities, and sleep variables) were explored, the number of steps recorded correlated negatively with weight-related measures (the weight loss percentage recorded at W2), indicating that the greater the number of steps the participants took, the more weight they lost. This was in line with the results presented in the large-scale systematic review by Ferguson and colleagues, where it was concluded that participants using FTs made, on average, 1800 steps per day more than participants not using FTs (2022).

FT steps also correlated positively with PAM (W2 and W3); in other words, the more activated participants were, the more steps they took. This result was in an expected direction as individuals with greater knowledge, skills and confidence in managing their health have overall better health outcomes (Hibbard & Gilburt, 2014). The association between Patient Activation and health outcomes has been shown in various populations and health conditions (Hibbard & Gilburt, 2014).

The number of steps was also associated with the intention to lose weight (at W2); the more steps participants took, the higher their intention to lose weight. This finding was in line with the TPB model, stating that intention predicts behaviour (Schifter & Ajzen, 1985). It has been argued that the TPB's reliance on the assumption of rationality in forming intention (through conscious, thoughtful processes) restricts its capacity to account for behaviours that occur without conscious awareness (Webb & Sheeran, 2006). When looking at FTs and predicting

steps in particular, intention was not found to be a significant predictor of steps (O'Shea & Frazer, 2018).

In terms of recorded physical activities through FTs, a similar pattern emerged regarding weight outcomes; the more activity units participants engaged in, the greater their weight loss. This was expected as it is widely known that engaging in PA through various activities helps maintain a healthy weight – it is an effective way of increasing daily energy expenditure (Hill et al., 2012). For most people, it is more practical to match their energy intake to a high level of energy expenditure rather than trying to restrict food intake to meet a low level of energy expenditure (Hill et al., 2012). It was also reported previously that employing other FT features (extended feature use) in addition to step counting has been found to have a positive impact on levels of PA (Giddens et al., 2017).

Additionally, a positive relationship was identified between depression scores at the end of the study period and the average activity recorded through the FT. This correlation suggested that the more depressed participants were, the more activities they engaged in. FTs have potentially provided a platform for self-monitoring of own behaviour that became particularly useful in participants with higher depression scores. Another possible explanation could be that the more activity participants engaged with, the more aware they became of what they could and could not do. Also, it is possible that increased self-monitoring of their own behaviours and activity recording could have led to a greater awareness of their symptoms.

While there is a clear potential for FTs in the mental health domain, there is still a lack of supporting evidence showing their effectiveness in people with depression (Robinson et al., 2023). As presented in Table 4.19, participants' BMI

was positively correlated with depression scores at W1, suggesting that some were depressed and had a higher BMI associated with their depression prior to the weight management intervention. The total number of recorded activities through FT also correlated with weight outcomes; the more activities were recorded, the more prominent the weight reduction at W2 and W3 and BMI reduction at W3.

To some degree, the FT data also provided an insight into the usage pattern, which showed that while some participants embraced their devices fully and used them for the entire study duration, others did not engage with them much or at all. Maher and co-authors (Maher et al., 2017) reported similar results as a third of their participants (n=237) discontinued using FTs prematurely. However, Chan and colleagues (2022) highlighted that the way adherence to FTs is measured and reported in studies is not universal due to the heterogeneity of studies. Therefore, it is hard to understand long-term engagement with FTs. Barriers to FT use/usage continuation are therefore worth exploring.

Several factors need to be considered when exploring low engagement levels with the FT. As the devices were set up with an email address dedicated to the study, some participants possibly changed this address to their private one earlier than instructed, leading to a breakdown in the data recording. Another reason for low device synchronisation might be the participants' lack of internet access or smartphone issues. In a group of service users from more deprived backgrounds, internet/smartphone access was flagged as problematic among HH programme participants in the past. Most participants with high device usage showed a continued engagement with their devices that did not decrease over time. It can be speculated that the use of devices continued beyond the study period for those

participants. However, these FT results must be treated cautiously because the missing values increased over time, rendering the data less robust.

4.6.2 Strengths and limitations of the study

This phase of the study had several notable strengths. Firstly, it represented HH service users well by including individuals from various ethnic backgrounds, age groups and deprived areas. This diverse sample enhanced the generalisability of the findings and ensured that the study's conclusions could be applied to a broader population. Additionally, effective recruitment strategies were employed, leading to good coverage of recruitment venues. This approach increased the likelihood of capturing a wide range of participants and minimised potential selection bias. Furthermore, the study capitalised on real-life HH data availability, which provided valuable information on attendance rates and health outcomes. This utilisation of authentic data (e.g., weight, waist circumference, HADs, etc.) allowed for a comprehensive analysis of the intervention's impact. Moreover, a good working relationship with the HH team was present, enabling continuous improvement in the recruitment process. This collaboration facilitated smooth data collection and ensured that the study was conducted in a supportive and effective manner.

Several limitations are also acknowledged. Firstly, some scales displayed low reliability, which restricted their suitability for analysis (PBC and WLOC). Additionally, employing self-reported measures, especially to measure PA, could have been susceptible to inaccuracies, recall errors and social desirability bias.

Another limitation stemmed from the unequal allocation of participants to the study conditions due to the unforeseen circumstances of the pandemic. This imbalance in group composition (FT condition=24, control condition=33) might have

introduced bias and affected the comparability of the results between the FT and intervention as usual groups. In addition, the study design did not permit for FTs to be provided to all service users within the weight management group. Instead, only a selected number of participants had this opportunity, while other individuals within the same weight management group were allocated to the control condition. This was an intentional design of this study implemented in order to avoid demotivating participants in the control condition. However, using this design also had its limitations, as participants were not able to use the social features of the FT, motivate each other and report their FT usage back to the group.

Additionally, as only two variables were identified as correlating with weight outcomes, only two predictors were tested in the regression model. This limitation prevented the exploration of all potential predictive relationships between variables of interest, while the two tested (anxiety and attitudes) were not significant. This meant that the third research question could not be fully answered. Other variables could have been at play in weight loss and should be considered in the future.

4.6.3 Implications for the thesis

This study provided valuable insights into the key variables relevant to weight management. The study findings suggested that the group of participants utilising FTs had more favourable weight-related outcomes following their weight management intervention when compared with participants in the intervention as usual condition. The FT group also had higher weight management programme attendance rates than their counterparts. This research sheds light on using FTs in the tier-two weight management context, mainly when applied to CVD prevention settings. The weight management programme outcomes and attendance rate

improvements in a group of participants considered harder-to-reach can have implications for practice and deserve more attention. This is discussed further in Chapter 6. It is suggested that further research is needed to understand the mechanisms underlying the weight differences and other significant results following the weight management programme. The main findings, coupled with the FT data, provided a solid basis for this thesis and are complemented by the data obtained in the qualitative phase of the study, which is presented in the next chapter.

4.7 Summary

This chapter presented the quantitative results of this research and offered insight into the data screening procedures and the rationale for including and excluding some measures and running specific tests. The key quantitative results were presented. Overall, the main findings showed that participants in the FT condition had better programme outcomes.

Weight loss was significant in the FT condition at W2 and W3 in the FT group, with individuals losing more weight than those in the control condition. Significant reductions in waist circumference and BMI at W3 were also observed in the FT condition. Some differences in PA were detected with more favourable results in the FT condition. The reductions in anxiety and depression scores at W3 were also more favourable in the FT condition. A significant decrease was also observed in external motivation between W1 and W2 in the FT condition. Patient Activation was higher only in the control condition at W2.

Relationships were observed between anxiety and attitudes measured at W1 and the actual and % weight difference at W3. These variables were used as predictors in regression analysis but did not significantly predict the 6-month weight difference %.

Participants in the FT condition attended 1.72 weight management sessions more than participants in the control group. The more participants engaged with their FTs (recording steps and types of activities), the better their weight outcomes were. Participants with higher depression scores recorded more activities on their FTs. The analysis of the FT data also showed that the usage of FTs varied widely, and while some participants embraced them fully, it was not the case for all.

This research provided insight into utilising FTs in CVD prevention among disadvantaged populations within a structured weight management intervention commissioned in Central London. The in-depth interpretation of these findings and their implications for practice, as well as their potential for improving intervention outcomes, are explored in the discussion chapter (Chapter 6). The next chapter (Chapter 5) presents an overview of the qualitative work carried out in this research.

Chapter 5 – Service users and health professionals' experiences of using fitness trackers (qualitative study)

This chapter presents the qualitative phase of the research conducted with two separate cohorts of participants. The main objective of this phase was to understand the service user and health professional participants' experiences of the weight management intervention that utilised FTs. This chapter begins by providing the study results from the service user participants, including the sample characteristics and main findings. This is followed by the presentation of results based on the health professional participants presenting the sample characteristics and the main findings. The results from both data sets are subsequently compared. The discussion section then outlines the main findings and considers them in light of the quantitative findings. The study's strengths and limitations and the implications for the thesis are also discussed.

5.1 Service users' experiences of using fitness trackers as part of the Healthy Hearts programme

5.1.1 Sample characteristics

Nine participants took part in the qualitative phase of the study. Seven of them were female, comparable with the total quantitative cohort of participants (79%). The age range of this group was 31-70 years, with a mean age of 49.44 years (SD=11.49), which is slightly lower than the study sample (M=52.93 years old and SD=12.07, respectively). Participants represented various ethnic backgrounds and occupations.

Participant confidence in using new technology (trying new computers, phones, apps) ranged from 'confident' to 'not very confident', and only one

participant declared themselves as ‘not confident at all’. The detailed breakdown of the participant characteristics can be viewed in Table 5.1 below. Participant names were changed to protect their identity.

Table 5.1. *Service user participants' characteristics*

Participant	Sex	Age	Ethnicity	Occupation	Confidence in using new technology
Anthony	Male	70	White British	Retired	Not confident
Bea	Female	41	Any other mixed ethnic group	Home Carer unpaid	Confident
Claire	Female	50	Any other mixed ethnic group	Routine and manual	Confident
Daisy	Female	31	White British	Managerial and professional	Confident
Edwin	Male	58	Black or Black Caribbean	Routine and manual	Average
Flora	Female	56	Black or Black African	Managerial and Professional	Average
Grace	Female	42	Any other mixed ethnic group	Routine and Manual	Average
Helen	Female	58	Black or Black Caribbean	Intermediate [a]	Average
Iris	Female	39	Asian or Asian British	Unemployed	Confident

Note. [a] Intermediate occupations include clerical, sales, service, and intermediate technical occupations (without general planning or supervisory powers)

Additionally, some key outcomes from participant weight management programmes (their weight and the number of sessions attended) and basic FT

engagement metrics (number of synchronisation episodes) are presented in Table 5.2.

Table 5.2. *Service user participants' programme outcomes and FT engagement metrics*

Participant	Weight Management Programme (10 weeks/wave 2) weight difference (and %)	Total (6 months/wave 3) weight difference (and %)	Number of weight management sessions attended	Number of device (FT) synchronisation episodes
Anthony	-2.70kg (-2.49%)	-3.90 kg (-3.45%)	9	1
Bea	-.40 (-.47%)	-2.00 kg (-2.33%)	7	29
Claire	-3.70 (-3.25%)	-5.00 kg (-4.39%)	9	158
Daisy	+1.60 kg (1.15%)	+2.60 kg (1.87%)	7	37
Edwin	-1.00 kg (-.79%)	Not available	5	215
Flora	-1.00 kg (-1.14%)	-1.00 kg (-1.14%)	9	108
Grace	+.60 kg (+.64%)	Not available	7	1
Helen	-5.00 kg (-5.21%)	-5.00 kg (-5.21%)	9	2
Iris	-3.80 kg (-4.98%)	-3.3 kg (-4.33%)	7	49

Key. FT=Fitness Tracker

5.1.2 Findings

The analysis of this data set identified two main themes. The first theme captured the '*positive attributes of FTs'* while the second considered the *'barriers to FT use'*. The themes, sub-themes, codes, and transcript line numbers of supporting quotations are presented in Table 5.3 and expanded further in the following narrative section.

Table 5.3. *A summary of results following the TA analysis of service users' data (themes, sub-themes, codes, and quote line numbers)*

Themes	Sub-themes	Codes	Quotations
Positive attributes of FTs	Self-monitoring feature	FT Biological feedback	*Anthony: 13-16, 21-22, 46-47; Bea: 5; Claire: 84-86; Daisy: 3, 14-15, 35-38; Edwin: 12, 14, 22-24; Flora: 26-27, 89-92; Helen: 114-116*
		FT PA feedback	*Anthony: 4-5, 13, 19-20, 21-22, 26-29, 97-98; Bea: 3-4, 8, 21; Claire: 12-14, 41-42; Daisy: 8-11, 41; Edwin: 3-4, 11-12, 29; Flora: 7, 25-26, 32-36; Grace: 18-19; Helen: 67-69; Iris: 5-10, 23-25, 36*
	Motivational tool	Goal-setting	*Bea: 4-5, 8-9, 17-19; Claire: 3-4, 48-50, 56-59; Edwin: 4-8; Grace: 13-16, 24-26; Helen: 4-7, 9-10*
		Nudges	*Anthony: 101-104; Claire: 8-12; Daisy: 41-43; Flora: 3-4; Helen: 3-4, 11, 44-53; Iris: 31-33, 35-36, 49-50*
	Knowledge expansion	Gain in knowledge facilitated via FT	*Clare: 21-22; Flora: 30-32, 66-70, 85-89, 90-93; Iris: 53-58*
		Maintenance of change	*Anthony: 10, 39-40, 106-108; Bea: 16-19; Claire: 20-22, 77-80; Edwin: 57-61; Grace: 27-28; Helen: 94-98, 104-110; Iris: 39-42, 124-127*
	Impact on Self-perception	An extension of self	*Bea: 25-27; Claire: 19-20; Edwin: 17-19; Flora: 3-4, 88, 141-143, Grace: 19-24*
Barriers to FT use	Personal barriers	Individual attitudes towards technology	*Anthony: 8-10, 16-17, 37-39; Flora: 39-43, 108-109; Grace: 95-96*
		Personal issues	*Anthony: 6-8, 51-54; Daisy: 3-5, 9; Grace: 3-7, 9-13, 26-27, 37-40, 65-75; Helen: 84-86, 99-101*
	Perceived technical limitations of the FT	Not waterproof	*Anthony: 40-41; Bea: 23-24; Claire: 22-24, 30-31; Helen: 40-42*
		Accuracy/synchronising issues	*Anthony: 14-15; Claire: 14-16, 31-34; Daisy: 18-19; Helen: 12-15, 70-73*
		Broken/lost device	*Daisy: 74-77; Edwin: 20-21, 52-56; Helen: 24-32*

Key. TA=Thematic Analysis; FT=Fitness Tracker; PA=Physical Activity

5.1.2.1 Positive attributes of fitness trackers

This theme captured the attributes of FTs seen by participants as positive during their interviews. The 'Positive attributes of FTs' theme consisted of four sub-themes: '*self-monitoring feature', 'motivational tool'*, '*knowledge expansion'* and *'an impact on self-perception'*. Each of these sub-themes is discussed below.

Self-monitoring feature

The ability to receive '*biological feedback'* and *'Physical Activity (PA) feedback'* was highlighted by most participants as an important positive attribute of FTs. Regarding biological feedback, participants mentioned utilising their devices to monitor their heart rate and receive information about their sleep. The feedback displayed on the devices' screens, e.g., heart rate, was considered beneficial as it helped participants to modify their behaviour in real-time. For instance, Daisy talked about monitoring her heart rate and how this led to some behaviour modifications *"The heart rate, I found the most interesting. Mostly, I am always worried that my heart rate is too high, so it [FT] helped me keep track of that and making sure I was not getting it too high".* Flora mentioned a similar experience.

> *I now use the facilities on the tracker to be able to see, like I'll say to myself: I'm out of breath. And I will look at it and I'll go - no, there's only 120. You're not! It's just a state of mind. So, I use that facility every day to manage what I perceive and what is real.*

Interestingly, the two quotes show that the heart rate monitoring feature was used for two reasons. While Daisy talked about using the heart rate feedback to adapt the exercise, as the high heart rate was the source of anxiety, Flora used the

device to continue exercising safely. Additionally, for Flora, the FT also provided context to enable her to interpret her sensations. In both examples, it seems that the FT impacted participants' mental processes, e.g., the anxiety related to physiological changes during exercise.

The monitoring of the PA feedback (mainly the step count) was also highlighted by some participants as very useful, leading to some adjustments in behaviours. As Anthony's quote below illustrates, most participants reported that monitoring the number of steps motivated them to walk more or made them realise how inactive they were.

> *I think having the Fitbit on is quite good because you can look at it every now and again and go: ohh, I have not walked very far, perhaps I'll go for a little walk. Which I wouldn't without that, I would not do it. I wouldn't even think about it. You know what I mean?*

Additionally, Daisy reported using the steps monitoring feature for pacing herself to manage pain caused by arthritis.

> *I was planning to be more active and improve the amount of steps I was doing. And in the end, I ended up having arthritis in my foot, which I didn't know at the time, I don't think. And basically, I would realise how many steps I took until it was quite severe pain. So I'd kind of use it as a limit. Does it make any sense? Which is Yeah, kind of opposite.* (Daisy)

While accessing biological and PA feedback in real-time was seen as the most beneficial element of FTs, some participants also highlighted that viewing summarised trends over time through the accompanying app was helpful as it enabled them to gain a better understanding of their activity patterns.

You can look back at the data. So, I could look back at what I've done in previous weeks or previous days and say, okay, then why didn't I, why wasn't I so active that day? Was I tired? (…) I could look back and actually summarise the week, the month, if there was a crisis in my family, and I couldn't actually be more active or whether I was down, and that was stopping me getting up and doing stuff. So, you can actually say, okay, then this is what's going on in my life at this point. What can I change to be more active? (Claire)

The quotation above illustrates how participants used biological and PA feedback displayed on their devices in real-time and as summarised trends available through the accompanying app to regulate their behaviour. Participants also considered the FT tools as motivational and contributing to behaviour changes, as outlined in the next section.

Motivational tools

This sub-theme identified two important motivational functions: the '*goal-setting*' and the *'nudge'* features. Participants shared their experiences of using the FT device's 'goal-setting' feature and how this motivated them to increase their activity levels. For instance, Edwin shared how his step goal motivated him to walk more during his lunch break.

I did set myself the target of about 10,000 steps a day, which was, which was possibly hard at first, because obviously I am working in an office, but then it did, encourage me to actually go out at lunch times, and you know, go for a walk for about an hour. And that would usually result in me doing something like six or seven thousand steps in that hour or so. So, it was good. (Edwin)

Many participants highlighted how positively they felt when they met their goals. Helen stated, for instance, *"when I reach 10,000 steps and it would make a noise on my hand [laughing] so when I looked at it, I could see stars all going and that was good".* Grace had a similar experience.

> *I found it very useful. It really motivates, really like, excites you. You can see, and you kind of know, this bip, bip, bip when it's celebrating a 5,000 or 10,000 [steps]. Like, wow, like you… this excitement and you want to reach, you want to do even more and more like, yeah!* (Grace)

Participants expressed how much they enjoyed the celebration of targets being achieved (gamification), which helped to keep their motivation levels high and reinforced their self-efficacy. Claire also reported that not reaching her goals helped her reflect on what had prevented her and make changes to ensure they were achievable.

> *It was really good that way to say, okay, then I didn't achieve my goals this week or last week, but this is what I've done. But if I rearranged my life, I can achieve my goals next week. Okay, so it was really good*. (Claire)

Another useful motivational function of the FT was the *'nudge'* feature, which acts as a discrete, vibrating reminder to get moving when a period of inactivity is identified. Many participants highlighted that they liked this feature as it prompted them to move when they had not realised they had been sedentary for an extended period.

> *So, every hour, and especially when you're working from home, when you are in front of that computer, you can be there for hours on end without moving*

away from it. So, with the Fitbit telling you ohh, you have to get up, you sort of force yourself. And so yes, I'm going to get up because I didn't realise I've been sitting for so long, you know? (Helen)

Others also reported how their sedentary behaviour was interrupted thanks to the '*nudge'* feature; for instance, Anthony acknowledged *"if you didn't have that [FT] on you, you'd probably just carry on sitting there or whatever (…) it's a good prompt".* Apart from using the nudge feature to identify periods of inactivity, Iris also highlighted how the feature helped her establish a better sleep routine.

I liked the alarm to say - go to bed. That was really good! Because that made me kind of say, right. I need to sleep. I need to stop. I need to just… and I think I utilised that quite well, I used that. So that was quite useful. (Iris)

As seen, the nudge feature was an important motivational tool that acted as a cue to action and helped participants become aware of their behaviour and change it accordingly. The following section illustrates how the use of FT contributed to behaviour change.

Knowledge expansion

Knowledge expansion encompassed *'gain in knowledge facilitated via FT' and the 'maintenance of change'*. Some participants mentioned ways the FT enabled them to gain new knowledge about their PA and certain body functions. Claire stated that for her, *"it was taking the information, and then having the Fitbit to do the activity",* while Flora shared:

I look at it [FT] sometimes and see what my heart rate is, I look and see if I've done my exercise, how fit my heart is. And I know and I can say without doubt, you know, I have a really, really, really, really, really healthy heart. So, it might be 90 right now having done a lot of exercise, and it will be 60, within 10 seconds, it drops really fast. So, I know, that for me is quite reassuring. I didn't understand that before, though. (Flora)

Some participants also highlighted how FTs contributed to the 'maintenance of change' by helping them consolidate what they learned during the HH weight management programme. For instance, Bea stated that "*with Healthy Hearts, I started looking at my portion sizes and exercise and the labelling and everything, so the Fitbit helped me monitor"* while other participants expressed similar views, as seen below.

I think it's a good venture. I think it's a good idea to what Healthy Hearts did in terms of getting people who have high blood pressure etc or some kind of need to curb the BMI etc. I think it's a good way and then with the Fitbit it is another motivational tool to use to help you keep on track as best you can. So, with the combination of the two, you're better equipped to sort of manage it because we all know what we have to do but actually doing it is another thing. So, when you have the tool and the exercise thing, you can do this, it's not impossible, you just need to retrain your mindset. I think it's very good. (Helen)

As seen, the FT helped to gain and consolidate new knowledge, enabling participants to embed the knowledge absorbed during the HH programmes.

The impact on self-perception

Some participants highlighted how the FT became essential to their daily health routines, while others saw it as a partner to rely on. Participants used very personal statements to describe their relationship with their FT, implying that they viewed their FT as an *'extension of the self,'* e.g., "*it is my everyday companion (…) when I don't wear it, when I charge it, I like, I'm missing something. It's like a part of my body now"* (Bea), "*it was like my partner! It challenged me to succeed and to achieve"* (Claire).

Flora described the FT as *"a metronome"* in her life and declared that she does not *"leave home without my watch",* further stating that the FT *"was like having a conscience on my wrist every day that I'm supposed to be participating in my active life".* Edwin stated that *"it [the FT] became like a daily routine, so I felt uncomfortable if I didn't have the watch on".* Another participant also expressed how despondent they felt when they did not wear the device, as if their exercise did not count.

> *You can maybe walk without that watch, for two hours or three hours, but I feel like… it's empty, because I don't know how many steps I did. I didn't know, like, what was the benefit? But with that watch what I find that you can track yourself, you can watch and when you watch, it motivates you to do even more and more. You know what I mean? But if let's say I walk without the watch, just I walk, I feel like… ohh I don't know, what's the benefit of that? You know? It's like a psychologist, maybe?* (Grace)

These quotes highlighted participants' personal experiences and emotional connections with their FTs. Some participants described their FTs as essential to

their daily health routines, while others viewed them as reliable partners. The language used by participants implied that they perceived their FTs as extensions of themselves, with one participant referring to it as a conscience on their wrist. Participants expressed discomfort when not wearing their FTs, stating that they felt something was missing. One participant compared the FT to a psychologist, highlighting how it served as a motivational tool by tracking and monitoring their PA, potentially offering a sense of reassurance and/or safety. These statements collectively revealed the significant emotional connection and perceived advantages that participants attributed to their FTs.

In summary, four positive attributes of the FT were identified from service user responses. The first one was the *'self-monitoring feature',* which comprised real-time '*biological'* and '*PA feedback'* and over time trends provided through the app, enabling identification, monitoring, and modification of behaviours over time. Participants also reported FT as a *'motivational tool'* enabling *'goal-setting'* in increasing PA and *'nudging'* them to reduce sedentary behaviours. Another positive feature was that FTs facilitated '*knowledge expansion'* as it supported *'gains in knowledge'* and the *'maintenance of change'*. The last one captured how FTs had '*an impact on participants' self-perception'* and how they viewed their devices as an *'extension of the self',* with some participants stating that they saw their FTs as a companion. Many of these positive attributes were seen as supporting behavioural change. However, while all participants saw many positive attributes of FTs when used as an addition to their intervention, some also brought up barriers to their use, which are discussed in the next section.

5.1.2.2 Barriers to fitness tracker use

This theme captured the barriers to FT use identified during interviews and consisted of two sub-themes: '*personal barriers'* and *'perceived technical limitations of the FT'*.

Personal barriers

Personal barriers to FT use related to *'individual attitudes towards technology'* or '*personal issues'*. Regarding participants' attitudes towards technology, some expressed that they were not technologically confident, preventing them from engaging with the device or the associated app. Flora, for instance, mentioned, "*anything that's, you know, slightly technical, I think oh, God, you know, I've got to learn this thing*" and admitted, "*I was slightly green with that sort of stuff (…) I'm a lagger when it comes to these kinds of things".* On the other hand, Anthony talked about struggling with the FT and focused specifically on the FT app (an essential feature that enables data uploads and viewing data trends).

> *I mean, I wasn't that keen, I think you might remember because I'm not so technology-minded on smartphones and that sort of thing (…) I actually had the app for a while and then I turned it off.*

It is important to note that in some cases, the attitudes could have been age-related, e.g., Anthony was in his 70s, which could have affected how he engaged with the device and the associated app. Interestingly, while Anthony did not engage with his FT, it did not have a negative impact on his weight loss. Several participants also reported personal issues that prevented them from using their FTs or using them to their full extent. Anthony, for instance, mentioned *"I did have a long period*

where I didn't actually use it [FT] because my osteoarthritis in one of my knees got very bad. And I actually ended up in A&E. So, I wasn't doing a lot of walking". Grace also expressed how the pandemic had a negative impact on her FT usage *"After we went into lockdown and I had very bad COVID and to be honest, long time I haven't used it, I'm not gonna lie. Hopefully, I will get back and start again, you know?"* Daisy mentioned that she initially intended to use the FT as recommended but *"had some health issues that kind of stopped me using it or used it in a different way that it might have been intended"* as due to arthritis in her foot, she used the tracker to limit her steps and control her pain levels. Helen also described how personal issues in her life prevented her from engaging with the FT *"it went out of sequence for a while (…) I went through bereavement; I lost my dad in May, and then I was made redundant in June (…) I was on autopilot with funerals and things".*

As illustrated, individual attitudes towards technology or personal issues affected participants' engagement with the FT or the accompanying app. Some participants also reported some perceived technical limitations of the FT that are presented next.

Perceived technical limitations of fitness trackers

The main perceived technical limitations of the device were FT's '*lack of water resistance*', '*accuracy/synchronising issues'* and *'broken/lost devices'*. The participants Anthony, Bea, Claire, and Helen pointed out that the Fitbit 2 device used in the study was not water-resistant, which prevented them from using it in water, e.g., *"that was the only thing that was quite negative, I couldn't use it in the water"* (Claire). Another participant shared a similar experience:

I erred on the side of caution because I didn't want it to get wet, so if I had a shower or doing certain things, I'll take it off, I didn't think it was water-friendly, so that's the only barrier I found. (Helen)

Some participants also reported data '*accuracy and synchronisation issues'* with the app. For instance, for Daisy, the FT's feature that she found the least useful was *"the number of stairs because it didn't tend to count them properly".* This suggested some limitations on how accurate the FT can be. Helen also described issues indicating that her FT device and the app were not set up correctly, as the data was not synchronising automatically*:*

You had to always go to the app so it would register on the app. Yes, I wouldn't say it was negative. But I had to remember each night to switch on the app so it could download to the app. (Helen)

In all cases, further instructions on the correct FT usage/interpretation of results would have been beneficial. In addition, Daisy, Edwin, and Helen reported that they discontinued using their devices as they were either lost or broken.

I lost it a few months ago. I can't find it. I've looked everywhere. It's driving me mad. Yeah, I know! I got really annoyed because I searched high and low, and I just cannot find it. I'm considering buying a new one. But it is quite expensive and don't have the money yet. (Daisy)

Edwin also stated, *"if it wasn't for the fact that it was broken, I'd still be using it* today". Although losing the FT is not in itself a limitation of the device, it was included in this sub-theme because participants identified it as a barrier. Both participants who had lost their FT were sent a new device by the researcher after their participation in

the study was completed. It was clear that they intended to continue using their trackers, but the cost acted as a barrier to replacing them.

Helen also reported that her FT experienced a technical fault, as the device broke *"it just stopped registering, so I had to send it back",* but in her case, the manufacturer provided her with a replacement FT.

In summary, several barriers to FT use were identified as '*personal'* or '*perceived technical limitations of the FT'*. Overall, barriers were linked to participants' circumstances or specific FT issues and, to a smaller or greater extent, contributed to the engagement with FT devices. Although participants mentioned various barriers to FT use, the obstacles listed were not regarded as significant issues by the participants, except in cases where the devices were lost or broken. Instead, all participants concentrated on the positive aspects of their devices and what they had gained from their usage. In general, the positive attributes of FTs seemed to have outweighed the barriers that were identified in the participant narrative, e.g., "*I could not take it to my shower (…) Otherwise it is my everyday companion"* (Bea: 23-25).

5.2 Health professionals' experiences of the intervention delivery utilising fitness trackers

5.2.1 Sample characteristics

Four HH health professionals took part in the qualitative phase of the study. All were females between 27 and 57 years old, with a mean age of 35.25 years (SD=12.62). All had completed higher education in healthy lifestyle-related fields and were classified as having professional positions. Three health professionals were White British, and one was from another ethnic background (not specified here as it might lead to the participant's identification). There were two HH practitioners and two care planners. This split represented the two roles among HH staff that service users interacted with during the programme. All health professionals were also current FT users. The detailed breakdown of the sample characteristics can be viewed in Table 5.4 below. For confidentiality, the names of the participants were altered.

Table 5.4. *Health professional participants' characteristics*

Health professional[a] name	Sex	Age	Role
Julia	Female	30	Practitioner
Kate	Female	57	Practitioner
Lea	Female	27	Care Planner
Megan	Female	27	Care Planner

Note. [a] Healthy Hearts professional participants will be referred to as health professionals throughout the rest of this chapter. The term 'participants' will be used to describe service users

5.2.2 Findings

The analysis of the qualitative data obtained from the health professionals captured three main themes identified in response to the topic guide questions. Similarly to the service users' data results, the first theme captured the *'positive aspects of using FTs'*, the second considered the '*negative aspects of using FTs'* and the third one the *'FT provision'.* The themes, sub-themes, codes, and transcript line numbers of representative quotes are presented in Table 5.5 and expanded further in the narrative sections.

Table 5.5. *A summary of results following the TA analysis of health professionals' data (themes, sub-themes, codes and quote line numbers)*

Themes	Sub-themes	Codes	Quotations
Positive aspects of using FTs	Behavioural change	Motivation	*Julia: 42; Kate: 12-15, 37, 88-89, 96-97; Lea: 30-33, 35-36, 48-50*
		Self-monitoring	*Julia: 15-19, 94-95; Kate: 19-20, 33-36, 46-49, 62-63, 97-98; Lea: 29-30, 38-39, 79-84; Megan: 146-147*
	Programme outcomes	Higher level of engagement	*Julia: 37-41, 44-50, 53-57, Kate: 84; Megan: 147-148*
		Improved health outcomes	*Julia: 62-68; Kate: 37-42, 49-52, 58-64, 133-137*
Negative aspects of using FTs	Service users' response to FT	Technology not suitable for everyone	*Kate: 84-86, 98-99, 101-103, 105-108, 115-120; Lea: 56-60, 64-66; Megan: 170-172, 176-177*
FT provision	Study design	Randomised FT provision	*Julia: 10-14, 72-86, 100-104; Kate: 69-74*

Key. TA=Thematic Analysis, FT=Fitness Tracker

5.2.2.1 Positive aspects of using FTs

This theme captured the positive aspects of using FTs as part of the HH weight management intervention as perceived by the health professionals delivering it. Two sub-themes were identified, one related to '*behavioural change'* and one capturing content related to '*programme outcomes'*. Each of these sub-themes is discussed below.

Behavioural change

Concerning behaviour change, health professionals mentioned increased *'motivation'* and '*self-monitoring'* observed among their service users. When motivation is considered, Julia, Kate and Lea talked about service users being more motivated thanks to their FT. Julia stated that *"it's been a helpful tool to boost their motivation"*, Lea mentioned that "*it can kind of keep them motivated to stay active"*, while Kate gave an example of one of her service users:

> *She's found it a very motivational tool. Even to the point of using it when she went on holiday as well, rather than being left behind, so she's found a lot of success with it (…) And what she was saying was that [FT] has encouraged her to do more.* (Kate)

All four health professionals mentioned self-monitoring of behaviour. Some of them referred to the monitoring of steps by service users "*they really like keeping track of their, their steps and things like that"* (Lea) and *"some of them have said, having that Fitbit is helpful, because it tracks the steps"* (Megan). When Kate was talking about one

of her service users, she shared *"I do think she was still very much enjoying the tool of the Fitbit because it gave her… Because it was giving you that analytical feedback?"* The self-monitoring feature was something health professionals commented on as they believed it helped service users during HH programmes. For instance, Julia noticed *"I've seen people kind of looking at their steps in class and things like that".* She also added*:*

> *We [HH] have food diaries, and we asked them [service users] to write down their exercise on the bottom of the food diary, so for them to be able to say I did 10,000 steps today, and that's obviously helped because they've got the fitness tracker, so I think that's been a really positive thing.*

This quote suggests that health professionals saw FTs as a valuable tool enabling their service users to monitor their steps and be more involved with the HH programme. Participants used HH materials provided during their weight management intervention, and thanks to the FT, they were able to quantify PA and report it back to health professionals in an objective way, bringing a level of accountability. Julia also commented about one of her service users utilising the sleep tracking function on their FT.

> *She did say she was using it to look at her sleep pattern (…) her feedback was to me generally at the end of the session was that she's sleeping better.* (Julia)

Julia mentioned that the usage of the FT evolved as the service user utilised their device to help them improve their sleep (which can also be seen as improved health outcomes). Once that aim was achieved, the device was no longer needed for that particular function. The service user seemed to learn enough about their sleep pattern

that no further monitoring was needed. This suggests the service user may have internalised sleep monitoring, making positive changes.

Programme outcomes

During their interviews, health professionals highlighted the '*higher level of engagement*' of service users with the HH programme and their improved weight management '*health outcomes*' as the two main positive aspects linked to FT use. Concerning service users' engagement, Julia believed the FT contributed to a higher level of engagement with the programme.

> *Those who've got a fitness tracker have seemed, and I can't say this for every single client, who's got a fitness tracker, but the ones that I've kind of noticed, have been very positive and very engaged. And I feel like maybe that could be something to do with the fact they've kind of been given this opportunity of, you know, like, I've got one of these, I'm going to make the best of this situation. Now I'm really going to try, really, really going to engage.*

Julia also felt that some service users who received the FT were making an extra effort to stay engaged with the programme, e.g., completing food diaries, asking questions in sessions and attending most weeks (e.g., *"the ones I've noticed have come for the 10 weeks as well, which is obviously another really great news"*). Megan also speculated that service users getting FTs would be "*quite keen on continuing their weight management*" intervention.

A higher level of engagement with the weight management programme was often also related to better intervention outcomes. Julia and Kate observed positive

improvements in the service users' health and that FTs contributed to those changes in programme outcomes.

> *She [the service user] has got more energy, she's sleeping better because of it and, and is exercising more regularly. Because she's got that continual feedback as to what she's done. I think she's saying that with that, that was the element of the competition she's got with her husband. That's kind of like keeping her going.* (Kate)

Julia also pointed out that in one of the groups she was delivering the weight management intervention to, a high proportion of service users with FT lost weight, achieving their 5% weight loss goal. She interpreted this as "*a nice sign to indicate that, hopefully, that [FT] was quite a positive influence on them"* and concluded that it *"looked really encouraging".*

In summary, several positive aspects of the FT have been identified. Health professionals highlighted that they observed positive behavioural changes among their service users, mainly linked to improved motivation and self-monitoring of behaviour. Additionally, health professionals noticed improvements to weight management programme outcomes, specifically around higher engagement of service users and their improved health outcomes in those allocated to the FT condition. While all health professionals noticed positive aspects of using FTs that they observed among their service users, some also brought up the negative aspects that should be considered, which are covered in the next section.

5.2.2.2 Negative aspects of using fitness trackers

This theme captured the negative aspects of using FTs as part of the HH weight management intervention, mainly centred on '*service users' responses to FT'*, particularly on issues related to the fact that '*technology is not suitable for everyone'.*

Service users' responses to fitness trackers

Some health professionals mentioned that FT technology was not suitable for everyone. As Kate stated about a handful of people who had declined the chance to get the FT through participation in the study, "*they're not motivated by something on their arm that's telling them that they've done this many steps"*. The lack of computer/internet access, service users' age or low confidence with technology were also mentioned as potential reasons behind the decision to decline the FT offer (through the study participation).

> *The main barrier would be for more elderly people, just being a bit overwhelmed by this kind of technology. They are, [saying] "oh, no, that's all sounds a bit too complicated for me". Kind of thing. So maybe they don't have a smartphone. Or maybe they just don't feel confident that they would be able to use it. So, I have had a few that would have been eligible. And when I discussed it with them, they said that oh, no, that's too much for me (…) I think the main barrier is just, yeah, unless they're not eligible for some reason, it's being confident enough with the technology side of things.* (Lea)

Health professionals acknowledged that FT technology is not suitable for everyone. Some individuals declined the opportunity to receive FTs during the study, and factors such as lack of computer or internet access, age, and low confidence with technology were mentioned as potential barriers to engaging with the FT. These factors highlight the importance of considering individual preferences and technological literacy when implementing FTs in health interventions. The strategy of the FT provision should also be considered, and this is looked at next.

5.2.2.3 Fitness tracker provision

Health professionals mentioned that due to the randomised design of the study, some service users were given the FT as they were allocated to the FT study condition, while others were allocated to the control condition without the FT. Julia admitted that she was projecting her feelings and was worried about this design in the first place as she felt it might have a negative impact on service users in the control condition.

> *I did notice a few people who were in the control group who dropped out. But I wouldn't say it's necessarily a recurring theme now. I would say it's, yeah, definitely more towards the beginning. There were definitely a few people who were like, you know, maybe they just wanted the Fitbit, in which case, maybe they weren't that engaged in the whole process anyway, but yeah. Definitely now, you might see someone be a little bit deflated, but actually, I don't think it necessarily, I don't think it necessarily stops the intervention. Which was something I was quite worried would happen actually when it started. But, actually, it hasn't. I don't think it has been detrimental to that.* (Julia)

Kate brought up the same issue but also pointed out that the study process was adapted to mitigate disappointment in the control group. Specifically, the timings of the FT provision were adjusted so that instead of providing the FT at the beginning of the group session, one-to-one meetings to hand over the devices were organised after the session to ensure that service users in the control condition were not feeling too disappointed about not getting the FT.

> *We didn't want to emphasise that this [the provision of FTs] was going on. And, at first, when we first started to do them, the researcher was coming and meeting the small pocket that were eligible to begin before the course started. And we found people were saying, what's that about? And why aren't we involved in that, and it seemed to be an exclusion. So, the researcher reshaped it so that she saw the clients after the sessions on a one-to-one basis and things like that.* (Kate)

While this negative aspect of using FT is closely linked to the study's design, any weight management intervention that uses these devices might have restrictions regarding their provision (e.g., on health grounds), inevitably disappointing some service users.

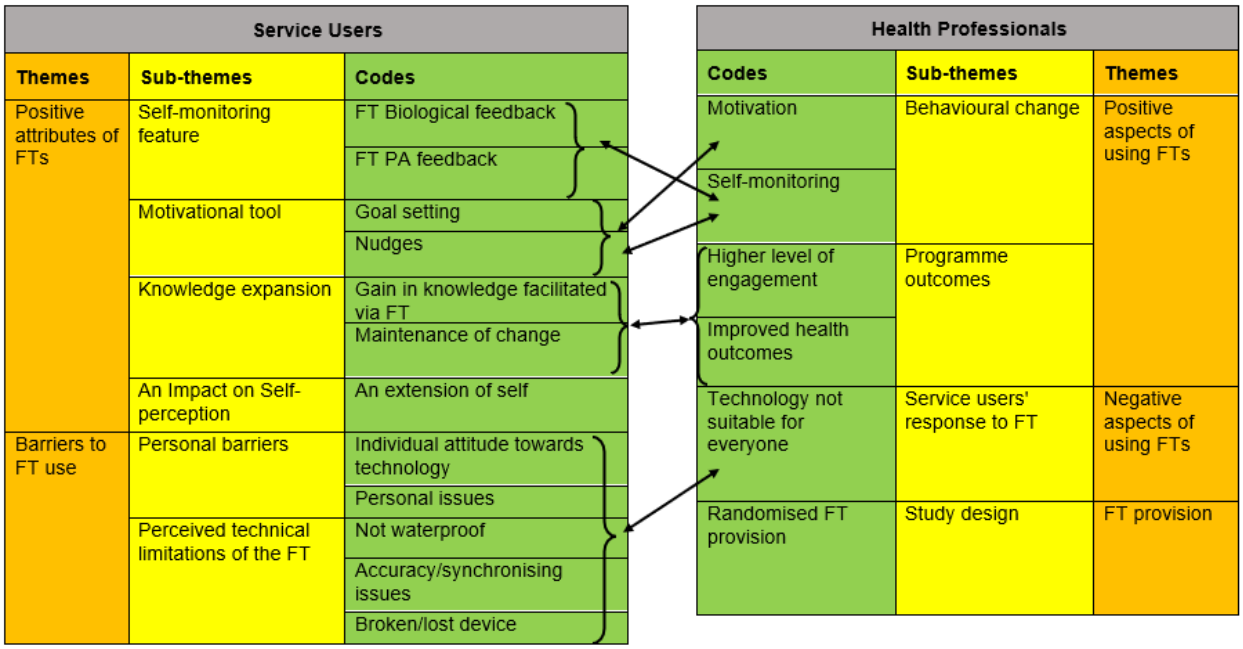
In summary, health professionals mentioned some negative aspects of using FTs in weight management programmes. The selective, randomised provision of FTs was seen as unfavourable for the control group, possibly impacting service users' motivation. Some health professionals also believed that FT technology is not suitable for everyone, stating that some service users might not be able to benefit from FTs. In addition to the negative aspects, health professionals talked about noticing improved self-monitoring of weight management behaviour and motivation of their service users,

potentially contributing to better programme engagement and outcomes. These points are discussed further in the next section.

5.3 Comparing service users' and health professionals' experiences

Following the analysis of the qualitative data from both cohorts of participants, some overlapping codes, sub-themes and themes were identified. Figure 5.1 below shows where the similarities are present.

Figure 5.1. *The themes, subthemes and codes identified in the service user and health professional cohorts of participants; arrows display similarities*



Key. FT=Fitness Tracker, PA=Physical Activity

As seen, service users and health professionals identified positive and negative aspects of using FTs. Motivation and self-monitoring of own behaviours came up as crucial

positive attributes of FTs in both data sets. Participants in both cohorts also identified knowledge expansion, which can contribute to higher engagement and improved health outcomes. Regarding the negative aspects of FT use, there were several barriers and perceived technical limitations of FT use. As health professionals stated, it was apparent that this technology is not suitable for everyone. The health professional results complemented service users' results, providing a broader angle and adding credence to the findings.

5.4 Discussion

5.4.1 Key findings

This study explored service user participants' experiences using FTs as part of the weight management intervention and health professionals' experiences of delivering the intervention with/without FTs. Positive attributes of FTs and barriers to their use or the negative aspects of their use within the weight management intervention context were identified.

In terms of the positives discerned from the service users' perspective, the benefits of self-monitoring through the observation of biological and PA feedback were brought up by most participants. This is in line with previous research. In a study exploring the experiences of using FT devices (Fitbit specifically), Jones and colleagues (2021) found that their participants also mainly had positive views about using their devices for goal-setting and activity tracking. The authors highlighted that one of the motivational factors for participants was becoming aware of their activity or sedentary behaviour (Jones et al., 2021), similar to the current study. In another qualitative study (Burford et al., 2021), participants also reported improvements in behaviours and

emphasised that the FT-provided feedback gave them motivation and validation as well as a sense of achievement.

When FTs are viewed in the context of motivation, the feedback, goal-setting, and self-monitoring functions are constructive as they may help to enhance intrinsic motivation. The FT could also be seen as beneficial in increasing automatic motivation as it can help to improve habits and routines around PA. As high levels of motivation predict more significant weight loss in general (Webber et al., 2010), FTs could have acted as a valuable tool to aid more significant weight management programme outcomes due to their facilitation of PA. In this research phase, several participants mentioned that their motivation to exercise was enhanced thanks to using some functions offered by the FT. Health professionals also discussed this. Both cohorts of participants believed that FT helped to increase motivation to exercise and reach goals. PHE recommended that using technology such as FTs may be considered to sustain service users' motivation during weight management programmes (2017d).

Other research found that the utilisation of FTs to self-monitor PA was associated with significant improvements in PA and weight loss, BMI and other health outcomes (Yen & Chiu, 2019). A study by Chia et al. (2019) emphasised that goal-setting, self-monitoring, and feedback on behaviour were the predominant BCTs employed in various FTs, including Fitbit. In the current study, participants indeed mentioned these techniques. Some stated that their motivation levels had improved as they were challenged to strive to achieve their goals. This is consistent with Jarrahi and colleagues' (2018) findings, which also highlighted the positive effect of FTs on motivation when goal-directed activities were performed.

Since goal-setting has been identified as a primary BCT in weight management (NICE, 2014a), FT devices that support this technique proved beneficial by offering an extra avenue for goal-setting and self-monitoring the progress against these goals. In the systematic review looking at 19 studies by Hu and colleagues, having a goal was highlighted as a motivation to use the FT (Hu et al., 2020). Participants in the current study found the display of rewards for achieving daily targets on the FT to be motivating, with celebratory screen displays received as particularly useful. This can be seen as a gamification technique.

Gamification involves incorporating game components into non-game settings, and it emerges as a promising pathway to improve the effectiveness of health interventions, especially around increasing PA (Mazeas et al., 2022). Gamification has been proposed as a viable and effective tool for health interventions across many domains, and gamified technologies such as FTs have been highlighted as having the potential to enhance the user experience by introducing additional motivators (Cho et al., 2021). A recent review of 53 studies on gamification revealed that there is a growing trend in employing gamification approaches to address various health conditions and enhance health results, such as increased PA, healthy eating habits, and improved mental well-being (Damaševičius et al., 2023).

Nudges, seen as cues to action, were found to be motivational in the current study, consistent with previous research. For instance, Kreitzberg and colleagues (2016) reported in their qualitative study that their participants found reminders to move as motivating to engage in PA. Almost all service user participants in the current study mentioned nudging as a crucial feature FTs offered, as without these reminders, they

would have continued being sedentary. Reminders helped to bring a new level of awareness that immediate action was needed to break the period of sitting (for example, reminding individuals to get up and do the recommended 250 steps per hour). It can be argued that FTs provided participants with the tools to act on the recommendations of the HH programme to break the sedentary periods. Some participants mentioned that getting up in response to the nudge usually led to achieving more steps. This was in line with the findings of Rosenberg and colleagues (2017), who concluded that incorporating inactivity alert features (nudges) in FTs has shown effectiveness in promoting small but significant improvements in reducing sedentary behaviour in adults with obesity. In the current study, this feature also assisted one participant in establishing a better sleep routine.

Some service users mentioned the gains in knowledge facilitated by the FT, e.g., in terms of their heart rate or sleep patterns. At the same time, others mentioned how the FT helped them apply the knowledge gained to their future behaviour during their HH programmes, for instance, monitoring the number of steps they were asked to write down by HH practitioners. Participants found that FTs helped them learn about PA patterns and health and make informed decisions to improve their well-being. The feedback and accountability provided by FTs helped some service users maintain behaviour change, and they expressed the intention to continue using their devices beyond the HH programme. Some participants became accustomed to wearing and checking their devices, which may assist in maintaining self-monitoring of their own behaviours and long-term behaviour change even after programme discharge. Health

professionals also noted how FT helped consolidate the knowledge gained through HH programmes.

Participants becoming aware of extensive sedentary periods or gaining knowledge around the interpretation of heart rate while exercising can be seen as knowledge expansion and greater activation. Similarly, a recent study by Edward and colleagues (2020) reported that individuals who wore FTs were more likely to be health-conscious and physically active. The researchers observed a positive association between wearing a PA tracker and both increased activity levels and heightened awareness about one's health.

FTs were also viewed as an essential part of people's daily health routine, and some viewed them as an extension of their bodies. Some participants mentioned their discomfort when they did not wear their FTs. Exercising without their trackers made some feel empty and question whether there is any benefit of exercising if the number of steps is not counted. The devices meant a lot to some participants.

The concept of FTs as an extension of self refers to the idea that people integrate these devices into their identities and use them as a tool for self-expression. In a study focusing on FT embodiment conducted by Nelson and colleagues (2019), self-extension through FT was also identified from participants' accounts. It corresponded to the object viewed as an integral component of an individual's identity or self-perception (Nelson et al., 2019). Nelson and colleagues suggested that individuals who use FTs tend to view them as a part of their identities, leading to a greater sense of attachment and motivation to use the device consistently (Nelson et al., 2019). FTs may also

enhance individuals' self-awareness and mindfulness around their PA habits, improving overall health and wellness.

The findings regarding self-monitoring of PA and identity, including the personalised use of self-monitoring technologies, support previous research investigating overweight or obese men's experiences of using pedometers in a gender-sensitive weight management programme (e.g., Hunt et al., 2013). Additionally, they are in line with studies examining the utilisation of pedometers and other forms of self-tracking technologies post-weight management intervention, with a particular emphasis on the potential maintenance of PA levels (Donnachie et al., 2017).

Additionally, both phases of the current study found that using FTs resulted in increased engagement among participants in the weight management programme, as reported by both service users and health professionals involved in the study. The attendance rates were also higher in the group of FT users than in the control condition. This was in line with previous research. In a study conducted by Jakicic and colleagues (2016), researchers found that overweight and obese adults who used FTs had greater attendance rates at weight management sessions compared to those who did not use the trackers.

The findings show that overall, participants had positive attitudes towards FTs and utilised them to track their PA; they saw them as valuable and affecting their behaviour. On the other hand, some participants also mentioned barriers to their FT use. Attitudes towards technology at the programme's start were negative for some participants, which was seen as a barrier. However, as they got used to wearing their FT and benefiting from its functions, some people's attitudes shifted to be more positive.

While the attitudes became more favourable for some as the exposure to FT technology increased, this was not true for every participant. Interestingly, one participant, who admitted that they were not keen on technology in the first place, did not engage with the FT, but it did not have a negative impact on his weight loss.

Many participants also talked about personal issues they experienced that prevented them from engaging with their FTs or the HH programme. This mainly involved health issues, especially prominent among participants participating in the study during the pandemic. It is also essential to point out that this cohort of participants was overweight or obese, and some participants had underlying health conditions that increased their risk of CVD. In some cases, this acted as a barrier to better engagement with the FTs and staying engaged with the HH programme, as it limited participants' ability to exercise or walk. While initially, participants' intention to engage with the FT and the HH programme was strong, their health or personal circumstances could have prevented them from acting on this intention. This finding demonstrated that such issues are frequent and significant obstacles to sustained FT use. As the FT synchronisation data showed in the current study, some participants abandoned their FTs prematurely. As pointed out in previous research (Attig & Franke, 2020), not all FT users discontinue tracking of their own accord, as often external factors such as shifting priorities lead to a cessation of tracking. According to research conducted by Maher and co-authors (Maher et al., 2017), a third of the participants in their study (n=237) discontinued using their FTs prematurely due to technical issues or malfunctioning of the device. While more recently manufactured FTs might be more engaging and reliable, Chan and colleagues (2022) highlighted in their systematic review that some issues are linked to

how validity and adherence to FT are measured and reported in studies. In a systematic review by Silfee and colleagues (2018), it was reported that considerable variability exists in the PA metrics reported, which hinders the ability to make direct comparisons across studies. Due to the heterogeneity of studies and no standard way of reporting FT outcomes, it is hard to understand the current levels of long-term PA and engagement with these devices.

Lastly, some participants also experienced technical barriers when utilising their devices. It is crucial to point out that some participants stated that their FTs were sometimes inaccurate. This was potentially due to participants' incorrect data reading, as mentioned earlier. It is also possible, however, that the data was not always completely accurate. This was reported previously; for instance, Chum and colleagues reported that six participants (out of 36) in their qualitative study also reported data accuracy issues (Chum et al., 2017). It is believed that this could have undermined participants' perception of FTs and led to decreased engagement. Several reviews have looked at the accuracy of FTs and compared them with research-grade trackers. Fitbit devices are considered to be among the most accurate FTs that are commercially available (Ringeval et al., 2020). In a systematic review conducted by Germini and colleagues, it was concluded that Fitbit Charge was consistently showing good accuracy for step counts but not for measuring energy expenditure (Germini et al., 2022). However, the consensus is that consumer FTs such as Fitbit are less accurate than devices specifically designed for research purposes (Chowdhury et al., 2017). At the same time, they are more user-friendly, less invasive, cheaper and have more functionalities (Henriksen et al., 2018). Thus, the numerous benefits of consumer FTs

may outweigh their limitations and make them a more feasible option for ecologically valid, community-based study types such as the current one.

The device used in the study not being waterproof was problematic for some participants. While all efforts were made to select a device that would offer a scope of features and be affordable at the same time, the researcher acknowledges that not every participant would have been entirely pleased with the device selected as the choice was limited. Additionally, misplaced or broken devices have also been brought up by some participants. As some issues could be assisted with (e.g., software issues), lost devices were beyond the researcher's assistance and could be attributed to participants' behaviours.

The health professionals' data largely supported the findings from the service users who used the FTs. Health professionals identified similar positive aspects of using FT and similar barriers to their use. For instance, health professionals noticed that their service users benefited from their FTs as the devices enabled the self-monitoring of behaviours, e.g., PA and that also enhanced the gains in knowledge through the HH programme. As HH practitioners routinely asked their service users to record PA during the weight management programme, FTs provided a valuable platform to keep track of these metrics. Some health professionals considered FTs an additional motivational tool providing support during the service users' weight management journey. Health professionals also noticed that those utilising FTs seemed to have a higher level of engagement in the HH programme. Some also emphasised that participants' health outcomes seemed to be improved.

On a more negative note, health professionals highlighted that FTs were unsuitable for every service user. It was highlighted that some HH attendees were not interested in using the tracker during the study recruitment phase, and service users' older age was quoted as one potential contributing factor to decreased engagement.

In terms of existing research available, there is limited knowledge regarding healthcare professionals' experiences and their perspectives on the benefits and drawbacks of adopting FTs, as most studies focus on FT users (Tomasella & Morgan, 2021). In their study, where nine health professionals were interviewed and asked to share experiences of dealing with patients utilising FTs (not within a weight management context), some highlighted behaviour change promotion (explicitly referring to goal-setting, motivation and tracking health) as potential advantages of FTs (Tomasella & Morgan, 2021), hence supporting findings from the current study. Age-related illiteracy issues were highlighted in the same research as possible barriers. Watt and colleagues (2019) also reported that health professionals interviewed in their study mentioned age as a potential barrier to FT usage. The authors also reported that their participants felt that future generations of older adults would have a greater familiarity and find it easier to use this technology.

In the current research, health professionals expressed concerns about how FTs were provided as part of the programme, raising questions about the study design. As these points relate to more operational aspects, they are expanded on in Chapter 6.

5.4.2 Participant accounts considered in light of the findings from the quantitative study

It is crucial to look at the findings of the qualitative phase of this study in the context of quantitative research as they complement each other. It needs to be pointed out, however, that some findings did not necessarily support the quantitative ones. In terms of weight measures, statistical tests have previously revealed that after participants' first 10 weeks of the intervention, a weight loss was observed, which was more prominent in the FT condition. Additionally, the reduction in weight in the FT group was also significant after six months of the intervention and not significant in the control group. When looking at the cohort of nine participants taking part in the qualitative study, it can be seen that seven out of nine lost weight after the 10-week weight management intervention (the other two put on weight). Six maintained the weight loss after six months; one put on weight, while the data for the other two participants were unavailable. In the qualitative findings, it was revealed that a few of the participants discussed losing weight and described their endeavours to sustain their weight loss. However, these outcomes were not as successful for everyone.

The qualitative results have also enabled an exploration of factors that were explicitly linked to weight loss. The PA level was closely linked with weight loss; all participants talked about their activity levels during their interviews. The initial quantitative data analysis showed some differences in PA levels favouring FT condition. These included the improvement in moderate PA (while in both groups, the group with FTs had a larger effect size), vigorous PA (same as above) and a significant decrease in sitting minutes (significant only in the FT condition). In the qualitative analysis,

however, most participants mentioned utilising their FTs and stating that the devices helped them with their PA levels. Many participants mentioned maintaining their PA habits beyond their HH programmes. It also became apparent that while some participants continued to utilise their FT, some experienced technical or personal issues that acted as barriers to using their devices long-term. This could have explained some trends behind the quantitative results, especially the data trends obtained from FTs. Health professionals also mentioned better outcomes among their service users who used FTs in terms of PA levels. They talked about observing how their service users self-monitored their activity while exercising during the programme and kept track of their activity levels between sessions, which helped them populate HH programme diaries that health professionals viewed.

Regarding attendance levels, the quantitative analysis showed that, on average, those who used an FT attended 1.72 sessions more than participants not utilising an FT. In their testimonies, healthcare providers also noted a rise in programme attendance. Some health professionals believed that service users who benefited from FTs were more engaged in the programme and attended more sessions, which supports the statistical outcomes.

In summary, the qualitative examination of both service users and healthcare professionals' data offered a distinctive viewpoint as it revealed additional insights that were not evident during the quantitative phase of the study. The discussion chapter comprehensively analyses all the results and their interpretation in a broader context.

5.4.3 Strengths and limitations

The qualitative phase of the study had several strengths that should be noted. The study's sample included a diverse range of service users representing different age groups, having a female/male split reflecting the total sample, different ethnic backgrounds, and occupations, increasing the sample population's representativeness. Furthermore, the study successfully engaged clients who were hard to reach. Participants also had various levels of engagement with the programme and attendance rates. They also had varying degrees of success with weight loss and FT usage. In addition to understanding the participants' perspectives directly, health professionals' perspectives in delivering the weight management intervention also offered valuable insights. As highlighted by Watt and colleagues (2019), most studies looking at the use of FTs in healthcare examined the perceptions of FT users, not those of health professionals. By incorporating health professionals' accounts, this study distinguishes itself as unique in the field and adds to the richness of the collected data.

The study also had several limitations. First, the sample size was relatively small. Second, the COVID-19 pandemic shortened the recruitment period, decreasing exposure to face-to-face programmes for service users. This may have impacted the effectiveness of the intervention and the data collected. Finally, regarding the part of the study involving health professionals, it is essential to note that the discontinuation of Local Authority-funded contracts, the high staff turnover rate at HH and the requirement of minimum exposure to the study procedures (6 months) limited the sample size.

5.4.4 Implications for the thesis

The qualitative phase of this study provided valuable insights into service users' experiences of using FTs in the context of a weight management intervention and health professionals' experiences of delivering the intervention with and without FTs. The study findings suggested that FTs can improve engagement and motivation and stimulate behaviour change in weight management interventions among a sample of harder-to-reach participants in an ecologically valid setting. However, it is essential to recognise that FTs are not suitable for everyone, and additional support may be required for certain groups of service users, for instance, with specific health conditions or negative attitudes towards technology. Further research is needed to understand the mechanisms underlying the positive effects of FTs and address the barriers to their use. These findings provided a valuable addition to the data obtained in the quantitative phase of the study.

5.5 Summary

This chapter presented the qualitative results and offered insight into the experiences of service users and health professionals involved in weight management interventions. Overall, the main findings showed that the positive attributes of FTs and the negative aspects of their use were identified. The research highlighted the benefits of FTs in enhancing motivation, self-monitoring of behaviour, and engagement in weight management programmes. While some barriers were identified, FTs were seen as having the potential to be valuable tools in promoting PA and overall health. The qualitative phase of the research provided complementary insights to the quantitative

findings, shedding light on factors related to weight loss, PA, and programme attendance.

The following chapter (6) presents a comprehensive discussion of the findings of this research, with a specific focus on their theoretical, practical, and methodological implications.

Chapter 6 – Discussion

This chapter synthesises the findings from both phases of the research, discusses them in the context of previously published evidence, draws conclusions and provides recommendations. It begins by summarising the key findings from the research and providing the interpretation of the results in the context of the key frameworks that were utilised, namely the TPB and the COM-B model. It highlights the contribution of this work to current knowledge on the use of FTs in the field of weight management. The study's implications are also examined alongside the research's strengths and limitations. Future research directions are outlined, and conclusions are provided at the end of the chapter.

6.1 Summary of findings

This research looked closely at the use of FTs among a sample of overweight and obese participants enrolled in a weight management intervention aimed at CVD prevention. Participants came mainly from deprived areas of Central London and were primarily from ethnic minority backgrounds. Their mean age was 53 years, and the majority were unemployed. Participants were enrolled on the HH CVD prevention programme for an average of six months. This tier-two intervention, within the broader obesity management pathway, was commissioned by Local Authorities to engage the most disadvantaged communities and help them lose weight. The targeted prevention of CVD delivered through HH was in line with the Marmot report recommendation (Marmot, Allen, Boyce, et al., 2020) that more intense intervention should target people lower down the social gradient. This research aimed to achieve this by successfully

recruiting participants representing the ‘harder-to-reach’ population. An established weight management intervention was necessary to test whether FTs could impact the intervention’s outcomes.

The first three research objectives were addressed using quantitative methodology. The main and overarching objective explored whether FTs impact weight management intervention outcomes in those at risk of CVD. The results identified significant reductions in weight after 10 weeks and six months of the intervention for participants who used FTs. No significant reductions were observed in the intervention as usual group. The waist circumference and BMI were also significantly lower in the FT condition at the 6-month follow-up. In terms of PA, there was a significant increase in PA across time in both groups. Vigorous PA increase (while significant in both groups) had a greater effect size in the FT condition, while decreased sitting minutes were only significant in the FT condition. Interestingly, when moderate PA levels recorded as part of HH (six months apart) were examined, both study groups significantly improved PA over time (with a larger effect size demonstrated in the FT condition).

On average, participants utilising FTs also had better attendance, attending 1.72 sessions more than participants in the control group. A pattern showed that weight-related programme outcomes and attendance rates were more favourable in the FT condition. Taken together, the present findings suggest that FTs had a positive impact on weight management intervention outcomes.

The second research objective tested whether health beliefs defined by the TPB constructs (attitudes, subjective norms, PBC and intention), WLOC, anxiety, depression, Patient Activation levels and motivation differed between participants in the FTs and the

intervention as usual conditions and whether these changed over time. This research showed that only a difference in depression scores was present, with participants in the FT condition showing a significant reduction in depression scores. Reductions in anxiety scores were also observed across time, but no differences were found between study groups. Similarly, the subjective norms and intention to lose weight defined by the TPB also displayed significant differences across time (reductions), but no differences between the study conditions were present.

The third research objective intended to examine factors associated with successful weight loss (health beliefs defined by the TPB, WLOC, anxiety, depression, Patient Activation levels and motivation). The only significant relationships that were identified were between attitudes (TPB) and weight outcomes and between anxiety and weight outcomes at six months. Attitudes towards losing weight had a negative relationship with weight difference, suggesting that the more positive participants' attitudes towards weight loss were at W1, the more weight loss participants achieved at six months. Anxiety positively correlated with weight difference, suggesting that the more anxious participants were, the less weight they lost at the end of the 6-month intervention. Attitudes and anxiety were tested in the regression model but did not predict weight outcomes significantly.

The fourth research objective explored the service user and health professional participants' experiences of the weight management intervention utilising FTs. Positive aspects of FTs, barriers, and negative effects were identified within the context of the weight management programme. From the perspective of service users, self-monitoring through observing biological and PA feedback was seen as a significant benefit of using

FTs. The motivational factors of becoming aware of activity levels and behaviour were also emphasised. Participants also mentioned the knowledge gained through FTs as positive. Some barriers to FT use, such as technical and personal issues, were nonetheless identified. Despite these barriers, the overall attitudes towards FTs were positive, with participants perceiving them as valuable tools that influenced their behaviour. FTs were seen as an extension of individuals' daily health routines and even considered as part of their identities by some service users.

Health professionals observed increased engagement in the weight management programme among FT users, leading to higher attendance rates. Apart from increased engagement, health professionals also recognised the benefits of FTs in terms of self-monitoring of PA behaviour and other metrics and knowledge enhancement. The negative aspects were also highlighted, and health professionals concluded that FTs were not suitable for everyone, mainly due to technological literacy.

These findings were complemented by the insights obtained from the FTs data. The results indicated that participants who recorded more steps on their FTs experienced more significant weight loss and improved weight-related measures such as BMI. Additionally, a positive relationship was observed between steps and Patient Activation and between steps and intention to lose weight. Similarly, engagement in recorded physical activities through FTs was associated with greater weight loss and more supportive subjective norms.

Furthermore, the study identified a positive relationship between depression scores and the average activity recorded through FTs. Participants with higher depression scores engaged in more activities, possibly utilising FTs as a self-monitoring

tool. The FT data also highlighted variations in device usage patterns among participants, with some fully embracing the devices while others having a low level of engagement or discontinuing their FT usage prematurely.

The findings from all phases of this research complemented each other and provided valuable insights into the impact of FTs on weight management intervention outcomes for individuals at risk of CVD. The study emphasised the potential benefits of FTs as valuable tools in weight management interventions. It also acknowledged the need for a personalised approach to ensure FT's suitability for individual users.

6.2 Interpretation of results

The data obtained in both study phases revealed some interesting findings that can be interpreted within health psychology frameworks discussed earlier in this thesis (TPB and COM-B – See Chapter 1).

6.2.1 Fitness tracker use within the TPB framework

The current results can be mapped against the TPB model, which states that attitudes, subjective norms, and PBC determine the intention to perform a behaviour (Ajzen, 1985). The predictive power of these determinants of behaviour was tested to a small degree, as only the attitudes scale was significantly correlated with weight outcomes. Attitudes did not have any predictive value on weight loss. Due to psychometric issues affecting the PBC scale, it was not used. Additionally, the TPB scale utilised in the study was weight-specific generally (Schifter & Ajzen, 1985; adapted using the recommended manual - Francis et al., 2004) and did not look

specifically at FTs. However, many links with these TPB determinants were established in this research, mainly through the qualitative results and the FT data analysis.

Attitudes

Attitudes are linked to the evaluation of the behaviour by individuals and their belief regarding the likely consequences/outcome of the behaviour, for instance, that increasing PA (behaviour) leads to weight loss (outcome) (Ajzen, 2020). In terms of the quantitative phase of the current study, negative relationships between attitudes and weight differences between W1, W2 and W3 study waves were found. The more positive the participants' attitudes were at W1, the more weight loss they achieved. The findings from the qualitative phase of the study showed that overall, participants had positive attitudes towards the FTs and utilised them to self-monitor their PA activities and other metrics. They saw them as valuable and, affecting their behaviour. The wearing of the FT was perceived by some participants as an extension of self, leading to a sense of attachment and motivation. Strong positive attitudes towards FTs were expressed as a result. People considered FTs to be an integral part of their daily health routine. Some participants mentioned their discomfort when not wearing their devices. These perspectives could be strongly linked to positive attitudes towards wearing FTs and evaluating behaviours such as PA. The value of the FTs was recognised by participants, who believed that wearing the devices impacted their behaviour. In a study on the experiences of using FT devices, particularly Fitbit, conducted by Jones and colleagues (2021), positive views were predominantly expressed by participants regarding the utilisation of the devices for goal-setting and activity tracking. The authors

also emphasised that one of the motivational factors for participants was the awareness of their activity or sedentary behaviour (Jones et al., 2021).

For some participants whose attitudes towards weight loss were initially more negative or neutral, they subsequently changed to be more positive as they got used to wearing their FT and benefiting from its functions. While the attitudes became more favourable for some as the exposure to FT technology increased, this was not true for every participant. Interestingly, some participants who admitted they were not keen on technology in the first place either stopped using their device altogether or stopped engaging with certain features, for example, the app. This did not necessarily impact their weight loss, but the sample of participants in the qualitative phase was too small to draw definite conclusions.

Health Professionals pointed out that FT were not necessarily suitable for all service users. Similar views from health professionals have been previously reported in the literature (e.g., Watt et al., 2019). As previously discussed, weight management interventions should be tailored to the individual's needs, characteristics, and attitudes. Instead of FT being a tool offered to everyone, it could be included as part of a pool of interventions to maximise outcomes.

Participants' attitudes towards FTs might need to be assessed during the one-to-one session with the health professional at the start of the weight management programme in the same way their attitudes to losing weight are routinely assessed. The degree to which an individual has a favourable or unfavourable evaluation of behavioural goals linked to FT usage could be explored. Those with more negative attitudes towards FTs might need to be assisted to shift them to more positive ones.

Alternatively, a decision might need to be made by the health professional that the FT is not suitable for those individuals. Regarding psychological factors in obesity and PA, addressing unhelpful attitudes and behaviours should be incorporated into prevention interventions and treatments of obesity (Chadwick et al., 2019).

Subjective Norms

Subjective norms are related to the perception that significant others approve or disapprove of individuals performing the behaviour, for instance, exercising to lose weight (Ajzen, 2020). In the current study, subjective norms concerning losing weight varied across time - scores went down at each study wave, indicating less supportive subjective norms. FTs did not yield more favourable results towards subjective norms in the quantitative phase of the study. In the qualitative accounts, however, participants talked about seeing the tracker as a partner to rely on. One could argue that the availability of FTs may have functioned as a perceived form of normative pressure, eliciting a tendency to conform to the expectations of healthcare professionals or the researcher. Participants may have potentially felt a certain level of pressure to utilise FTs and were conscious of the researcher having access to their activity data. The researcher spent time with each participant to complete the study surveys and provide the FT device. This time invested with each participant could have given them a sense of pressure and a desire to avoid disappointing the research team.

Similarly, insurance companies utilise FTs to motivate their clients to exercise by offering discounts if, for instance, a certain number of physical activities in a month is

achieved (*Vitality Insurance Plans*, 2023). This can create a sense of accountability and heighten motivation to participate in PA.

Regarding support from significant others, only 19% of participants in the current study attended the HH programme with a family member (despite this being an option for all service users). This suggests that only a fraction of participants had the support of significant others who would attend their weight management sessions. Having the FT device could, therefore, make some people feel supported as they had a new '*partner they can rely on*' or '*a conscience on their wrist'.* Subjective norms were routinely examined in HH sessions when social pressures were explored during group discussions. These were discussed mainly in relation to PA and weight loss in general. Conversations about FTs could have been easily incorporated into sessions at this point.

Perceived Behavioural Control

As defined by Ajzen (1998), PBC encompasses the individual's perception of how easy or challenging it is to engage in a specific behaviour, such as weight loss, and their belief in their ability to carry out that behaviour successfully. It is also seen as the perception of people's control over performing the behaviour (as outlined within the TPB; Ajzen, 1998). Unfortunately, the PBC scale, which had been previously presented as one of the strongest predictors of weight-related intentions (e.g., Chung & Fong, 2015), was not tested in the current study as it had poor psychometric properties. Participants' qualitative accounts revealed, however, several interesting experiences that were linked to PBC.

When speaking about goals specifically, participants expressed how they enjoyed their goals being broken down into smaller segments, giving them more control over their activity. As stated earlier by Carver and Scheier (1998), behaviour is regulated through a negative feedback loop, where individuals compare their current state to their desired goal, influencing their actions, behavioural changes, and maintenance of health behaviours. Techniques like setting goals, getting feedback on performance, keeping track of behaviour, and reviewing goals are part of self-regulation and control theory (Carver & Scheier, 1998). In the current study, many participants expressed how they found goal-setting, ongoing feedback and celebrating targets beneficial and empowering. Moreover, participants shared how disappointed they felt when they did not reach the daily target (e.g., steps, activities, etc.) and how this motivated them to strive to reach their goals.

As both self-efficacy and control are linked to PBC, it can be argued that these features enabled participants to increase self-efficacy and have greater control over their PA levels as part of their programmes. The FT helped develop essential skills, for instance, assessing participants' sedentary behaviours. Some participants also spoke about the gains in knowledge, how their FT enabled them to read their heart rate while exercising, and how this helped them control their level of PA. Strategies to lose weight discussed during HH sessions were linked to PBC, for example, controlling portion sizes or tracking exercise sessions. If FTs were routinely provided as part of weight management intervention, these could help increase PBC as greater self-monitoring of PA and other metrics would be enabled.

Intention

All three constructs mentioned above (attitudes, subjective norms and PBC) lead to the formation of intention, which is a central factor in performing the behaviour according to the TPB (Ajzen, 1991). Therefore, as expected, attitudes and subjective norms were positively correlated with intention in the current study (PBC was not tested). However, the only relationship with intervention outcomes was observed between attitudes and weight difference at six months. In terms of weight loss, the intention was previously reported to be a significant determinant of weight loss (Chung & Fong, 2015), but it was not the case in the current study. Similarly to the results reported by Gardner and Hausenblas (2006), intention was also not associated with PA. This was in contrast to the results reported by Ashe and colleagues (2015), where intention was correlated with PA only in the FT condition.

At the study's first wave, intention only correlated with autonomous motivation and Patient Activation (an individual's knowledge, skill, and confidence in managing their health and health care). In addition to being correlated with intention, autonomous motivation was also positively associated with Patient Activation. The current research indicated that Patient Activation was an important factor related to other psychological factors. Participants who were more involved in their health and healthcare seemed to have a greater intention and autonomous motivation to lose weight. This is in line with previous evidence stating that Patient Activation is predictive of most health behaviours (Hibbard & Gilburt, 2014). While Patient Activation was correlated with intention to lose weight and autonomous motivation, it did not predict the actual weight loss in the current study.

Monitoring the feedback through the device helped participants to be actively engaged and participate more in the programme. This can be viewed as generating higher levels of Patient Activation when the Patient Activation concept (Hibbard & Gilburt, 2014) is considered. Specifically, for people with low levels of Patient Activation, there is a greater need to self-monitor their behaviour as they need to build self-awareness around key health behaviours. Individuals with the lowest initial activation scores tend to experience the greatest increases in activation after participating in tailored interventions (Hibbard & Gilburt, 2014). An extensive systematic review by Cuevas and colleagues reported that tailoring the intervention to participants' baseline activation effectively increased people's activation (Cuevas et al., 2021). It is necessary to tailor interventions to offer help proportionately to those who most need it. In the current study, many participants stated that they had learnt about their health behaviours and adjusted them accordingly while on the programme. Some mentioned that FTs helped them to adjust their behaviours.

Looking at the local context, in areas where HH intervention was delivered, obesity rates varied according to Patient Activation levels. Obesity rates were correlated with Patient Activation levels according to the Central London CCG collaboration network results (internal reports, 2016; level 1=36%, level 2=32%, level 3=31% and level 4=29%). It can be argued that targeting those with lower activation levels in a tailored way using FTs might help to increase their activation and intention to lose weight.

Regarding the maintenance of change, participants also talked about their intention to use their FTs beyond the HH programme, expressing the desire to maintain

the changed behaviour. Some participants got so used to wearing and checking their devices that it could help them continue self-monitoring their behaviour and maintain long-term behaviour change. This can be seen as an improved intention to perform or maintain behaviour within Ajzen's TPB model (1991).

Furthermore, while in some cases, participants' intention to engage with the FT and the HH programme was strong to start with, their health or personal circumstances prevented them from acting on this intention. When dealing with a cohort of participants from disadvantaged backgrounds who were at increased risk of CVD, it needs to be taken into account that their health or personal issues might have acted as barriers to programme engagement. Thus, any additional tools to support this engagement (e.g., FTs) could have been beneficial.

6.2.2 Fitness tracker use within the COM-B model

The results from the research were also mapped up against the COM-B model, which states that the occurrence of behaviour requires individuals to possess the capability (physical or psychological) to engage in that behaviour, have opportunities (physical and social) to do so, and be adequately motivated (automatic or reflective motivation) to embrace the new behaviour instead of the old one (Michie et al., 2011). While no specific framework was used to map out the COM-B constructs to the current study, for instance, the TDF (Michie et al., 2005; Cane et al., 2012), some themes that emerged in the qualitative phase of the study were considered within the COM-B perspective. The following section discusses the present findings in the context of the three dimensions of the COM-B model.

Capability

FTs can be seen as enhancing the capability to perform the behaviour by, for example, improving understanding of what safe exercise is and by providing certain self-monitoring functions such as heart rate monitoring. Howlett and colleagues previously reported that when COM-B was applied to sitting behaviour, the capability was shaped by self-monitoring within the behavioural regulation domain (Howlett et al., 2021). Howlett and colleagues also reported previously that psychological capability was characterised by self-monitoring of behaviour, action planning and habits when applied to PA (2021).

Participants in the current study reported that their knowledge had expanded and that they had gained new skills around safe PA. The focus could be placed on enhancing motivation among individuals by providing them with education (e.g., how many steps they have achieved) and demonstrating that they could increase their PA levels by adopting simple and attainable activities (SMART goals). Gamification was an essential strategy here, and some participants stated how they enjoyed the celebration of their daily targets. Psychological awareness (psychological capability) of certain lifestyle aspects (e.g., how much time individuals spent being sedentary) was crucial to implementing the behavioural change. FTs were seen as a tool that helped participants increase psychological awareness and thus capability, for instance, of PA through nudges and help them break up periods of sitting.

It became apparent during the qualitative interviews that some participants' capability to use the FTs, exercise or even attend the HH programme was affected by the health and personal issues they experienced. This is an essential consideration for

the FT provision and the delivery of healthy lifestyle programmes in general. A potential solution to overcome these barriers is to offer remote modules of support, for example, online weight management groups, which participants affected by health issues could join. Offering the FTs on this programme could provide additional support and monitoring. This was trialled by researchers in the USA, where the remote Diabetes Prevention Programme enhanced by FTs was utilised (Stewart et al., 2022). They suggested that a FT-enhanced remote intervention might be a suitable alternative option where barriers to accessing the service face-to-face exist (Stewart et al., 2022).

The self-monitoring of behaviour that the FTs enabled can be viewed as improving 'capability' within the COM-B model as it enabled behavioural regulation. Participants reported responding to the feedback FTs provided them with and engaging in more exercise to meet the required number of steps. Overall, FTs could be seen as improving psychological and physical capability as well as motivation in this context.

Opportunity

The FT provided for free as part of the weight management programme could be seen as a physical opportunity to self-monitor behaviour. Being given the device that can be used as an additional tool for self-monitoring various health metrics, especially for those with no means to purchase the FT, can be seen as very useful. Accessing free exercise classes through HH can be viewed as an opportunity the environment provides, and the FT can be seen as a good addition in this context. If service users were given the right opportunity, for example, the space to exercise through HH and the FT that enables them to self-monitor their PA, the behaviour (PA) could be more likely

to occur according to the COM-B model (Michie et al., 2011). In the current study, participants highlighted their gratitude for receiving their tracker. As Friel and Garber (2020) highlighted, receiving a FT as a gift might play a role in determining its usage. It can also be speculated that the greater attendance rates in the FT condition (when compared with the intervention as usual) could have been, to some extent, influenced by the FT opportunity given to those participants.

The present study's design precluded the facilitation of digital social interactions, such as collaborative goal-sharing among users of the platform and competitive challenges. This set-up also had an advantage as the engagement of participants with their FTs was not influenced by others. However, as a result, the potential benefits of those interactions could not be observed, but if this function had been enabled, perhaps it would have provided benefits.

A systematic review by Ringeval and colleagues reported that the positive effects of healthy lifestyle interventions on well-being were explicitly linked to the social interaction and data management functionalities of FTs (2020). Previous studies also mentioned the potential of FTs as clinically important tools that enable the sharing of data with health professionals to permit ‘Automated Hovering’ of patient health (the use of technology to monitor and provide feedback to patients and health professionals when used outside of a clinical setting), providing them with patients’ health data while not under medical supervision (Asch et al., 2012).

Motivation

While the quantitative phase of this research, utilising the questionnaire developed by Levesque and colleagues (2007) based on the Self Determination Theory approach (Deci & Ryan, 1985; Deci & Ryan, 2000), did not identify any differences in motivation levels between the study groups, many participants in the qualitative phase highlighted that they found the FT motivated them. FTs were seen as a tool to enable goal-setting, monitoring and feedback around PA, sleep and other functions, enhancing (primarily reflective) motivation. FTs were also seen as contributing to the formation of habits, seen as automatic motivation. Several participants mentioned that their motivation to exercise was enhanced thanks to using some functions offered by the FT. Some also highlighted gamification as participants enjoyed achieving their targets and seeing celebratory screens displayed on their devices. This acted as reinforcement and stimulated participants' motivation, which is considered a core part of the COM-B model (West & Michie, 2020). If the FT enhanced people's motivation, they could have been more likely to adopt the new behaviour, for instance, exercising. As reported previously, motivation is one of the most important drivers of PA (Howlett, Schulz et al., 2019).

Behaviour

According to the COM-B model, the target behaviour results from capability, opportunity and motivation in combination (Michie et al. 2015). In the current study, participants' capability to exercise has been potentially improved thanks to FTs; through the FT, they had an opportunity to increase their self-monitoring of the behaviours involved in weight loss. Free FTs provided to participants were seen as an opportunity.

It seems that FTs also helped to increase individuals' motivation to exercise. It can be, therefore, argued that FTs enhanced all these three elements in combination. Some behaviour change was observed among individuals who were interviewed. They discussed some underlying psychological processes that could be mapped against COM-B in their qualitative accounts.

6.3 Contribution to knowledge

6.3.1 Theoretical contribution

This study was based on the TPB and COM-B, and the results were mapped against these frameworks. Overall, the results confirmed the relevance of these models to behaviour change, and in particular weight management, but with various degrees of success. The TPB was not fully tested, as the PBC scale had poor psychometric qualities. This highlights the need to assess individual scales and their suitability more thoroughly if the same scales were to be applied again. Other TPB constructs (attitudes, subjective norms and intention) yielded no promising results when tests for differences were explored. Furthermore, the attitudes scale was the only variable correlated with weight outcomes at the final session (the more positive the attitudes, the greater the weight loss), and when used in the regression analysis, it did not have any predictive value. While TPB constructs were useful to explore (especially when contextualising the results obtained in the qualitative part of this research), some limitations of TPB, particularly the TPB's inability to predict weight loss, were also noticed. Potential reasons behind this are discussed below.

As previously highlighted by Psouni and colleagues (2016), TPB was applied more successfully in participants with average weight compared to the

overweight/obese group. It is likely that in the current study, the application of the TPB model was not as successful at predicting intervention outcomes due to the nature of the study sample (overweight/obese). Additionally, it has been pointed out that the TPB does not necessarily account for cultural differences. In various studies, it has been observed that in collectivist cultures, subjective norms exert a more significant influence on intention, whereas in individualistic cultures, attitudes play a more critical role (Conner & Heywood-Everett, 1998). This can lead to varying predictive power across different populations, making it less suitable for the participant sample used in the current study as it comprised of participants representing various cultures. Moreover, TPB does not consider determinants such as environmental context, resources and physical ability (Howlett et al., 2021). Some of these determinants could have played a role in the current study, e.g., the environment available to some participants (i.e., a busy urban area of central London) could have affected some participants' ability to exercise.

With all of those aspects in mind, it can be concluded that the TPB model might not be the best option for this type of research and the studied population. Other models should also be looked at if utilised in similar research to build a more comprehensive picture of weight management behaviour.

The themes identified in the qualitative phase of the current research were mapped against the COM-B model using the Behaviour Change Wheel and loosely TDF (see section 1.2.2). This mapping exercise overall was successful. Various domains associated with using FTs in the weight management intervention were identified under each COM-B component. They included knowledge, skills and behavioural regulation

under capability, environmental context and resources, and social influences under opportunity. Some domains were identified as linked to motivation, namely, intention and goals (reflective motivation) and reinforcement and emotion (automatic motivation).

It has been previously highlighted that the COM-B model and Behaviour Change Wheel are practical tools for developing behaviour change interventions rather than explanatory theories and that their direct application to habitual behaviour remains uncertain (Pinder et al., 2018). While the direct application of the COM-B to habitual behaviours and weight management remains less explored, this framework was instrumental in mapping some themes emerging in the current research. It was recommended that COM-B is applied more systematically to future research in this field. The TDF could also be fully utilised to provide further insights.

In summary, this research contributed to the field of theoretical knowledge by applying the TPB and COM-B to the study of FTs in weight management interventions. It was concluded that the TPB was not the most suitable framework for the type of exploration conducted in the current research, primarily due to the population studied. On the other hand, COM-B was a more appropriate model as it took into account broader factors due to its transdisciplinary design. It is recommended that further research is carried out to map the FT utilisation within weight management further.

6.3.2 Methodological contribution

At the start of the research process, many studies focused on FTs used by White, middle-class female participants likely to be already fitness-oriented (Lewis et al., 2015). This study contributed to the field of knowledge by looking at service users from

less privileged backgrounds, unemployed or on low-income and from deprived wards in Central London. It is known that low income and higher deprivation are strongly associated with CVD (Lewer et al., 2020). The population investigated in this study was also less likely to be interested in fitness than samples typically recruited to FT studies, for instance, self-selected, owners of FTs and not necessarily obese.

None of the studies in the scoping review included in this study (Chapter 2) offered a design solution where two groups would have received identical (standard) weight management intervention, with one group using FTs in addition. It is believed that the current study's design made the comparisons between groups more robust and enabled an actual assessment of the FT's efficacy as a direct comparison with the control group possible.

This research incorporated data from several sources. The subjective data obtained through self-reported measures was complemented by the objective data in the form of HH measures recorded as part of the intervention and the FT data. The FT data accessed through Fitabase was a valuable addition to the research as it shed light on the actual engagement of participants with their devices. Accessing participants' objective PA activity data through Fitabase has been reported before. For instance, Robertson and colleagues found that self-efficacy was a successful predictor of MVPA in 96 obese participants attending a 6-month weight management intervention and their MVPA variable was objectively measured (Robertson et al., 2020). An increasing number of studies use the Fitabase data platform that provides researchers with access to participants' FT data. In 2014, seven intervention studies utilised FTs and used the Fitabase platform for data management; in 2022, there were 49 (*Fitabase*, 2023). This

is a testament to the increasing interest in objective measures gained through these devices to be examined alongside more subjective measures. The current study added to this field of knowledge by incorporating data that were objectively measured and accessed conveniently for research purposes. The procedure of incorporating these data and the hurdles that arose were comprehensively described in the current study. As a result, this study offered practical recommendations on how to overcome or avoid some methodological problems in future research.

Each method offered a different perspective and allowed to build a comprehensive picture of FT usage as part of weight management intervention in the studied population. It is recommended that future studies in this domain also utilise various methodologies to explore this topic.

6.3.3 Contribution to practice

This research demonstrated that FTs could be embedded in a tier-two face-to-face weight management programme delivered in a group format across community settings in harder-to-reach groups. The study highlighted some issues worth considering, including that FTs are not suitable for everyone. However, when individuals engage with them, they can significantly enhance PA, weight loss and programme attendance.

The FT data showed that some participants engaged with their devices very well while others abandoned their use. For some participants, FTs impacted their PA patterns and weight loss, while others did not respond well. Some health professional participants raised that some service users were not keen on FT technology or felt that

FTs were unsuitable for older service users. This confirms that FT technology is not suitable for everyone, and their provision should be adequately planned. It is recommended to consider carefully the selection of service users to be provided with FTs. More research should be conducted to identify those who might respond well to this technology and those who might not initially present as positive towards FTs but might also respond well with the proper support. This research highlighted that segmenting the target audience is necessary in order to ensure FTs are provided to those needing them the most, who, with the right support from health professionals, will use FTs to their advantage. Additional barriers must be considered when working with a population of service users from more deprived backgrounds.

This study also provided insights into logistical issues. These included consideration about how to provide FTs to service users without making others feel that they are missing out. This aspect is particularly important when delivering this type of intervention to groups of service users from more deprived areas and ethnic minority groups. Other practical points should also be considered when using FTs in weight management research. Factors that may influence participant motivation and adherence, such as the user-friendliness of the device, ease of data synchronisation, and the relevance of the collected data to the research objectives, should be considered. Providing clear instructions and support to participants can enhance their understanding and compliance with using the FT throughout the study.

Additionally, this study had access to participants' live FT data. Future interventions could make use of this 'objective' data and enable health professionals to monitor their service users remotely between weight management sessions. This would

make the identification of disengaged service users early on in the intervention possible and allow health professionals to follow them up and offer additional support. In addition, remote monitoring could be seen as linked to subjective norms, with service users being aware that they are being monitored. This can provide additional motivation in the initial stages when users are getting familiar with their devices.

Staff capacity needs to be considered, and some dedicated time for FT-related work might need to be factored in at the intervention design stage. While this might appear as an additional costly resource on top of the FT device costs that the weight management intervention provider ought to consider, it might be cost-effective in the longer term as it will likely lead to better engagement and potentially better health outcomes.

In summary, this research contributed to knowledge in the area of weight management intervention by offering some important insights into embedding FTs as part of existing weight management interventions. Many practical aspects were considered as this research highlighted some hurdles and offered practical solutions to how these can be overcome. If weight management intervention providers intend to offer FTs routinely, this provision should be planned at the intervention implementation stage. This would ensure adequate staffing capacity to support service users and make sure they get the most out of this additional self-monitoring tool.

6.4 Study implications

Due to the positive impact of FTs on service users' experiences and weight management programme outcomes, it is crucial to consider the provision of FTs to service users on a routine basis. Adding a tool that enables self-monitoring of behaviour

could help to increase individuals' engagement in weight management programmes and lead to positive results. Even if FTs only increased participants' attendance, this could be already considered successful as individuals would have greater exposure to the educational components of the intervention.

However, as stressed earlier, FTs may not be suitable for everyone. Some people might not be interested in wearing them, while others might be intimidated by the technology. In addition, some people might already have FTs. Therefore, the provision of FTs should be carefully planned.

One of the potential options to consider would be to provide FTs only to those who are on the lowest levels of the social gradient. From a long-term perspective, this approach holds promise in terms of cost-effectiveness, as facilitating higher levels of engagement among individuals and fostering improved health outcomes can yield substantial savings over time by helping to prevent obesity-related ill-health. However, if FTs are not offered equally to all service users, this could create issues around fairness and equity.

It is recommended that a decision-making tool is developed to guide health professionals when the decision about FT provision is made. The researcher is not aware of the existence of such a tool. For instance, people's attitudes towards technology could be assessed to aid the decision-making process. Additional support may be necessary for certain groups, such as individuals with specific health conditions or negative attitudes towards technology. Also, Patient Activation could be considered to identify those with the lowest PAM levels and the greatest need to improve self-monitoring of behaviours involved in weight loss.

In terms of costs, FTs are not expensive and could enhance the efficiency, quality and cost-effectiveness of weight management interventions (Hinchliffe et al., 2022). In areas where face-to-face interventions to aid residents in losing weight are unavailable, an online weight management intervention enhanced by FTs could also be considered. As trialled in the remote Diabetes Prevention Programme enhanced by FTs (Stewart et al., 2022), the authors reported a lowered cost of intervention when compared with a face-to-face provision.

Apart from acting as a crucial self-monitoring tool for service users, FTs would also allow health professionals to monitor their service users' PA levels objectively instead of relying on self-reported measures that are often subject to recall errors. Brickwood and colleagues (2019) highlighted that FTs could be an effective means for healthcare providers to monitor and provide support continuously.

Device costs should be considered when the FT device is selected. The FT used in the current study (Fitbit Charge 2) was not considered cumbersome (unlike some devices used in studies analysed as part of the scoping review in Chapter 2). Most participants highlighted that they were happy with the FT they received, and in terms of functions, they mainly regretted the lack of water resistance. As highlighted in the qualitative phase of the study, each participant utilised FTs in different ways and prioritised different functions. This confirms that the provision of devices that enable the self-monitoring of various actions (in addition to steps) and offer gamification components might be preferable by service users to utilising simple pedometers.

Depending on the exact requirements of the weight management intervention, if FTs were to be used, their specific functions, costs and access to the data (from the

health professional or research perspective) should be considered. A co-production (the provider working in partnership with service users) is recommended to identify what service users find the most important in a FT device. As highlighted recently (Palozzi & Antonucci, 2022), when it comes to PA and CVD prevention, the participation of citizens in the process of delivering services has not been thoroughly explored yet. Additionally, other important factors related to weight management programme design and implementation could be discussed.

Finally, if FTs were to be provided as part of a weight management programme, some operational aspects of the programme delivery would need to be considered, such as the capacity of health professionals and service users' confidence in technology. The researcher dedicated a significant amount of time to offering guidance on fundamental aspects of smartphone usage and providing over-the-phone technical support. In addition to the provision of the Fitbit manual and a bespoke handout, a 'go to' person to contact would be needed for those experiencing technical issues. This aspect would need to be considered to make the FT-enhanced weight management intervention successful. An additional online platform with content written in an accessible way could be developed to include common questions and answers, troubleshooting strategies and tips on how to deal with any accuracy issues.

In summary, FTs were well-received by service users and health professionals alike, and their provision may benefit harder-to-reach populations. However, careful planning is essential before any FT-enhanced interventions are implemented. Costs, device selection, and operational aspects also need to be taken into account to ensure effective programme delivery.

It is crucial to emphasise that the tier-two intervention discussed in this study (HH), i.e., the weight management programme, was just one example, as similar face-to-face interventions are implemented throughout England. While the HH programme has ceased to be delivered, it is thought that FTs could be utilised in similar weight management programmes or the NHS National Diabetes Prevention Programme. The recommendations proposed in this study might be applicable to many interventions that target harder-to-reach populations.

Weight management interventions should be tailored to individual needs, characteristics, and attitudes. Instead of offering Fitbit to everyone, it could be included as one of several interventions that can be provided to maximise outcomes. Therefore, research investigating the association between individual differences and Fitbit use and outcomes is essential.

The next section of this chapter focuses on the strengths and limitations identified in the current study.

6.5 Strengths and limitations of the research

6.5.1 Strengths of the study

Participant related strengths

The sample used in this research encompassed a wide variety of service users, as outlined in sections 4.6.2 and 5.5.3. The participants exhibited varying levels of involvement in their weight management programmes. Furthermore, they achieved different degrees of success in weight loss and usage of FTs. Additionally, thanks to the study, less privileged participants were provided with an additional tool for self-

monitoring of behaviours that they could keep after the study. This can be seen as an opportunity, as some participants mentioned financial barriers to buying FTs in their qualitative accounts.

Methodology related strengths

This study was designed with the already established weight management intervention (HH) at its heart; as a result, the study was ecologically valid, and the findings could be transferrable to other real-life settings where harder-to-reach populations from urban areas are considered. Using a pragmatic paradigm allowed to draw on a top-down quantitative approach and a bottom-up qualitative approach, providing a unique chance to understand the usage of FTs within the weight management context. As pragmatism allows quantitative and qualitative methods to be used together (Creswell & Plano Clark, 2011), the current study had many methodological strengths because both perspectives provided unique insights into FT implementation within weight management settings. Additionally, these perspectives could be compared and contrasted.

The quantitative research used HH intervention data that was largely objective (e.g., weight, BMI, cholesterol, blood pressure, attendance rates) and the self-reported survey data. The qualitative phase of the study enabled the research team to understand the participants' accounts from their own standpoint, and this was supplemented by the views of health professionals delivering the weight management intervention. As mentioned in previous research (Watt et al., 2019), there is a shortage of studies examining the views of health professionals working with individuals using

FTs as part of their interventions. Implementing health professionals' accounts in this research made this study unique. The study was complemented by the FT data that provided an objective record of participants' device synchronising and PA. This study has, therefore, drawn on several research methods to address research objectives.

6.5.2 Limitations of the study

Participant related limitations

Similarly to what was highlighted in some earlier studies (e.g., Bender et al., 2017; Rogers et al., 2016), participants' access to technology as the prerequisite to participate in this study was a potential barrier. As smartphones with Internet access were necessary, people without this access were excluded from this study. Chapter 2 stated that mitigating this was difficult as smartphone and Internet access was needed for the FT to work effectively.

For participants with smartphones and Internet access, various technology literacy skills were observed. For those with poorer technology skills, a significant amount of support from the researcher was needed to ensure that participants' devices were set up correctly. This additional time spent with some participants could be seen as a potential confounding factor as possibly a stronger relationship was formed with those participants.

It also became apparent during the qualitative research phase that some participants' FT devices broke down or were misplaced. While it can be argued that in one case, the breakdown of the device was due to a genuine software issue of the FT, it was possible that in other cases, the problem was caused by participants' behaviours.

Misplacing the device or not wearing it correctly could have led to the accuracy issues of the collected data. Simply forgetting to wear the FT (as highlighted by participants in the qualitative phase of the study) was also a behavioural issue that made some participants feel uncomfortable as they felt that their exercise did not count. While it is a limitation of using commercial FT in this research, there is not much (apart from providing clear instructions and reminders to wear or charge) that the researcher could have done.

The feasibility of the 10,000-step target for the HH intervention's target population should be also considered, as it could be considered quite high for this population. Proposing alternative approaches, such as a graduated stepping or walking programme based on individual baseline levels might be the way forward. Lower cost and more accessible technologies, notably pedometers, are indicated as potentially more suitable. Chaudry et al.'s (2020) meta-regression suggested that simpler pedometers offer greater advantages compared to newer devices like body-worn FTs and smartphone applications. Thus, simple pedometer-based interventions are recommended for broader implementation in the public health promotion of PA, indicating both short and long-term efficacy.

All the documents and questionnaires were aimed to be written in plain language; however, it is possible that people with poorer English skills did not choose to take part in the study. As highlighted by HH health professionals, some service users declined the opportunity to participate as they felt it was not for them. Health professionals believed that, in some cases, this was age-related. It is also possible that participants in the current study were more interested in fitness than others in the HH programme. As

a result, the current study's cohort might not have reflected the demographic characteristics of the inner London population needing weight loss treatment. Problems with the generalisability of results in studies looking at FTs in weight management were also reported by Jakicic et al., 2016; Bender et al., 2017; Peyer et al., 2017; Rogers et al., 2016 and Shin et al., 2017.

In addition to the limitations outlined in section 5.5.3., it is crucial to acknowledge the potential influence of social desirability bias on health professionals' responses in this study. As the researcher was their work colleague, it is possible that this relationship may have led health professionals to express more positive views about the study.

Finally, it needs to be acknowledged that while the male/female ratio of this study's sample (79% female) mirrored the ratio observed on HH programmes, it did not represent the general population. As most men chose to attend the MAN V FAT programme, which was seen as a better alternative to the HH weight management programme (as explicitly tailored for men), the presence of men on HH programmes was lower. This made the results of the current study harder to generalise.

Methodology related limitations

As the initial stage of the recruitment process relied on HH staff members, the process was occasionally interrupted due to the discontinuation of the HH contract, staff turnover/other pressing priorities. During busy periods at HH, the recruitment of participants was not prioritised. The researcher joined various team meetings and supported staff members individually to ensure the study continued being advertised.

Regarding the part of the study involving health professionals, it is also essential to note that the high staff turnover rate at HH and the requirement of minimum exposure to the study procedures (6 months) limited the sample size.

In terms of the quantitative phase of the study, one limitation was the unequal distribution of participants among study groups caused by unforeseen pandemic-related circumstances. This imbalance in group composition could have introduced a bias in the results and influenced the comparability of results between the FT and intervention as usual groups. Future studies should ensure an equal distribution of participants between the study groups.

The potential disappointment participants in the intervention as usual condition could have felt when they had learnt that they were not getting the FT was also identified even before the study commenced. It was speculated at that stage that when participants learnt they would not be getting a FT, they could have felt disappointed and lost interest in the study or dropped out of the weight management programme. There is no evidence that this speculation materialised, but the study's results clearly show that participants in the condition with FTs had greater attendance rates than the control group. While this could have been linked to the use of FTs (health professionals mentioned that they noticed greater engagement from those who wore FTs), there could also be other reasons behind this trend. Participants with FTs might have had an average attendance rate, but the intervention as usual group might have had more significant attrition. Unfortunately, this remains unclear as the current study did not explore the participants' experiences from the intervention as usual group and why they

dropped out. A different type of study design (e.g., a waitlist control) could have circumvented this problem.

Additionally, low internal reliability hindered the use of specific scales (WLOC and PBC), limiting their appropriateness for analysis and potentially compromising the completeness and reliability of the data. The data set also had a lot of missing values. This was true in the case of the FT data set (due to not wearing or synchronising the device), the study data (W2 and W3) and the HH data set. The pandemic significantly impacted the latter two data sets. Steps were taken to minimise missing data, for instance, by encouraging participants to complete online surveys. The HH measurements and data typically gathered during the final session with care planners were unavailable once the pandemic started, as no face-to-face sessions occurred.

As the HH programme, which this study was designed around, had an average duration of six months, it can be argued that insufficient time was permitted to allow participants to rehearse the behavioural change and embed all the changes that could lead to greater weight loss. One of the limitations of the current study was the utilisation of a programme that had a short duration. Ferguson and colleagues (2022) reported that in interventions with short durations, observable physiological advantages resulting from sustained changes in PA behaviour might not have had sufficient time to develop fully. Brickwood and colleagues suggested, on the other hand, that adding a FT can help to maintain self-monitoring of behaviours long-term in interventions with short durations (2019).

In the current research, health professionals also expressed concerns about how FTs were provided as part of the programme, raising questions about the study design.

Furthermore, the low number of significant correlations among the main variables did not allow for all psychological predictors to be tested, while the two tested variables (attitudes and anxiety) did not predict weight loss. Consequently, the third research question was left unanswered. These limitations might have affected the validity or generalisability of the current study's findings.

Further limitations regarding the use of FTs need to be considered. Given the demographic characteristics of the participants in the study, some individuals may not have had access to essential technology, such as smartphones, laptops, or the internet. This lack of access could have exacerbated health inequalities. While this issue was acknowledged from an ethical standpoint, certain barriers could not be overcome due to the nature of the research, such as the absence of a smartphone to synchronize data. In future research, simpler devices that do not rely on smartphones, such as pedometers, could be considered for participants facing barriers related to internet or smartphone accessibility. Participants could also be advised to utilize computers and internet services available at local libraries to gain access to necessary self-monitoring features. These measures need to be carefully considered to ensure that the amplification of health and social inequalities does not occur as a result of the provision of FTs in future studies.

In addition, FTs and self-tracking technologies, while beneficial for personal health management, also raise critical concerns, as highlighted in Lupton's work on 'The Quantified Self' highlights several issues (2016). Data sharing and surveillance are major concerns, as FTs collect personal data that can be accessed by third parties, potentially leading to privacy breaches. Commercial organisations, particularly

insurance companies, could use this data to adjust premiums based on activity levels, potentially resulting in discriminatory practices. Government and political interests could influence public health policies based on data from these devices, raising questions about individuals' autonomy and state surveillance. Additionally, the future impact of Artificial Intelligence in self-tracking technologies, while promising more personalised health insights, also brings risks of data security, algorithmic bias, and over-reliance on technology. It can be speculated that for some of these reasons, some service users could have been concerned and declined the chance to participate in the study.

COVID-19 pandemic-related limitations

As was already briefly mentioned in section 5.5.3., the COVID-19 pandemic interrupted how HH weight management programmes were run, bringing them to a halt in March 2020. This meant that all recruitment efforts had to be stopped. Participants who had already consented to participate in the study were informed that the recruitment had to cease (before they were allocated to study conditions or provided with the FT). The last cohort of participants recruited in January 2020 had enough time to complete their weight management programmes. The pandemic affected, however, their 6-month follow-up period. As no final face-to-face sessions with health professionals took place, only self-reported measures were available for a small group of participants; therefore, there was no objective measure of weight loss as participants reported their weight back over the phone. This might have interfered with intervention fidelity for some participants.

The programme outcomes could also have been affected by the pandemic. It has been reported that many individuals became more inactive as lockdown restrictions were introduced (Robertson et al., 2022). This could have impacted PA and other outcomes of clients from this study's final cohorts. The researcher still engaged with the study participants, and the remaining study questionnaires were moved online while the last qualitative interviews were conducted over the phone - this adjustment to the unforeseen circumstances allowed the data gathering to continue. It needs to be highlighted, however, that a different method of data collection may have introduced confounding variables.

In addition, due to the pandemic, the initially planned number of participants to be recruited for this study was not achieved. This also contributed to an unbalanced participant allocation to the study groups. It became apparent that some clients were more reluctant to engage once the pandemic started (in the quantitative and qualitative phases of the research).

Local Authority contract-related limitations

As two Local Authority areas where the recruitment of participants was taking place (the City of Westminster and the Royal Borough of Kensington and Chelsea) stopped the provision of HH, the study recruitment process had to evolve to keep up with the changing context. The service was recommissioned and rebranded as One You Integrated Healthy Lifestyle Services in these two areas in 2019. The initial number of participants for the study was calculated based on the recruitment in all three areas. As the first two areas ceased delivering the HH programme in 2019, the researcher adjusted recruitment processes and shifted all efforts to LBHF. During the pandemic (in

2020/2021), LBHF Local Authority decommissioned the HH programme completely. At the time of writing, there was no face-to-face level two weight management programme commissioned by Local Authorities available to the residents of this borough. Only digital support was available through a free NHS app focusing on healthy eating (NHS, 2020).

Regarding exercise, the PA referral scheme was operational instead (*Healthwise Physical Activity Referral Scheme*, 2022). In July 2023, the NHS Primary Care Network in the North of LBHF decided to fund a healthy lifestyle service in a reduced format as they felt that programme options funded by the Local Authority were not adequate for their most disadvantaged patients. Thrive Tribe was invited to reintroduce the healthy lifestyle service that is currently delivered across nine practices in the north of LBHF. The LBHF residents can now benefit from one-to-one sessions with trained health coaches/care planners and group programmes consisting of 6 weekly sessions. While this modified service is shorter in duration than the previously offered HH service, the programme uses many strategies deemed successful, e.g., self-monitoring of behaviour and goal-setting.

As this study was designed to utilise a Local Authority-funded intervention, the study processes relied heavily on external factors. Due to the short duration of Local Authority contracts (providers often being commissioned only for 3-5 years), weight management programmes usually have a short duration (e.g., 12 weeks with a follow-up at 6 months). The assessment of the long-term effectiveness of such interventions and weight loss maintenance is, therefore, difficult. It was previously reported that the maintenance of weight loss remains challenging (Elfhag & Rossner, 2005) and that

within five years of losing weight, approximately 80% of weight loss is regained (Hall & Kahan, 2018). With this in mind, interventions should have longer durations, but due to contractual restrictions, it is often not possible. Designing studies around these contracts can prove difficult as frequently, there is not enough time for the study to be adequately implemented and evaluated. This limitation of the current study should be considered if similar studies are planned.

6.6 Future research directions

The current research showed that some participants responded well to FTs while others did not. The factors contributing to the differences in weight outcomes and attendance rates are unclear based on the results obtained in this study. Further research is required to address the gaps in the current study, investigate the underlying mechanisms behind the positive effects of FTs on some participants, and address barriers to their implementation.

As discussed earlier, not all study measures could be utilised due to reliability issues with some scales used in this study. Further research should look into utilising scales with more robust psychometric properties, and a range of psychological factors should also be considered to pinpoint which factors make some people more likely to respond to FT better than others. The COM-B model could be used to examine which factors impact the habitual use of FTs. In a study by Creaser and colleagues (2022), the COM-B model and the TDF (Atkins et al., 2017; Cane et al., 2012) were used to study these factors in children and adolescents. Future studies should consider applying the same measures to the cohort of adults at risk of CVD attending weight management

programmes. If the TPB and COM-B frameworks were to be used again, refined measures should be utilised to investigate them. The TPB scale could be tailored to study the intention to use FTs according to the TPB manual (Francis et al., 2004). The current study only examined the intention to lose weight as a target behaviour.

Health professionals' feedback is one potential area that can be explored. At the time of writing (2023), there were still only a few studies investigating the point of view of health professionals delivering interventions to service users utilising FTs. If health professionals promoted FTs, participants would be more inclined to use them (Mercer et al., 2015). On the other hand, some research also looked at the phenomena when participants/clients bring their self-tracked data and share it with health professionals during consultations (Rutjes et al., 2022). Authors of the study reported that this has potentially created disruptions in the client/health professional relationship as clients presented as better informed. However, they also concluded that clients' self-tracked data could be beneficial as it can provide an objective and reliable view of clients' behaviour in comparison with self-reported measures (Rutjes et al., 2022). Turakhia and others reported that merging the FT data from a group of users enabled the identification of new health concerns, such as atrial fibrillation, subsequently enhancing the algorithms employed in health coaching programmes (2019). As it is increasingly more common for users who already own a FT to bring their FT data into consultations (Rutjes et al., 2022), the views of health professionals and health coaches should be studied further.

Another area that requires further investigation is linked to attendance rates, and it would be interesting to see whether the trend observed in the current study would be

repeated in other studies and, if so, which factors would be associated with this change. It seems that FTs led to greater attendance, but whether the self-monitoring of behaviour, social desirability bias or other factors contributed to this improvement is unclear. Obtaining the views of participants from the control condition would also be beneficial to understand whether not getting the FT had any negative influence on them. Further studies could investigate this.

The effect of seasons on the results could also be one of the potential areas to investigate. It could be tested whether people attending summer programmes have different results from those attending winter ones. This factor was highlighted by Peyer and colleagues (2017) as a potential factor that might have influenced study outcomes. Additionally, the referral source should be explored to investigate whether people referred by their GP to access the service would have different weight management intervention outcomes to those who self-referred.

As interventions such as HH work with harder-to-reach populations, Patient Activation levels might be lower in those referred by their GP. Sometimes, people who are referred do not have a sufficient understanding or motivation to make behavioural changes. They follow the recommendations of their health professionals. It was previously reported by a group of researchers in Norway (Følling et al., 2021) that those who self-referred to the weight management programme on their own initiative had more positive attitudes towards the FT than those who did not. It would be of interest to check whether this variable has any impact and leads to differences in intervention outcomes in a UK-based sample.

As men were underrepresented in the current study, it is also recommended that future research look at men's experiences of FT technology within the weight management context. Men may be more hesitant to alter their lifestyles than women (Zhang & Rashad, 2008) and may exhibit scepticism towards government health messages (Gough & Conner, 2006). Media and other sociocultural influences often encourage men to maintain a larger, more muscular, masculine physique (McCabe & McGreevy, 2011). Men might be less focused on achieving an ideal body weight as defined medically and more interested in PA, regaining fitness, and attaining a masculine body shape (Hunt et al., 2013). Additionally, men and women may perceive PA differently, with men viewing it more as a means to become stronger, fitter, and healthier (Wolfe & Smith, 2002). Weight-loss programmes and facilities, including commercial options, might be perceived as feminised spaces (Hunt et al., 2013).

Similar to the study focusing on the use of pedometers in men taking part in a football-focused weight management programme in Scotland (Hunt et al, 2013), the current study also intended to recruit men from a football-focused intervention (MAN V FAT). This plan was, however, disrupted due to the pandemic. The use of FTs in men is therefore recommended, especially in relation to the social support element FTs can help to facilitate. As such interventions rely heavily on peer support, the utilisation of FTs can enable comparisons and competition between service users. Further research in this area is needed to build on previous work, e.g., by Donnachie and colleagues (2017).

There is also a need to look at the utilisation of FTs as part of weight management interventions longer than six months. Ferguson stated that FTs

successfully promote PA, and this effect remains consistent over an extended period (2022). However, studying how effective FTs are long-term in this particular population would be beneficial. As revealed in the qualitative data analysis, there might have been a longer-term effect of FTs. This study showed that some participants became so used to checking their devices that it was speculated that this might help them maintain self-monitoring of behaviours involved in weight management and the change in their behaviour.

On the other hand, the overreliance on FTs could also have negative consequences. In a study conducted by Simpson and Mazzeo (2017), links between FT usage and eating disorder symptoms were identified. The authors concluded that these devices might have adverse rather than beneficial effects for specific individuals (Simpson & Mazzeo, 2017). McDonald and colleagues (2017) also reported that while the majority of their participants found self-monitoring of symptoms in glaucoma to be a positive experience, one participant reported negative feelings arising from a constant focus on monitoring. Additionally, Ryan and colleagues highlighted that for those FT users who are more educated and conscientious, there was an increased risk of negative effect, especially when prevented from wearing their FTs (Ryan et al., 2019). Authors emphasised, however, that using FTs was a positive experience for the majority of users, and there was little risk of negative psychological consequences.

It was emphasised in the NHS Long Term Plan (NHS, 2019a) that in the future, the data held by the NHS in conjunction with the data generated by smart devices worn by individuals (such as FTs) will start a new wave of ‘intelligent public health’ where interventions will be personalised, and individuals will have access to their health

information. Recent developments in the field of Artificial Intelligence also show promising results. Kumar and colleagues (2021) reported how machine learning algorithms could be utilised to scan FT data and identify early signs of depression. This can be achieved by training machine learning models to identify patterns in sleep records, heart rate variability, body temperature, electrodermal activity, levels of PA and GPS mobility. In a longitudinal study conducted by Opoku Asare and colleagues, participants were successfully categorised into depressed and non-depressed groups based on digital biomarkers collected via smartphones and FTs (2022). This group of researchers reported that participants with depression had recorded more sleep time, less PA and showed less mobility through GPS (Opoku Asare et al., 2022). The authors concluded that these methodologies are considered promising in facilitating early detection, accurate diagnosis, and monitoring of depression in an unobtrusive way.

While several risk factors contribute to the development of CVD, obesity and physical inactivity were focused on in the current thesis. Modifiable risk factors such as weight and PA levels have been highlighted as important outcomes in weight management interventions to reduce the risk of CVD. As the declines in PA contribute significantly to increases in obesity rates (Chadwick et al., 2019), it was necessary to consider them together. Future studies should, however, look at other CVD risk factors, such as high blood pressure and cholesterol, that are also closely linked with obesity. Wider determinants of health, such as employment, education, housing and environment, could also be explored in addition to psychological factors explored in this research. Additionally, the link between depression and increased activity levels should

be explored, potentially utilising new approaches such as Artificial Intelligence and Machine Learning.

There is still a lack of uniformity in the literature regarding how adherence to wearing FTs and the corresponding PA data are analysed and reported. A call has been made to introduce minimum reporting thresholds for data generated by FTs (Chan et al., 2022). Further work in this area is needed.

This study was unique as it looked at a cohort of overweight and obese participants at risk of CVD in real-life settings. More studies that have access to harder-to-reach service users accessing community weight management groups should be conducted to expand the understanding of this population.

6.7 Conclusion

Addressing obesity is complex and involves taking various factors into account. The utilisation of FTs as part of weight management interventions can benefit certain disadvantaged groups. However, FTs may not be suitable for everyone (e.g., some older people and those with more negative attitudes towards them). The findings suggest that FTs can contribute to weight loss by offering feedback, goal-setting and self-monitoring features. However, the effectiveness of FTs may vary depending on individual factors, and further research is necessary to determine how their use can be optimised for different populations. While some individuals may find the feedback and accountability provided by FTs effective in maintaining behaviour change, others may require additional support and strategies to sustain their progress over time.

In conclusion, FTs can be valuable tools in facilitating and maintaining behavioural change, but they should be used with other strategies as part of structured weight

management interventions. There is scope to provide FTs to disadvantaged populations routinely, but such enhanced interventions should be adequately designed to ensure the devices reach those who need them most. Support must also be offered to ensure people can make the most of FTs and maintain their usage beyond the structured programme.

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Appendix I: Study questionnaire-wave 1

Please answer the questions in the sections below. Each section has its own instructions.

Section 1. We would like to ask you a few questions about the way you think about weight loss and maintaining a healthy weight. Please note that there are no right or wrong answers. For each statement, please CIRCLE the statement that most closely matches how you feel.

	Strongly disagree					**Strongly agree**
Whether I gain, lose, or maintain my weight is entirely up to me.	1	2	3	4	5	6
Being the right weight is largely a matter of good luck.	1	2	3	4	5	6
No matter what I intend to do, if I gain or lose weight, or stay the same in the near future, it is just going to happen.	1	2	3	4	5	6
If I eat right and get enough exercise and rest, I can control my weight	1	2	3	4	5	6

Section 2. This section is linked to technology and to what extent you engage with it. Please tick the most relevant option under each question.

I consider myself to be: (Please tick ONE)

- A confident individual ready to try new technology - whether it's new computers, phones, apps
- I do not feel very confident when it comes to trying new technology. I feel overwhelmed by new computers, phones, apps
- I am somewhere in between

Which electronic devices would you find hard to live without? (Please tick all that apply)

- Laptop/computer
- Mobile phone
- Tablet
- Other (please specify) ……
- None

Which type of mobile phone do you MOST use? (Please tick ONE)

- A smartphone (such as iPhone, Samsung etc) that enables the download of apps
- A basic mobile phone (takes photos and plays music but no apps)
- No mobile phone
- Other (please specify) ……

Do you use any of these networking sites? If yes, which one(s)? (Please tick all that apply)

- Twitter
- Facebook
- Blogs
- Other (please specify) ……..
- No, I really don't

Do you use any fitness tracking/weight management apps or websites?

- Yes (please specify which one(s)…….……
- No

Do you have a close family member/friend who uses a fitness tracker for fitness tracking/weight management?

- Yes (please specify which one(s) …….……
- No

Section 3. The next section deals with Attitudes people may have about changing health behaviours. Please answer each of the following questions by CIRCLING the number that best describes your opinion or most closely matches your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

For me to reduce weight is:

Good :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Bad

Beneficial :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Harmful

Desirable :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Undesirable

For me <u>to try</u> to reduce weight is:

Good :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Bad

Beneficial :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Harmful

Desirable :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Undesirable

Most people who are important to me think that:

I should :_1_:_2_:_3_:_4_:_5_:_6_:_7_: I should not

reduce my weight

Most people who are important to me would:

Support:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Oppose

me to reduce my weight

Most people who are important to me think that:

I should :_1_:_2_:_3_:_4_:_5_:_6_:_7_: I should not

<u>try to</u> reduce my weight

Most people who are important to me would:

Support:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Oppose

me to <u>try to</u> reduce my weight

I intend to reduce weight:

Likely :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Unlikely

I will try to reduce weight:

Likely :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Unlikely

I have decided to lose weight:

True :_1_:_2_:_3_:_4_:_5_:_6_:_7_: False

I am determined to lose weight:

Very much:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Not at all

I am confident that I would reduce weight if I wanted to:

Strongly agree :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly disagree

For me to reduce my weight it is:

Easy :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Difficult

The decision to lose weight is beyond my control:

Strongly Agree:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly Disagree

Whether I lose weight or not is entirely up to me:

Strongly Agree:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly Disagree

Section 4. The next questions relate to your physical activity levels and your work pattern. We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. You will be asked about the time you spent being physically active in the **last 7 days.** Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and garden work, to get from place to place, and in your spare time for recreation, exercise or sport.

*Think about all the **vigorous** activities that you did in the **last 7 days. Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those vigorous physical activities that you did for at least 10 minutes at a time.*

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ days per week ☐ No vigorous physical activities - Skip to question 3

2. How much time (on average) did you usually spend doing vigorous physical activities on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*Now, think about all the **moderate** activities that you did in the **last 7 days. Moderate** activities refer to activities that take moderate physical effort and make you breathe*

somewhat harder than normal. Think only about those moderate physical activities that you did for at least 10 minutes at a time.

3. During the last 7 days, on how many days did you do <u>moderate</u> physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ days per week ☐ No moderate physical activities - Skip to question 5

4. How much time (on average) did you usually spend doing <u>moderate</u> physical activities on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*Think about the time you spent **<u>walking</u>** in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.*

5. During the last 7 days, on how many days did you <u>walk</u> for at least 10 minutes at a time?

_____ days per week ☐ No walking - Skip to question 7

6. How much time (on average) did you usually spend <u>walking</u> on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*The last question is about the time you spent **sitting** on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.*

7. During the last 7 days, how much time (on average) did you spend sitting on a week day?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

8. Do you work? (please include any regular activities for which you do not get paid i.e., volunteering activities)

- ☐ Yes
- ☐ No (please go to section 5)

9. What is your current working pattern?

- ☐ Regular daytime
- ☐ Regular nights
- ☐ Rotating shifts
- ☐ Irregular shifts
- ☐ Other, please specify……..

10. How many hours did you work in the last 7 days? _____ hours

Section 5. In this section, we would like to ask you a few questions about your motivation to lose weight.

Would you like to have or maintain a healthy body weight?

☐ yes ☐ no ☐ it does not matter to me

Please answer the questions in the table below by circling the statement that most closely matches how you feel.

The reason I would like to have a healthy body weight is because:	**do not agree at all**			**Somewhat agree**			**totally agree**
1. It is very important to be as healthy as possible	1	2	3	4	5	6	7
2. I personally believe that it is the best for my health	1	2	3	4	5	6	7
3. I would like to take responsibility for my own health	1	2	3	4	5	6	7
4. It is an important decision I really want to make	1	2	3	4	5	6	7
5. I thought about it carefully and think that this is important for many aspects of my life	1	2	3	4	5	6	7

6. It fits my life goals	1	2	3	4	5	6	7
7. I would be embarrassed if I did not have a healthy body weight	1	2	3	4	5	6	7
8. I would feel bad about myself if I do not have a healthy body weight	1	2	3	4	5	6	7
9. I would have a guilty conscience if I do not have a healthy body weight	1	2	3	4	5	6	7
10. I feel undisciplined when I do not have a healthy body weight	1	2	3	4	5	6	7
11. I permanently feel pressured by others to have a healthy body weight	1	2	3	4	5	6	7
12. Others would be upset with me if I do not have a healthy body weight	1	2	3	4	5	6	7
13. I want others to see that I can do it	1	2	3	4	5	6	7
14. I want others to accept me	1	2	3	4		6	7
15. I would like to have or maintain a healthy body weight because (Please describe): ……							

……

……

Section 6. Below are some statements that people sometimes make when they talk about their health. Please indicate how much you agree or disagree with each statement as it applies to you personally by circling your answer. There are no right or wrong answers, just what is true for you. If the statement does not apply to you, circle N/A.

1. I am the person who is responsible for taking care of my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
2. Taking an active role in my own health care is the most important thing that affects my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
3. I am confident I can help prevent or reduce problems associated with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
4. I know what each of my prescribed medications do.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
5. I am confident that I can tell whether I need to go to the doctor or whether I can take care of a health problem myself.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

6. I am confident that I can tell a doctor or nurse concerns I have even when he or she does not ask.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
7. I am confident that I can carry out medical treatments I may need to do at home.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
8. I understand my health problems and what causes them.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
9. I know what treatments are available for my health problems.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
10. I have been able to maintain lifestyle changes, like healthy eating or exercising.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
11. I know how to prevent problems with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
12. I am confident I can work out solutions when new problems arise with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
13. I am confident that I can maintain lifestyle changes, like healthy eating and exercising, even during the times of stress.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

Thank you for taking part in the first wave of the study. Your input is much appreciated.

Please return this questionnaire to Weronika Reed or alternatively a staff member.

Once you do, we will be able to allocate you to one of the study groups.

You will be asked to fill in a wave 2 survey at the end of your weight management programme.

Weronika Reed (The University of West London)

Appendix II: Study questionnaire-wave 2

Please answer the questions in the sections below. Each section has its own instructions.

Section 1. We would like to ask you a few questions about the way you think about weight loss and maintaining a healthy weight. Please note that there are no right or wrong answers. For each statement, please CIRCLE the statement that most closely matches how you feel.

	Strongly disagree					**Strongly agree**
Whether I gain, lose, or maintain my weight is entirely up to me.	1	2	3	4	5	6
Being the right weight is largely a matter of good luck.	1	2	3	4	5	6
No matter what I intend to do, if I gain or lose weight, or stay the same in the near future, it is just going to happen.	1	2	3	4	5	6
If I eat right and get enough exercise and rest, I can control my weight	1	2	3	4	5	6

Section 2. The next section deals with Attitudes people may have about changing health behaviours. Please answer each of the following questions by CIRCLING the number that best describes your opinion or most closely matches your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

For me to reduce weight is:

Good :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Bad

Beneficial :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Harmful

Desirable :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Undesirable

For me to try to reduce weight is:

Good :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Bad

Beneficial :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Harmful

Desirable :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Undesirable

Most people who are important to me think that:

I should :_1_:_2_:_3_:_4_:_5_:_6_:_7_: I should not

reduce my weight

Most people who are important to me would:

Support:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Oppose

me to reduce my weight

Most people who are important to me think that:

I should :_1_:_2_:_3_:_4_:_5_:_6_:_7_: I should not

<u>try to</u> reduce my weight

Most people who are important to me would:

Support:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Oppose

me to <u>try to</u> reduce my weight

I intend to reduce weight:

Likely :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Unlikely

I will try to reduce weight:

Likely :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Unlikely

I have decided to lose weight:

True :_1_:_2_:_3_:_4_:_5_:_6_:_7_: False

I am determined to lose weight:

Very much:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Not at all

I am confident that I would reduce weight if I wanted to:

Strongly agree :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly disagree

For me to reduce my weight it is:

Easy :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Difficult

The decision to lose weight is beyond my control:

Strongly Agree:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly Disagree

Whether I lose weight or not is entirely up to me:

Strongly Agree:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly Disagree

Section 3. The next questions relate to your physical activity levels and your work pattern. We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. You will be asked about the time you spent being physically active in the **last 7 days.** Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and garden work, to get from place to place, and in your spare time for recreation, exercise or sport.

*Think about all the **vigorous** activities that you did in the **last 7 days. Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those vigorous physical activities that you did for at least 10 minutes at a time.*

1. During the last 7 days, on how many days did you do <u>vigorous</u> physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ days per week ☐ No vigorous physical activities - Skip to question 3

2. How much time (on average) did you usually spend doing <u>vigorous</u> physical activities on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*Now, think about all the **<u>moderate</u>** activities that you did in the **last 7 days. Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those moderate physical activities that you did for at least 10 minutes at a time.*

3. During the last 7 days, on how many days did you do <u>moderate</u> physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ days per week ☐ No moderate physical activities - Skip to question 5

4. How much time (on average) did you usually spend doing <u>moderate</u> physical activities on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*Think about the time you spent **walking** in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.*

5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

_____ days per week ☐ No walking - Skip to question 7

6. How much time (on average) did you usually spend walking on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*The last question is about the time you spent **sitting** on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.*

7. During the last 7 days, how much time (on average) did you spend sitting on a week day?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

8. Do you work? (please include any regular activities for which you do not get paid i.e., volunteering activities)

- ☐ Yes
- ☐ No (please go to section 4)

9. What is your current working pattern?

- Regular daytime
- Regular nights
- Rotating shifts
- Irregular shifts
- Other, please specify……..

10. How many hours did you work in the last 7 days? _____ hours

Section 4. In this section, we would like to ask you a few questions about your motivation to lose weight.

Would you like to have or maintain a healthy body weight?

☐ yes ☐ no ☐ it does not matter to me

Please answer the questions in the table below by circling the statement that most closely matches how you feel.

The reason I would like to have a healthy body weight is because:	**do not agree at all**			**Somewhat agree**			**totally agree**
1. It is very important to be as healthy as possible	1	2	3	4	5	6	7

2. I personally believe that it is the best for my health	1	2	3	4	5	6	7
3. I would like to take responsibility for my own health	1	2	3	4	5	6	7
4. It is an important decision I really want to make	1	2	3	4	5	6	7
5. I thought about it carefully and think that this is important for many aspects of my life	1	2	3	4	5	6	7
6. It fits my life goals	1	2	3	4	5	6	7
7. I would be embarrassed if I did not have a healthy body weight	1	2	3	4	5	6	7
8. I would feel bad about myself if I do not have a healthy body weight	1	2	3	4	5	6	7
9. I would have a guilt conscience if I do not have a healthy body weight	1	2	3	4	5	6	7
10. I feel undisciplined when I do not have a healthy body weight	1	2	3	4	5	6	7
11. I permanently feel pressured by others to have a healthy body weight	1	2	3	4	5	6	7

12. Others would be upset with me if I do not have a healthy body weight	1	2	3	4	5	6	7
13. I want others to see that I can do it	1	2	3	4	5	6	7
14. I want others to accept me	1	2	3	4	5	6	7
15. I would like to have or maintain a healthy body weight because (Please describe): …… ……							

Section 5. Below are some statements that people sometimes make when they talk about their health. Please indicate how much you agree or disagree with each statement as it applies to you personally by circling your answer. There are no right or wrong answers, just what is true for you. If the statement does not apply to you, circle N/A.

1. I am the person who is responsible for taking care of my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
2. Taking an active role in my own health care is the most important thing that affects my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
3. I am confident I can help prevent or reduce problems associated with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

4. I know what each of my prescribed medications do.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
5. I am confident that I can tell whether I need to go to the doctor or whether I can take care of a health problem myself.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
6. I am confident that I can tell a doctor or nurse concerns I have even when he or she does not ask.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
7. I am confident that I can carry out medical treatments I may need to do at home.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
8. I understand my health problems and what causes them.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
9. I know what treatments are available for my health problems.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
10. I have been able to maintain lifestyle changes, like healthy eating or exercising.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
11. I know how to prevent problems with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

12. I am confident I can work out solutions when new problems arise with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
13. I am confident that I can maintain lifestyle changes, like healthy eating and exercising, even during times of stress.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

Thank you for taking part in the second wave of the study. Your input is much appreciated. Please return this questionnaire to Weronika Reed or alternatively a staff member. You will be asked to fill in a similar, wave 3 questionnaire at the end of the study (approximately 3 months from now).

Weronika Reed (The University of West London)

Appendix III: Study questionnaire-wave 3

Please answer the questions in the sections below. Each section has its own instructions.

Section 1. We would like to ask you a few questions about the way you think about weight loss and maintaining a healthy weight. Please note that there are no right or wrong answers. For each statement, please CIRCLE the statement that most closely matches how you feel.

	Strongly disagree					**Strongly agree**
Whether I gain, lose, or maintain my weight is entirely up to me.	1	2	3	4	5	6
Being the right weight is largely a matter of good luck.	1	2	3	4	5	6
No matter what I intend to do, if I gain or lose weight, or stay the same in the near future, it is just going to happen.	1	2	3	4	5	6
If I eat right and get enough exercise and rest, I can control my weight	1	2	3	4	5	6

Section 2. The next section deals with Attitudes people may have about changing health behaviours. Please answer each of the following questions by CIRCLING the

number that best describes your opinion or most closely matches your opinion. Some of the questions may appear to be similar, but they do address somewhat different issues. Please read each question carefully.

For me to reduce weight is:

Good :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Bad

Beneficial :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Harmful

Desirable :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Undesirable

For me <u>to try</u> to reduce weight is:

Good :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Bad

Beneficial :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Harmful

Desirable :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Undesirable

Most people who are important to me think that:

I should :_1_:_2_:_3_:_4_:_5_:_6_:_7_: I should not

reduce my weight

Most people who are important to me would:

Support:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Oppose

me to reduce my weight

Most people who are important to me think that:

I should :_1_:_2_:_3_:_4_:_5_:_6_:_7_: I should not

<u>try to</u> reduce my weight

Most people who are important to me would:

Support:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Oppose

me to <u>try to</u> reduce my weight

I intend to reduce weight:

Likely :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Unlikely

I will try to reduce weight:

Likely :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Unlikely

I have decided to lose weight:

True :_1_:_2_:_3_:_4_:_5_:_6_:_7_: False

I am determined to lose weight:

Very much:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Not at all

I am confident that I would reduce weight if I wanted to:

Strongly agree :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly disagree

For me to reduce my weight it is:

Easy :_1_:_2_:_3_:_4_:_5_:_6_:_7_: Difficult

The decision to lose weight is beyond my control:

Strongly Agree:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly Disagree

Whether I lose weight or not is entirely up to me:

Strongly Agree:_1_:_2_:_3_:_4_:_5_:_6_:_7_: Strongly Disagree

Section 3. The next questions relate to your physical activity levels and your work pattern. We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. You will be asked about the time you spent being physically active in the **last 7 days.** Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and garden work, to get from place to place, and in your spare time for recreation, exercise or sport.

*Think about all the **vigorous** activities that you did in the **last 7 days. Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those vigorous physical activities that you did for at least 10 minutes at a time.*

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ days per week ☐ No vigorous physical activities - Skip to question 3

2. How much time (on average) did you usually spend doing <u>vigorous</u> physical activities on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*Now, think about all the **<u>moderate</u>** activities that you did in the **last 7 days. Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those moderate physical activities that you did for at least 10 minutes at a time.*

3. During the last 7 days, on how many days did you do <u>moderate</u> physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ days per week ☐ No moderate physical activities - Skip to question 5

4. How much time (on average) did you usually spend doing <u>moderate</u> physical activities on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*Think about the time you spent **<u>walking</u>** in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.*

5. During the last 7 days, on how many days did you <u>walk</u> for at least 10 minutes at a time?

_____ days per week ☐ No walking - Skip to question 7

6. How much time (on average) did you usually spend <u>walking</u> on one of those days?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

*The last question is about the time you spent **<u>sitting</u>** on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.*

7. During the last 7 days, how much time (on average) did you spend <u>sitting</u> on a week day?

_____ hours per day _____ minutes per day ☐ Don't know/Not sure

8. Do you work? (please include any regular activities for which you do not get paid i.e., volunteering activities)

- ☐ Yes
- ☐ No (please go to section 4)

9. What is your current working pattern?

- ☐ Regular daytime
- ☐ Regular nights
- ☐ Rotating shifts

- Irregular shifts
- Other, please specify……..

10. How many hours did you work in the last 7 days? _____ hours

Section 4. In this section, we would like to ask you a few questions about your motivation to lose weight.

Would you like to have or maintain a healthy body weight?

☐ yes ☐ no ☐ it does not matter to me

Please answer the questions in the table below by circling the statement that most closely matches how you feel.

The reason I would like to have a healthy body weight is because:	**do not agree at all**			**Somewhat agree**			**totally agree**
1. It is very important to be as healthy as possible	1	2	3	4	5	6	7
2. I personally believe that it is the best for my health	1	2	3	4	5	6	7
3. I would like to take responsibility for my	1	2	3	4	5	6	7

own health							
4. It is an important decision I really want to make	1	2	3	4	5	6	7
5. I thought about it carefully and think that this is important for many aspects of my life	1	2	3	4	5	6	7
6. It fits my life goals	1	2	3	4	5	6	7
7. I would be embarrassed if I did not have a healthy body weight	1	2	3	4	5	6	7
8. I would feel bad about myself if I do not have a healthy body weight	1	2	3	4	5	6	7
9. I would have a guilt conscience if I do not have a healthy body weight	1	2	3	4	5	6	7
10. I feel undisciplined when I do not have a healthy body weight	1	2	3	4	5	6	7
11. I permanently feel pressured by others to have a healthy body weight	1	2	3	4	5	6	7
12. Others would be upset with me if I do not have a healthy body weight	1	2	3	4	5	6	7
13. I want others to see that I can do it	1	2	3	4	5	6	7

14. I want others to accept me	1	2	3	4	5	6	7
15. I would like to have or maintain a healthy body weight because (Please describe): …… ……							

Section 5. Below are some statements that people sometimes make when they talk about their health. Please indicate how much you agree or disagree with each statement as it applies to you personally by circling your answer. There are no right or wrong answers, just what is true for you. If the statement does not apply to you, circle N/A.

1. I am the person who is responsible for taking care of my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
2. Taking an active role in my own health care is the most important thing that affects my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
3. I am confident I can help prevent or reduce problems associated with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
4. I know what each of my prescribed medications do.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

5. I am confident that I can tell whether I need to go to the doctor or whether I can take care of a health problem myself.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
6. I am confident that I can tell a doctor or nurse concerns I have even when he or she does not ask.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
7. I am confident that I can carry out medical treatments I may need to do at home.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
8. I understand my health problems and what causes them.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
9. I know what treatments are available for my health problems.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
10. I have been able to maintain lifestyle changes, like healthy eating or exercising.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
11. I know how to prevent problems with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A
12. I am confident I can work out solutions when new problems arise with my health.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

13. I am confident that I can maintain lifestyle changes, like healthy eating and exercising, even during times of stress.	Disagree Strongly	Disagree	Agree	Agree Strongly	N/A

Section 6. Additional questions relating to your experience during the weight management programme

1. Have you attended any other programmes following the weight management programme?

- □ No
- □ Yes - please specify which one(s)……

2. Have there been any changes to your medications (if you take any) e.g., change in dosages or medications in general?

- □ No
- □ Yes - please specify which one(s)……

3. How would you describe your experience of the weight management programme you have attended?

……

……

……

4. If you used the fitness tracker (Fitbit) as part of this study, could you tell us about your experience of using it as part of the programme? Which aspects of the Fitbit have you found the most and least useful and why?

……

……

……

……

……

Thank you for taking part in the last wave of the study. Your input is much appreciated! Please return this questionnaire by post, please contact the researcher (Weronika Reed) to arrange an alternative way of passing this survey (tel. 07860750687).

We will be sending a **summary of this research** to all participants who express an interest, please indicate below whether you would like to be included.

We may conduct several **interviews** on the same themes as a follow-up of this study. Please indicate below whether you would be happy to be contacted for this purpose.

Thank You!

Weronika Reed (The University of West London)

- ☐ I would like to receive the summary of research findings from this study **(please provide your full name and home address or email address written in capital letters below)**

- ☐ I am happy to be contacted for further research to share my experiences on the weight management programme **(please provide your full name and phone number below)**

Name……..……...

Home address……

Email Address……

Phone number……

Date……..Signature……..

Appendix IV: The Hospital and Depression Scale used as part of the HH programme

Healthy Hearts
CHANGE TODAY, FOR A BETTER TOMORROW

Wellbeing (HADS) Questionnaire	Score at start	Score at end
(A) I feel tense or 'wound up'		
Most of the time (3), A lot of the time (2), From time to time/Occasionally (1), Not at all (0)		
(D) I still enjoy the things I used to enjoy		
Definitely as much (0), Not quite so much (1), Only a little (2), Hardly at all (3)		
(A) I get a sort of frightened feeling as if something awful is about to happen		
Very definitely and quite badly (3), Yes, but not too badly (2), A little, but it doesn't worry me (1), Not at all (0)		
(D) I can laugh and see the funny side of things		
As much as I always could (0), Not quite so much now (1), Definitely not so much now (2), Not at all (3)		
(A) Worrying thoughts go through my mind		
A great deal of the time (3), A lot of the time (2), From time to time, but not too often (1), Only occasionally (0)		
(D) I feel cheerful		
Not at all often (3), Not often (2), Sometimes (1), Most of the time (0)		
(A) I can sit at ease and feel relaxed		
Definitely (0), Usually (1), Not often (2), Not at all (3)		
(D) I feel as if I am slowed down		
Nearly all the time (3), Very often (2), Sometimes (1), Not at all (o)		
(A) I get a sort of frightened feeling like 'butterflies' in the stomach		
Not at all (0), Occasionally (1), Quite often (2), Very often (3)		
(D) I have lost interest in my appearance		
Definitely (3), I don't take as much care as I should (2), I may not take quite as much care (1), I take just as much care as ever (0)		
(A) I feel restless as I have to be on the move		
Very much indeed (3), Quite a lot (2), Not very much (1), Not at all (0)		
(D) I look forward with enjoyment to things		
As much as I ever did (0), Rather less than I used to (1), Definitely less than I used to (2), Hardly at all (3)		
(A) I get sudden feelings of panic		
Very often indeed (3), Quite often (2), Not very often (1), Not at all (0)		
(D) I can enjoy a good book or radio or TV programme		
Often (0), Sometimes (1), Not often (2), Very seldom (3)		
TOTAL A Score - **TOTAL D Score -**		

Appendix V: Service users study information sheet (Quantitative)

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the Researcher: Weronika Reed

Key Study Information

You are invited to take part in a study conducted by the University of West London. Information about this project is provided below so please read it carefully. You will need to make the decision as to whether to take part before your first weight management session. If you have any queries, please contact the researcher.

Study context and aims

Fitness trackers have become very popular but it is not clear whether they can help people lose weight. This study will look into the impact of these devices when used as part of a weight management programme and it will explore factors that may influence programme outcomes. We are interested in finding out whether using such trackers will lead to different outcomes. You can find out more about fitness trackers at the end of this document (Appendix VI).

Participants

We are inviting you as you have enrolled on the Healthy Hearts weight management programme. We plan to recruit 200 clients who will be allocated to one of two study groups: with or without fitness trackers. Strict screening criteria to identify participants for this study will be used. Only service users starting the weight management programme, who are able to exercise and have no objection to using the fitness tracker are invited to participate. People with a history of cardiovascular events (e.g., heart attack/stroke) and certain medical conditions (e.g., epilepsy) or pacemakers, as well as those who already use a fitness tracker, are not eligible to participate.

Taking part in the study

If you choose to take part, we will ask for your written consent. You will be able to withdraw from the study at any time without giving a reason or without it affecting the care you receive.

Study procedure

There are three separate waves of this study. At each wave, a paper survey will need to be completed:

Wave 1 – You will be asked to come 45 min before the start of your weight management session in week 1. When you arrive, you will be invited to complete a questionnaire (taking about 25 min). The researcher will support you if you have any issues with completing it. Following the first weight management session, each

participant will be randomly allocated to either: a fitness trackers group or no fitness trackers group. To ensure fair and equal participant allocation to groups, this will be done by the researcher using a computer-based randomisation allocation tool. Before the second session, you will be notified which group you were allocated to. If you are allocated to the fitness trackers group, the researcher will provide you with the device and explain how to use it.

Wave 2 - In week 9 of your weight management programme, you will be asked to complete a second questionnaire and bring the completed form to the final weight management session (in week 10).

Wave 3 – Once your final care planning session is booked (approximately 6 months after your first one), you will receive your third and final questionnaire. You will be asked to bring it back completed to your final care planning session. If you require any assistance at that stage, you will be encouraged to call the researcher.

More information about the study

Both groups will follow the standard weight management programme. If you are randomly allocated to the fitness trackers group, you will be required to wear the device during the day and encouraged to wear it at night for the duration of the study. The fitness tracker will remain the property of Healthy Hearts during the study, however, participants may keep their device after the end of the study.

If you are allocated to the group without the fitness tracker, please rest assured that your contribution is valuable, as we need to make comparisons between the two groups and look at factors influencing everyone's treatment outcomes.

Confidentiality and data storage

Data will be treated in the strictest confidence and will be anonymised. Your identity will be kept confidential. Anonymised study data will be retained for up to 3 years and stored securely. The fitness tracker data will only be accessed during the study (for up to 6 months).

Benefits of taking part

Whichever group you are allocated to, you will be helping with an innovative piece of research. Programmes that help people manage their weight are increasingly important as they provide the knowledge and tools to assist in weight loss and help reduce the risks of ill health. It will be beneficial to learn how current weight management programmes can be developed further. This study may be of no personal benefit to you.

Drawbacks of taking part

As the study has an experimental design with random allocation, the devices will be distributed by chance. Whilst we would like to avoid any disappointments, the way the study is designed means that we have no control over which group you will be allocated to. We would like to assure you that both groups are necessary for the success of the study.

The results

We hope that the results from this study will be used to identify potential improvements to weight management interventions. The results are anticipated to be published in professional journals and presented at conferences. If you wish to receive a summary of the findings, you will be able to request this and provide your preferred contact details at the end of the questionnaire (wave 3).

The researcher

This study is conducted as part of a PhD research project being run in the School of Human and Social Sciences at the University of West London. It is led by Weronika Reed and supervised by senior researchers. This study has received ethical approval from the University of West London and the NHS ethics committees. If you have any questions related to the study, you may contact the researcher, contact details:

Weronika Reed, Tel: 07860750687, email: 21330456@student.uwl.ac.uk.

If you have any concerns about the study or the way it is conducted, please contact the project principal supervisor: Dr Maddie Ohl, Tel: 0208 231 2079, email: maddie.ohl@uwl.ac.uk. If you have any general concerns or would like to raise a complaint, please contact the Head of Healthy Lifestyle Service: Samia Arshad, Tel: 075 9544965, email: samia.arshad@thrivetribe.org.uk

Next steps

If you are happy to take part in the study, please fill in the next section, which includes the consent form. Thank you for taking the time to read this information.

Appendix VI: Fitness Tracker information for study participants

What is a fitness tracker?

Fitness trackers are usually worn as a wrist band like watches. They are upgraded versions of pedometers but, in addition to measuring steps, they also keep track of many other functions, e.g., heart rate and sleep quality (please see below).

The features of the fitness tracker (Fitbit Charge 2):

PurePulse® Heart Rate
Get continuous, automatic, wrist-based heart rate & simplified heart rate zones. Learn more.

Multi-Sport Modes
Track workouts like running, biking & weights and get real-time stats on display. Then see post-workout summaries on screen & in the app.

Connected GPS
Connect Charge 2 with the GPS on your phone to see real-time stats like pace and distance on display and record a map of your route.

Cardio Fitness Level
Get a better understanding of your fitness level and see how you can improve over time with a personalised Cardio Fitness Score.

SmartTrack™
Automatically recognises select activities and records them in the exercise section of the Fitbit app.

Guided Breathing
Find moments of calm throughout your day with personalised breathing sessions based on your heart rate.

All-Day Activity Tracking
Track steps, heart rate, distance, calories burned, active minutes, floors climbed, hourly activity & stationary time.

Reminders to Move
Get friendly Reminders to Move that encourage you to reach an hourly goal of 250 steps.

Smartphone Notifications
See call, text and calendar alerts on display when your phone is nearby.

Auto Sleep Tracking & Silent Alarms
Automatically track your sleep quality & wake up peacefully with a silent alarm.

Sleep Stages
See your time in light, deep and REM stages to better understand your sleep quality. Learn more.

Hi-Res Tap Display
An interactive OLED display makes it easy to view your stats. Simply tap the screen to get the information you need.

Interchangeable Bands
Switch up your look with accessory bands in leather and more.

Long Battery Life
Battery life up to 5 days so you can track all day and night without needing a charge.*

Wireless Syncing
Sync stats wirelessly & automatically to computers and 200+ leading iOS, Android and Windows devices.

Why Fitbit Charge 2?

After a thorough comparison of many fitness trackers, e.g., Garmin, Jawbone, TomTom, Misfit, Fitbit etc, we concluded that Fitbit Charge 2 is the most appropriate device for this study. It is simple to use, has a large display screen that provides feedback, has good battery life (up to 5 days), and tracks sleep and several types of activities. Fitbit works best when used in conjunction with the Fitbit account which can be accessed through a smartphone/tablet or a computer.

There is no relationship between the manufacturers of Fitbit and the research team. Therefore, there is no conflict of interest. The research team has no interest in promoting this specific brand, and the decision was made based on the device's functionalities. There are no benefits to the research team as a result of choosing this brand.

How the fitness tracker will be used in the study?

Basic feedback, e.g., daily number of steps, calories burnt, heart rate, active minutes etc is displayed on the device itself. In addition, all data gathered through the fitness tracker is securely stored on the Fitbit cloud server. Participants will have access to this data through a Fitbit account where exercise history, sleep patterns, and activity levels can be viewed (examples shown below). The anonymised Fitbit account will be created for all participants at the beginning of the study by the researcher.

Examples of Fitbit account displays on a computer and a mobile phone (from the Fitbit website):

What fitness tracker data will be used in the study?

Steps, activity intensity, tracked activities (such as walks and runs), estimated energy expenditure (calories burnt), sleep patterns, heart rate and usage information will be shared with the research team in an anonymised format for a duration of six months. No data will be shared with the research team after the final questionnaire (wave 3) is completed by participants. The anonymised fitness tracker data will be securely kept in agreement with the University of West London (like other data from this study) for a duration of 3 years.

Important to remember:

- Fitbit is NOT waterproof; therefore it cannot be worn when taking a bath/shower or going swimming.
- Fitbit needs to be charged at least every 5 days. It charges quickly when connected to a main socket or a computer (the cable will be provided).
- Fitbit tracks activity during the day and provides useful feedback. When used at night it monitors sleep quality.

If you agree to participate in the study and are allocated to the intervention with fitness tracker condition, you will be shown how to use the tracker when you receive it and you will be provided with a detailed Fitbit manual.

Appendix VII: Service users informed consent (Quantitative)

IRAS ID: 225481

Participant Identification Number for this study:

Consent form

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the Researcher: Weronika Reed

Thank you for taking the time to read the Participant Information Sheet. To show your agreement to take part in the study, please **insert your initials** next to the statements below.

Please initial box

1. I confirm that I have read and understood the information sheet provided (version number 2, dated 15th January 2018) for the above study and have had the opportunity to consider the information, ask questions and received satisfactory answers. ☐

2. I understand that my participation in the study is voluntary and that I will be able to withdraw from the study at any time without providing a reason or without it affecting the care I receive from Healthy Hearts. Any data related to me will be destroyed. ☐

3. I understand that the anonymised data collected in the study may be looked at by authorised individuals from the University of West London. I give permission for these individuals to collect, store, analyse and publish information obtained from my participation in this study. I understand that my personal details will be kept confidential. ☐

4. I understand that the study will require to use anonymised information gathered from the Healthy Hearts programme and the fitness trackers. ☐

5. I understand that all information and data collected will be held securely and in confidence in the Healthy Hearts office, in agreement with the University of West London, for a duration of 3 years, and that I will not be identified as a participant. ☐

6. I understand that if I am allocated to the fitness trackers group, I will receive a device that I will be required to wear continuously during waking hours and preferably while asleep. I understand that I cannot give the device to anyone else to wear during the time of the study. ☐

7. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Person taking consent	Date	Signature

2 copies: 1 for participant, 1 for the project notes

Appendix VIII: Study Debrief

Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Debrief Sheet

Thank you for taking part in our study, which aims to investigate the impact of fitness trackers on the outcomes of a weight management intervention to prevent Cardiovascular Disease. Fitness trackers have become very popular, but it is not clear whether they can help people lose weight. This study will look into the impact of these devices when used as part of a Healthy Hearts weight management programme and it will explore factors that may influence programme outcomes. We are interested in finding out whether using such trackers will lead to different outcomes. We hope that the results from this study will be used to identify potential improvements to weight management interventions. The results are anticipated to be published in professional journals and presented at conferences. If you have any questions about the study or would like to request a summary of the findings, please email the researcher Weronika Reed at: 21330456@student.uwl.ac.uk. Please remember that your data will be treated in the strictest confidence and will be anonymised. Your identity will be kept confidential. Anonymised study data will be retained for up to 3 years and stored securely. The fitness tracker data will only be accessed during the study (for up to 6 months). If

answering the questions made you think about any additional support or advice you might need in relation to losing weight or to find out about types of support available locally, please contact Healthy Hearts at https://healthyhearts.org.uk/.

Thank you for taking the time to help with this study, we hope you found it interesting, Weronika Reed (PhD student), Dr Maddie Ohl, Dr Caroline Lafarge, Dr Raffaella Milani. This debrief can be kept for your own records.

Appendix IX: Service users study information sheet (Qualitative)

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the Researcher: Weronika Reed

Key Study Information

You are invited to take part in the qualitative (interview-based) study conducted by the University of West London. This is a follow-up of the research you participated in while being enrolled on the Healthy Hearts programme. Information about this part of the study is provided below, so please read it carefully. If you have queries, please contact the researcher.

Study aim

We would like to learn more about fitness trackers and how service users used them when added to the standard Healthy Hearts programme. Sharing your experiences will be very valuable, and along with experiences and opinions gained from other service users, we are hoping to understand how fitness trackers can be utilised in future interventions.

Participants

We are inviting 10 Healthy Hearts service users who took part in the research and wore fitness trackers throughout the programme. We aim to interview a broad range of fitness trackers' users as we would like different experiences to be represented.

Taking part in the study

If you agree to be interviewed, we will ask for your written consent, and you will be able to withdraw from the study at any time without providing a reason or without it affecting the care you receive from Healthy Hearts.

Interview structure

The interview will take between 30 min and 1 hour, it will depend on how much information you would like to share. You will be asked a range of open-ended questions about your experiences of using the fitness tracker while on the Healthy Hearts programme. We will record this interview to be able to listen to it again and write up your responses for the analysis.

Confidentiality and data storage

Data will be treated in the strictest confidence and will be anonymised. Your identity will be kept confidential. All audio recordings will be destroyed after transcription. Anonymised transcripts will be retained for up to 3 years and stored securely in the Healthy Hearts office in agreement with the University of West London.

The results

The results and/or any quotes that may be used in future publications will be anonymised and no one will be able to identify you. The results are anticipated to be published in professional journals as well as presented at conferences. If you would like to receive a summary of this research, please indicate below and provide your contact details.

- ☐ I would like to receive a summary of research findings from this study **(please provide your full name and home address or email address written in capital letters below)**

Name……..……....

Home address……

Email Address……

Date……..Signature……..

The researcher

This study is conducted as part of a PhD research project being run in the School of Human and Social Sciences at the University of West London. It is led by Weronika Reed and supervised by senior researchers. This study has received ethical approval from the University of West London and the NHS ethics committees. If you have any questions related to the study, you may contact the researcher, contact details:

Weronika Reed, Tel: 07860750687, email: 21330456@student.uwl.ac.uk.

If you have any concerns about the study or the way it is conducted, please contact the project principal supervisor: Dr Maddie Ohl, Tel: 0208 231 2079, email: maddie.ohl@uwl.ac.uk. If you have any general concerns or would like to raise a complaint, please contact the Head of Healthy Hearts service: Andrew Emerson, Tel: 07540108893, email: Andrew.emerson@thrivetribe.org.uk

Next steps

If you are happy to take part in the study, please fill in the next section, which includes the consent form. Thank you for taking the time to read this information.

UNIVERSITY OF WEST LONDON

Appendix X: Service users study informed consent (Qualitative)

IRAS ID: 225481

Participant Identification Number for this study:

Consent form

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.
Name of the Researcher: Weronika Reed

Thank you for taking the time to read the Participant Information Sheet. To show your agreement to take part in the study, please insert your initials next to the statements below.

Please initial box

1. I confirm that I have read and understood the information sheet provided (version number 2, dated 15th January 2018) for the above study and have had the opportunity to consider the information, ask questions and received satisfactory answers. ☐

2. I understand that my participation in the study is voluntary and that I will be able to withdraw from the study at any time without providing a reason or without it affecting the care I receive from Healthy Hearts. Any data related to me will be destroyed. ☐

3. I understand that the anonymised data collected in the study may be looked at by authorised individuals from the University of West London. I give permission for these individuals to collect, store, analyse and publish information obtained from my participation in this study. I understand that my personal details will be kept confidential. ☐

4. I understand that all information and data collected will be held securely and in confidence and that I will not be identified as a participant. ☐

5. I agree to the researcher recording the interview. ☐

6. I understand that all audio recordings will be destroyed after transcription and anonymised transcripts of the interview will be kept securely in the Healthy Hearts office in agreement with the University of West London for a duration of 3 years. ☐

7. I understand that anonymous direct quotes from the interview may be used in the study reports. ☐

8. I agree to take part in the above study. ☐

_____	_____	_____
Name of Participant	**Date**	**Signature**

_____	_____	_____
Name of Person taking consent	Date	Signature

2 copies: 1 for participant, 1 for the project notes

Appendix XI: Service users qualitative interviews topic guide

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the Researcher: Weronika Reed

Qualitative Semi-Structured Interview guide

Introduction

Thank you for agreeing to take part in this study. You can tell me anything that refers to your opinion about the use of the Fitbit fitness tracker as part of the weight management programme and share your experiences from the duration of the study (approximately the last 6 months). There are no right or wrong answers.

Do you have any questions you would like to ask before we get started?

Interview questions

- How would you describe your experiences of using a Fitbit fitness tracker as part of the Healthy Hearts programme?
- Which aspects of the Fitbit have you found the most and least useful and why?
- How do you think Fitbit contributed to your overall experience on the programme?
- What barriers to wearing your Fitbit did you experience (if any)?

- Would you recommend the use of the Fitbit? (Yes/No - why is that, can you expand?)
- In which way, if at all, did you find the accompanying app/website useful? (And if so why was that? Or if not why not?)
- Did you receive support from other Fitbit device users- was this useful? (this can be through the Fitbit device accompanying app/web – virtual support or in person from other Fitbit users).
- How motivated are you to continue/How do you feel about continuing to follow the Healthy Hearts recommendations?
- Do you have any other experiences/comments you would like to share?

Closing statement

Thank you very much for participating. Would you like to ask any questions about the study?

You will be able to get in touch with me if you have any questions and request the opportunity to review your transcript from this interview.

Here is my business card, please keep it safe in case you need to contact me in the future. Please do not hesitate to get in touch.

Appendix XII: Health professionals study information sheet

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the lead Researcher: Weronika Reed

Name of the interviewer: Caroline Lafarge

Key Study Information

You are invited to take part in a qualitative study conducted by the University of West London. Information about this project is provided below, so please read it carefully. If you have queries, please contact the researcher.

Study context and aims

Fitness trackers have become very popular but it is not clear whether they can help people lose weight. This study will look into the impact of these devices when used as part of a Healthy Hearts weight management programme and it will explore factors that may influence programme outcomes. We are interested in finding out whether using such trackers to self-monitor behaviours (e.g., the number of steps taken) by Healthy Hearts service users will lead to different programme outcomes.

Participants

We are inviting 6 Healthy Hearts health professionals to be interviewed as part of the qualitative study. We would be aiming to interview staff members from all Tri-borough services, the sample will include care planners and practitioners.

Taking part in the study

If you choose to take part, we will ask for your written consent and you will be able to withdraw from the study at any time without providing a reason or without it affecting your work or work relationships. It is important to note that this study is not an assessment of your practice but an exploration of your observations of how service users experienced the Healthy Hearts programme that utilised Fitbit fitness trackers. We would like to emphasize that it is not our intention to make you feel you or your work are being evaluated.

Study procedure

Another member of the research team (Caroline Lafarge) will conduct your semi-structured interview to eliminate any potential for bias. The interview will take between 20 and 40 minutes, the duration will depend on how much information you would like to share. You will be asked a range of open-ended questions about your experiences of working with Healthy Hearts service users who used Fitbit as part of the study. We will record this interview to be able to listen to it again and write up your responses for the analysis.

Confidentiality and data storage

Data will be treated in the strictest confidence and will be anonymised. Your identity will be kept confidential. Anonymised study data will be retained for up to 3 years and stored securely in the Healthy Hearts office.

The results

The results and/or any quotes that may be used in future publications will be anonymised and no one will be able to identify you. The results are anticipated to be published in health and academic journals as well as presented at conferences.

The researcher

This study is conducted as part of a PhD research project being run in the School of Human and Social Sciences at the University of West London. It is led by Weronika Reed and supervised by a multidisciplinary team comprising Health Psychologists and other academics. This research has received ethical approval from the University of West London and the NHS ethics committees. If you have any questions related to the study, you may contact the researcher or the interviewer, contact details:

Weronika Reed, Tel: 07860750687, email: 21330456@student.uwl.ac.uk

Caroline Lafarge, email: Caroline.Lafarge@uwl.ac.uk

If you have any concerns about the study or the way it is conducted, please contact the project principal supervisor: Dr Maddie Ohl, Tel: 0208 231 2079, email: maddie.ohl@uwl.ac.uk. If you have any general concerns or would like to raise a

complaint, please contact the Head of Healthy Hearts service: Andrew Emerson, Tel: 07540108893, email: Andrew.emerson@thrivetribe.org.uk

Next steps

If you are happy to take part in the study, please fill in the next section, which includes the consent form. Thank you for taking the time to read this information.

Appendix XIII: Health professionals informed consent form

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the Researcher: Weronika Reed

Participant Consent form

Thank you for taking the time to read the information about the study. We hope that the findings we obtain through this research will be used to develop further weight management programmes within the cardiovascular disease prevention intervention. To take part in the study, please tick each of the statements below and sign where indicated.

☐ I confirm that I have read and understood the information sheet provided (version number 1, dated 23rd July 2017) for the above study and have had the opportunity to ask questions

☐ I understand that my participation in the study is voluntary and that I will be able to withdraw from the study at any time without providing a reason or without it affecting my work relationships, while my unprocessed data will be withdrawn from the study

☐ I understand that the anonymised data collected in the study may be looked at by authorised individuals from the University of West London. I give permission for these individuals to collect, store, analyse and publish information obtained from my participation in this study. I understand that my personal details will be kept confidential

☐ I understand that all information and data collected will be held securely and in confidence and that I will not be identified as a participant

☐ I agree to the researcher recording the interview

☐ I understand that a copy of the recording of the interview will be kept securely in the Healthy Hearts office for a duration of 3 years

☐ I understand that anonymous direct quotes from the interview may be used in the study reports

☐ I agree to take part in the above study

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____

Name of Person taking consent Date Signature

2 copies: 1 for participant, 1 for the project notes

Appendix XIV: Health professionals qualitative interviews topic guide

Title of the study: Investigating the impact of Fitness Trackers on the outcomes of a weight management intervention delivered within a cardiovascular disease prevention context.

Name of the Researcher: Weronika Reed

Interviewee: Caroline Lafarge

Qualitative Semi-Structured Interview guide

Introduction

Thank you for agreeing to take part in this study. You can tell me anything that refers to your opinion about the use of the Fitbit fitness trackers by Healthy Hearts service users during their programmes. We are interested to learn about your perceptions of clients' experiences, not about the specific group of clients. Please share your experiences and observations, there are no right or wrong answers.

Do you have any questions you would like to ask before we get started?

Interview questions

- What is your experience of working with Healthy Hearts service users using Fitbit as part of this study?
- How (if at all) did FTs influence the adult weight management programme outcomes of your clients?
- Were there any barriers to FT use among participants that you observed?
- How was the dynamic of running the HH adult weight management programme changed when the devices were added (if it was changed at all)?
- Do you have any other experiences/comments you would like to share?

Closing statement

Thank you very much for participating. Would you like to ask any questions about the study?

You will be able to get in touch with me if you have any questions and request the opportunity to review your transcript from this interview.

Here is my business card, please keep it safe in case you need to contact me in the future. Please do not hesitate to get in touch.

Appendix XV: The COREQ checklist utilised in the qualitative research phase

Personal Characteristics		
1. Interviewer/facilitator	Which author/s conducted the interview or focus group?	WR (lead researcher) and CL (principal supervisor)
2. Credentials	What were the researcher's credentials? E.g. PhD, MD	MSc and PhD respectively
3. Occupation	What was their occupation at the time of the study?	Head of stop smoking services and MSc Health Psychology module leader respectively
4. Gender	Was the researcher male or female?	Female
5. Experience and training	What experience or training did the researcher have?	MSc and PhD in Psychology respectively
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	No
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Health Professional participants knew the lead researcher therefore their interviews were completed by the principal supervisor
8. Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	It was reported that the lead researcher is employed by Thrive Tribe as Head of stop smoking services

Domain 2: Study design		
Theoretical framework		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Thematic Analysis
Participant selection		
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Purposive sampling
11. Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Telephone
12. Sample size	How many participants were in the study?	Nine service user and four health professional participants
13. Non-participation	How many people refused to participate or dropped out? Reasons?	15 service users and five health professionals were invited to take part. Of the six service users who did not take part, Two were no longer interested, and four were not reachable at the time of data collection. One additional health professional initially agreed to take part but then was off work due to long-term sickness and subsequently left HH.

Setting		
14. Setting of data collection	14. Setting of data collection Where was the data collected? e.g. home, clinic, workplace	Community settings when face-to-face and over the phone
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Obese service users from deprived areas of central London, accessing weight management intervention
Data collection		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The topic guide was developed before interviews commenced, no pilot was conducted due to a small sample
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	One repeated interview took place
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Yes
20. Field notes	Were field notes made during and/or after the interview or focus group?	Yes
21. Duration	What was the duration of the interviews or focus group?	20-30 minutes with service users, 10-20 minutes with health professionals
22. Data saturation	Was data saturation discussed?	Yes
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No

Domain 3: Analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	One (WR) and codes were subsequently cross-checked with members of the supervisory team
25. Description of the coding tree	Did authors provide a description of the coding tree?	No
26. Derivation of themes	Were themes identified in advance or derived from the data?	Derived from the data
27. Software	What software, if applicable, was used to manage the data?	Taguette (https://app.taguette.org/) This tool uses tags to help highlight codes and organise them into sub-themes, enabling better management of the coding process.
28. Participant checking	Did participants provide feedback on the findings?	No
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes
30. Data and findings consistent	Was there consistency between the data presented and the findings?	Yes
31. Clarity of major themes	Were major themes clearly presented in the findings?	Yes
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes (named sub-themes)